# Coronavirus Disease 2019 (COVID-19) Treatment Guidelines

Credit NIAID-RML

**How to Cite the COVID-19 Treatment Guidelines:**

COVID-19 Treatment Guidelines Panel. Coronavirus Disease 2019 (COVID-19) Treatment Guidelines. National Institutes of Health. Available at https://www.covid19treatmentguidelines.nih.gov/. Accessed [insert date].

The COVID-19 Treatment Guidelines Panel regularly updates the recommendations in these guidelines as new information on the management of COVID-19 becomes available. The most recent version of the guidelines can be found on the COVID-19 Treatment Guidelines website (https://www.covid19treatmentguidelines.nih.gov/).

# Table of Contents

**What's New in the Guidelines** ..... 4

**Introduction** ..... 7

**Overview of COVID-19** ..... 10
- Testing for SARS-CoV-2 Infection ..... 15
- Prevention and Prophylaxis of SARS-CoV-2 Infection ..... 21
- Clinical Spectrum of SARS-CoV-2 Infection ..... 32

**Clinical Management Summary** ..... 40
- General Management of Nonhospitalized Patients with Acute COVID-19 ..... 43
- Therapeutic Management of Nonhospitalized Adults With COVID-19 ..... 50
- Therapeutic Management of Hospitalized Adults With COVID-19 ..... 55

**Care of Critically Ill Adult Patients With COVID-19** ..... 66
- General Considerations ..... 68
- Infection Control ..... 76
- Hemodynamics ..... 79
- Oxygenation and Ventilation ..... 83
- Acute Kidney Injury and Renal Replacement Therapy ..... 90
- Pharmacologic Interventions ..... 91
- Extracorporeal Membrane Oxygenation ..... 92

**Antiviral Drugs That Are Approved or Under Evaluation for the Treatment of COVID-19** ..... 94
- Remdesivir ..... 96
  - Table 2a. Remdesivir: Selected Clinical Data ..... 99
- Chloroquine or Hydroxychloroquine and/or Azithromycin ..... 105
  - Table 2b. Chloroquine or Hydroxychloroquine and/or Azithromycin: Selected Clinical Data ..... 109
- Ivermectin ..... 119
  - Table 2c. Ivermectin: Selected Clinical Data ..... 124
- Lopinavir/Ritonavir and Other HIV Protease Inhibitors ..... 143
- Nitazoxanide ..... 148
  - Table 2d. Nitazoxanide: Selected Clinical Data ..... 150
- Table 2e. Characteristics of Antiviral Agents That Are Approved or Under Evaluation for the Treatment of COVID-19 ..... 153

**Anti-SARS-CoV-2 Antibody Products** ..... 157
- Anti-SARS-CoV-2 Monoclonal Antibodies ..... 159
  - Table 3a. Anti-SARS-CoV-2 Monoclonal Antibodies: Selected Clinical Data ..... 168
- Convalescent Plasma ..... 172
  - Table 3b. COVID-19 Convalescent Plasma: Selected Clinical Data ..... 179
- Immunoglobulins: SARS-CoV-2-Specific ..... 190

Table 3c. Characteristics of SARS-CoV-2 Antibody-Based Products Under Evaluation for the Treatment of COVID-19 ... 191

**Cell-Based Therapy Under Evaluation for the Treatment of COVID-19** ... 195

**Immunomodulators Under Evaluation for the Treatment of COVID-19** ... 198

Colchicine ... 199

Corticosteroids ... 203

Table 4a. Systemic Corticosteroids: Selected Clinical Data ... 210

Table 4b. Inhaled Corticosteroids: Selected Clinical Data ... 221

Fluvoxamine ... 223

Granulocyte-Macrophage Colony-Stimulating Factor Inhibitors ... 226

Table 4c. Granulocyte-Macrophage Colony-Stimulating Factor Inhibitors: Selected Clinical Data ... 229

Immunoglobulins: Non-SARS-CoV-2-Specific ... 233

Interferons (Alfa, Beta) ... 235

Interleukin-1 Inhibitors ... 239

Interleukin-6 Inhibitors ... 242

Table 4d. Interleukin-6 Inhibitors: Selected Clinical Data ... 248

Kinase Inhibitors: Baricitinib and Other Janus Kinase Inhibitors, and Bruton's Tyrosine Kinase Inhibitors ... 260

Table 4e. Characteristics of Immunomodulators Under Evaluation for the Treatment of COVID-19 ... 267

**Antithrombotic Therapy in Patients with COVID-19** ... 280

**Supplements** ... 289

Vitamin C ... 290

Vitamin D ... 293

Zinc ... 295

**Considerations for Certain Concomitant Medications in Patients with COVID-19** ... 299

**COVID-19 and Special Populations** ... 305

Special Considerations in Pregnancy ... 306

Special Considerations in Children ... 311

Special Considerations in Adults and Children With Cancer ... 322

Special Considerations in Solid Organ Transplant, Hematopoietic Stem Cell Transplant, and Cellular Therapy Candidates, Donors, and Recipients ... 330

Special Considerations in People With HIV ... 337

Influenza and COVID-19 ... 343

**Appendix A, Table 1. COVID-19 Treatment Guidelines Panel Members** ... 347

**Appendix A, Table 2. Panel on COVID-19 Treatment Guidelines Financial Disclosure for Companies Related to COVID-19 Treatment or Diagnostics** ... 349

# What's New in the Guidelines

*Last Updated: August 4, 2021*

The *Coronavirus Disease 2019 (COVID-19) Treatment Guidelines* is published in an electronic format that can be updated in step with the rapid pace and growing volume of information regarding the treatment of COVID-19.

The COVID-19 Treatment Guidelines Panel (the Panel) is committed to updating this document to ensure that health care providers, patients, and policy experts have the most recent information regarding the optimal management of COVID-19 (see the Panel Roster for a list of Panel members).

New Guidelines sections and recommendations and updates to existing Guidelines sections are developed by working groups of Panel members. All recommendations included in the Guidelines are endorsed by a majority of Panel members (see the Introduction for additional details on the Guidelines development process).

Major revisions to the Guidelines within the last month are as follows:

## August 4, 2021

### *Key Updates to the Guidelines*

#### Anti-SARS-CoV-2 Monoclonal Antibodies

This section has been updated to incorporate information that was previously included in the Panel's anti-SARS-CoV-2 monoclonal antibody statements. The changes to this section include:

- Adding sotrovimab as a recommended treatment for nonhospitalized patients with mild to moderate COVID-19 who are at high risk for clinical progression.
- Revising the dosing and administration information for casirivimab plus imdevimab.
- Recommending against the use of bamlanivimab plus etesevimab at this time because the Gamma (P.1) and Beta (B.1.351) variants of concern (VoC), which have reduced susceptibility to both agents, are circulating in the United States.
- Discussing the Food and Drug Administration's decision to revise the Emergency Use Authorizations for anti-SARS-CoV-2 monoclonal antibodies to include a broader range of conditions that place patients at high risk for clinical progression.
- Clarifying and updating the discussion on using anti-SARS-CoV-2 monoclonal antibodies in patients who are hospitalized for severe COVID-19.
- Updating the information on the in vitro susceptibility of circulating VoC and variants of interest to different anti-SARS-CoV-2 monoclonal antibodies, as well as the potential activities of these antibodies against these variants. The Panel has also added a new table to the section to summarize this information.

#### Corticosteroids

This section now includes a discussion on the use of inhaled corticosteroids in nonhospitalized patients with COVID-19. Based on available clinical trial data, the Panel has determined that there is currently insufficient evidence to recommend either for or against the use of inhaled budesonide for the treatment of COVID-19.

## July 8, 2021

### *New Sections of the Guidelines*

#### General Management and Therapeutic Management of Nonhospitalized Patients

Outpatient Management of Acute COVID-19 has been divided into two sections:

- General Management of Nonhospitalized Patients With Acute COVID-19
- Therapeutic Management of Nonhospitalized Adults With COVID-19

A new figure has been created for Therapeutic Management of Nonhospitalized Adults With COVID-19 to provide guidance on the use of therapeutic agents (e.g., anti-SARS-CoV-2 monoclonal antibodies) based on the patient's disposition.

#### Nitazoxanide

This section has been added to discuss the evidence and considerations for using nitazoxanide as an antiviral drug for the treatment of COVID-19. The Panel **recommends against** the use of **nitazoxanide** for the treatment of COVID-19, except in a clinical trial **(BIIa)**.

#### Granulocyte Colony-Stimulating Factor Inhibitors

This section has been added to address the use of granulocyte-macrophage colony-stimulating factor (GM-CSF) inhibitors as immunomodulators for the treatment of COVID-19. Based on the preliminary results from two, randomized, placebo-controlled trials investigating otilimab and lenzilumab, and a small, randomized, placebo-controlled trial of mavrilimumab, the Panel has determined that there is insufficient evidence to recommend either for or against the use of GM-CSF inhibitors for the treatment of hospitalized patients with COVID-19.

### *Key Updates to the Guidelines*

#### Therapeutic Management of Hospitalized Adults with COVID-19

This section has been updated to incorporate new recommendations and rationale for when to use baricitinib in combination with dexamethasone in certain hospitalized patients with COVID-19. The update is based on results from the COV-BARRIER trial. The Panel **recommends against** the use of **baricitinib** in combination with **tocilizumab (AIII)**.

#### Chloroquine or Hydroxychloroquine and/or Azithromycin

This section has been updated with new clinical data from multiple clinical trials. The recommendation for the use of these agents in nonhospitalized patients has been revised, and a recommendation regarding azithromycin monotherapy has been added.

#### Colchicine

A large, unpublished, randomized, placebo-controlled trial (RECOVERY) evaluated the role of colchicine in hospitalized patients with COVID-19. The study showed no difference in 28-day all-cause mortality between patients who received colchicine and those who received usual care. Based on these results, the Panel has updated its recommendation, and **recommends against** the use of **colchicine** for the treatment of hospitalized patients with COVID-19 **(AI)**.

#### Special Considerations in Pregnancy

This section has been updated to include more recent epidemiologic data indicating that some pregnant people may be at increased risk of COVID-19. In general, the therapeutic management of COVID-19 should be the same for pregnant patients as for nonpregnant patients. Developing a treatment plan should involve shared decision-making between the patient and the clinical team, with considerations based

on the severity of maternal disease and the safety of the medication for the pregnant individual and the fetus. Breastfeeding in the setting of COVID-19 is not contraindicated, and decision-making surrounding feeding breast milk while the patient is receiving therapeutic agents for COVID-19 is addressed. Updates to this section also include safety data on the use of COVID-19 vaccines during pregnancy.

### *Other Updates*

The following sections have been updated with more current information:

- Overview of COVID-19 (updated information on SARS-CoV-2 variants of concern and variants of interest)
- Prevention and Prophylaxis of SARS-CoV-2 Infection (added information on vaccine-related adverse effects)
- Hemodynamics (update on rationale for using norepinephrine as vasopressor of choice)
- Ivermectin: Selected Clinical Data (additional clinical trial data)

### *Sections Under Revision*

The following sections are currently under revision:

- Anti-SARS-CoV-2 Monoclonal Antibodies
- Corticosteroids
- Interleukin-1 Inhibitors
- Interleukin-6 Inhibitors
- Kinase Inhibitors: Baricitinib and Other Janus Kinase Inhibitors, and Bruton's Tyrosine Kinase Inhibitors
- Antithrombotic Therapy in Patients With COVID-19

# Introduction

*Last Updated: July 8, 2021*

The COVID-19 Treatment Guidelines have been developed to provide clinicians with guidance on how to care for patients with COVID-19. Because clinical information about the optimal management of COVID-19 is evolving quickly, these Guidelines will be updated frequently as published data and other authoritative information become available.

## Panel Composition

Members of the COVID-19 Treatment Guidelines Panel (the Panel) are appointed by the Panel co-chairs based on their clinical experience and expertise in patient management, translational and clinical science, and/or development of treatment guidelines. Panel members include representatives from federal agencies, health care and academic organizations, and professional societies. Federal agencies and professional societies represented on the Panel include:

- American Association of Critical-Care Nurses
- American Association for Respiratory Care
- American College of Chest Physicians
- American College of Emergency Physicians
- American College of Obstetricians and Gynecologists
- American Society of Hematology
- American Thoracic Society
- Biomedical Advanced Research and Development Authority
- Centers for Disease Control and Prevention
- Department of Defense
- Department of Veterans Affairs
- Food and Drug Administration
- Infectious Diseases Society of America
- National Institutes of Health
- Pediatric Infectious Diseases Society
- Society of Critical Care Medicine
- Society of Infectious Diseases Pharmacists

The inclusion of representatives from professional societies does not imply that their societies have endorsed all elements of these Guidelines.

The names, affiliations, and financial disclosures of the Panel members and ex officio members, as well as members of the Guidelines support team, are provided in the Panel Roster and Financial Disclosure sections of the Guidelines.

## Development of the Guidelines

Each section of the Guidelines is developed by a working group of Panel members with expertise in the area addressed in the section. Each working group is responsible for identifying relevant information and published scientific literature and for conducting a systematic, comprehensive review of that information

and literature. The working groups propose updates to the Guidelines based on the latest published research findings and evolving clinical information.

New Guidelines sections and recommendations are reviewed and voted on by the voting members of the Panel. To be included in the Guidelines, a recommendation statement must be endorsed by a majority of Panel members; this applies to recommendations for treatments, recommendations against treatments, and cases where there is insufficient evidence to recommend either for or against treatments. Updates to existing sections that do not affect the rated recommendations are approved by Panel co-chairs without a Panel vote. Panel members are required to keep all Panel deliberations and unpublished data considered during the development of the Guidelines confidential.

### *Method of Synthesizing Data and Formulating Recommendations*

The working groups critically review and synthesize the available data to develop recommendations. Aspects of the data that are considered can include, but are not limited to, the source of the data, the type of study (e.g., randomized controlled trial, prospective or retrospective cohort study, case series), the quality and suitability of the methods, the number of participants, and the effect sizes observed.

The recommendations in these Guidelines are based on scientific evidence and expert opinion. Each recommendation includes two ratings: an uppercase letter (**A**, **B**, or **C**) that indicates the strength of the recommendation and a Roman numeral with or without a lowercase letter (**I**, **IIa**, **IIb**, or **III**) that indicates the quality of the evidence that supports the recommendation (see Table 1).

**Table 1. Recommendation Rating Scheme**

| Strength of Recommendation | Quality of Evidence for Recommendation |
|---|---|
| **A:** Strong recommendation for the statement | **I:** One or more randomized trials without major limitations |
| **B:** Moderate recommendation for the statement | **IIa:** Other randomized trials or subgroup analyses of randomized trials |
| **C:** Optional recommendation for the statement | **IIb:** Nonrandomized trials or observational cohort studies |
| | **III:** Expert opinion |

To develop the recommendations in these Guidelines, the Panel uses data from the rapidly growing body of published research on COVID-19. The Panel also relies heavily on experience with other diseases, supplemented with members' evolving clinical experience with COVID-19.

In general, the recommendations in these Guidelines fall into the following categories:

- **The Panel recommends using [blank] for the treatment of COVID-19 (rating).** Recommendations in this category are based on evidence from clinical trials or large cohort studies that demonstrate the clinical or virologic efficacy of a therapy in patients with COVID-19, with the potential benefits outweighing the potential risks.
- **There is insufficient evidence for the Panel to recommend either for or against the use of [blank] for the treatment of COVID-19 (no rating).** This statement is used when the collective results from clinical trials and/or observational cohorts do not provide the evidence needed to support a recommendation due to too few or conflicting data.
- **The Panel recommends against the use of [blank] for the treatment of COVID-19, except in a clinical trial (rating).** This recommendation is used for an intervention that has not clearly demonstrated efficacy in the treatment of COVID-19 and/or has potential safety concerns. More clinical trials are needed to further define the role of the intervention.

- **The Panel recommends against the use of [blank] for the treatment of COVID-19 (rating).** This recommendation is used in cases when the available data clearly show a safety concern and/or the data show no benefit for the treatment of COVID-19.

## Evolving Knowledge on Treatment for COVID-19

Currently, remdesivir, an antiviral agent, is the only Food and Drug Administration-approved drug for the treatment of COVID-19. An array of drugs approved for other indications and multiple investigational agents are being studied for the treatment of COVID-19 in clinical trials around the globe. These trials can be accessed at *ClinicalTrials.gov*. In addition, providers can access and prescribe investigational drugs or agents that are approved or licensed for other indications through various mechanisms, including Emergency Use Authorizations (EUAs), Emergency Investigational New Drug (EIND) applications, compassionate use or expanded access programs with drug manufacturers, and/or off-label use.

Whenever possible, the Panel recommends that promising, unapproved, or unlicensed treatments for COVID-19 be studied in well-designed, controlled clinical trials. This recommendation also applies to drugs that have been approved or licensed for indications other than the treatment of COVID-19. The Panel recognizes the critical importance of clinical research in generating evidence to address unanswered questions regarding the safety and efficacy of potential treatments for COVID-19. However, the Panel also realizes that many patients and providers who cannot access these potential treatments via clinical trials still seek guidance about whether to use them.

A large volume of data and publications from randomized controlled trials, observational cohorts, and case series are emerging at a very rapid pace, some in peer-reviewed journals, others as manuscripts that have not yet been peer reviewed, and, in some cases, press releases. The Panel continuously reviews the available data and assesses their scientific rigor and validity. These sources of data and the clinical experiences of the Panel members are used to determine whether new recommendations or changes to the current recommendations are warranted.

Finally, it is important to stress that the rated treatment recommendations in these Guidelines should not be considered mandates. The choice of what to do or not to do for an individual patient is ultimately decided by the patient and their provider.

# Overview of COVID-19

*Last Updated: July 8, 2021*

## Epidemiology

The COVID-19 pandemic has exploded since cases were first reported in China in December 2019. As of July 1, 2021, more than 182 million cases of COVID-19—caused by SARS-CoV-2 infection—have been reported globally, including more than 3.9 million deaths.[1]

Individuals of all ages are at risk for SARS-CoV-2 infection and severe disease. However, the probability of serious COVID-19 disease is higher in people aged ≥60 years, those living in a nursing home or long-term care facility, and those with chronic medical conditions. In an analysis of more than 1.3 million laboratory-confirmed cases that were reported in the United States between January and May 2020, 14% of patients required hospitalization, 2% were admitted to the intensive care unit, and 5% died.[2] The percentage of patients who died was 12 times higher among those with reported medical conditions (19.5%) than among those without medical conditions (1.6%), and the percentage of those who were hospitalized was six times higher among those with reported medical conditions (45.4%) than among those without medical conditions (7.6%). The mortality rate was highest in those aged >70 years, regardless of the presence of chronic medical conditions. Among those with available data on health conditions, 32% had cardiovascular disease, 30% had diabetes, and 18% had chronic lung disease. Other conditions that may lead to a high risk for severe COVID-19 include cancer, kidney disease, obesity, sickle cell disease, and other immunocompromising conditions. Transplant recipients and pregnant people are also at a higher risk of severe COVID-19.[3-10]

Data from the United States suggest that racial and ethnic minorities experience higher rates of COVID-19 and subsequent hospitalization and death.[11-15] However, surveillance data that include race and ethnicity are not available for most reported cases of COVID-19 in the United States.[4,16] Factors that contribute to the increased burden of COVID-19 in these populations may include over-representation in work environments that confer higher risks of exposure to COVID-19, economic inequality (which limits people's ability to protect themselves against COVID-19 exposure), neighborhood disadvantage,[17] and a lack of access to health care.[16] Structural inequalities in society contribute to health disparities for racial and ethnic minority groups, including higher rates of comorbid conditions (e.g., cardiac disease, diabetes, hypertension, obesity, pulmonary diseases), which further increases the risk of developing severe COVID-19.[15]

## SARS-CoV-2 Variants

Like other RNA viruses, SARS-CoV-2 is constantly evolving through random mutations. Any new mutations can potentially increase or decrease infectiousness and virulence. In addition, mutations can increase the virus' ability to evade adaptive immune responses from past SARS-CoV-2 infection or vaccination. This may lead to an increased risk of reinfection or decreased efficacy of vaccines.[18] There is already evidence that some SARS-CoV-2 variants have reduced susceptibility to plasma from people who were previously infected or immunized, as well as to select monoclonal antibodies that are being considered for prevention and treatment.[19]

Since December 2020, several variants have been identified that have now been assigned Greek letter designations by the World Health Organization (WHO). These SARS-CoV-2 variants are designated as variants of concern (VoC) if they are associated with select characteristics, such as increase in transmissibility or virulence, decrease in effectiveness of vaccines and/or therapeutics, or interference with diagnostic test targets. WHO has designated variants that are important but not yet fully

characterized to meet the criteria for VoC as variants of interest (VoI); however, designations for these variants by other organizations may differ.[20] There is emerging evidence that the B.1.1.7 (Alpha) variant first seen in the United Kingdom is more infectious than earlier variants and may be more virulent.[21-23] It has become the predominant variant in the United Kingdom, and it continues to spread across the globe, including throughout many regions of the United States. The B.1.351 (Beta) variant that was originally identified in South Africa is now the predominant variant in that region and has spread to many other countries, including the United States. The P.1 (Gamma) variant was originally identified in Manaus, Brazil, and has now emerged in the United States. The B.1.617.2 (Delta) variant, first identified in India and designated a VoC by WHO, is also circulating in the United States. Other variants that have emerged in the United States are receiving attention, such as the B.1.427/B.1.429 (Epsilon) variants that were originally identified in California and select VoIs such as the B.1.526 (Iota) variant originally identified in New York and the B.1.617.1 (Kappa) variant first identified in India. For a detailed discussion on the susceptibility of select VoCs and VoIs to available anti-SARS-CoV-2 monoclonal antibodies, please see Anti-SARS CoV-2 Monoclonal Antibodies.

The data on the emergence, spread, and clinical relevance of these new variants is rapidly evolving; this is especially true for research on how variants might affect transmission rates, disease progression, vaccine development, and the efficacy of current therapeutics. Because the research on variants of concern is moving quickly, websites such as the Centers for Disease Control and Prevention's National Genomic Surveillance Dashboard, CoVariants.org, and WHO's Tracking SARS-CoV-2 Variants provide regular updates on the data for SARS-CoV-2 variants. The COVID-19 Treatment Guidelines Panel will review the emerging data on these variants, paying particular attention to research on the impacts of these variants on testing, prevention, and treatment.

## Clinical Presentation

The estimated incubation period for COVID-19 is up to 14 days from the time of exposure, with a median incubation period of 4 to 5 days.[6,24,25] The spectrum of illness can range from asymptomatic infection to severe pneumonia with acute respiratory distress syndrome and death. Among 72,314 persons with COVID-19 in China, 81% of cases were reported to be mild (defined in this study as no pneumonia or mild pneumonia), 14% were severe (defined as dyspnea, respiratory frequency ≥30 breaths/min, oxygen saturation [$SpO_2$] ≤93%, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen [$PaO_2/FiO_2$] <300 mm Hg, and/or lung infiltrates >50% within 24 to 48 hours), and 5% were critical (defined as respiratory failure, septic shock, and/or multiorgan dysfunction or failure).[26] In a report on more than 370,000 confirmed COVID-19 cases with reported symptoms in the United States, 70% of patients experienced fever, cough, or shortness of breath, 36% had muscle aches, and 34% reported headaches.[2] Other reported symptoms have included, but are not limited to, diarrhea, dizziness, rhinorrhea, anosmia, dysgeusia, sore throat, abdominal pain, anorexia, and vomiting.

The abnormalities seen in chest X-rays of patients with COVID-19 vary, but bilateral multifocal opacities are the most common. The abnormalities seen in computed tomography of the chest also vary, but the most common are bilateral peripheral ground-glass opacities, with areas of consolidation developing later in the clinical course of COVID-19.[27] Imaging may be normal early in infection and can be abnormal in the absence of symptoms.[27]

Common laboratory findings in patients with COVID-19 include leukopenia and lymphopenia. Other laboratory abnormalities have included elevated levels of aminotransferase, C-reactive protein, D-dimer, ferritin, and lactate dehydrogenase.

Although COVID-19 is primarily a pulmonary disease, emerging data suggest that it also leads to cardiac,[28,29] dermatologic,[30] hematologic,[31] hepatic,[32] neurologic,[33,34] renal,[35,36] and other complications.

Thromboembolic events also occur in patients with COVID-19, with the highest risk occurring in critically ill patients.[37]

The long-term sequelae of COVID-19 survivors are currently unknown. Persistent symptoms after recovery from acute COVID-19 have been described (see Clinical Spectrum of SARS-CoV-2 Infection). Lastly, SARS-CoV-2 infection has been associated with a potentially severe inflammatory syndrome in children (multisystem inflammatory syndrome in children, or MIS-C).[38,39] Please see Special Considerations in Children for more information.

## References


1. Johns Hopkins. COVID-19 Dashboard by the Center for Science and Engineering. 2021; Available at: https://coronavirus.jhu.edu/map.html. Accessed March 15, 2021.
2. Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus disease 2019 case surveillance—United States, January 22–May 30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69. Available at: https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6924e2-H.pdf.
3. Cai Q, Chen F, Wang T, et al. Obesity and COVID-19 severity in a designated hospital in Shenzhen, China. *Diabetes Care*. 2020;43(7):1392-1398. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32409502.
4. Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19): cases in U.S. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html. Accessed November 25, 2020.
5. Garg S, Kim L, Whitaker M, et al. Hospitalization rates and characteristics of patients hospitalized with laboratory-confirmed coronavirus disease 2019—COVID-NET, 14 states, March 1–30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(15):458-464. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32298251.
6. Guan WJ, Ni ZY, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med*. 2020 30;382(18):1708-1720. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32109013.
7. Wu C, Chen X, Cai Y, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. *JAMA Intern Med*. 2020;180(7):934-943. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32167524.
8. Palaiodimos L, Kokkinidis DG, Li W, et al. Severe obesity, increasing age and male sex are independently associated with worse in-hospital outcomes, and higher in-hospital mortality, in a cohort of patients with COVID-19 in the Bronx, New York. *Metabolism*. 2020;108:154262. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32422233.
9. Zambrano LD, Ellington S, Strid P, et al. Update: characteristics of symptomatic women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status—United States, January 22–October 3, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(44):1641-1647. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33151921.
10. Centers for Disease Control and Prevention. COVID-19 (coronavirus disease): people with certain medical conditions. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html. Accessed December 7, 2020.
11. Azar KMJ, Shen Z, Romanelli RJ, et al. Disparities In outcomes among COVID-19 patients in a large health care system in California. *Health Aff (Millwood)*. 2020;39(7):1253-1262. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32437224.
12. Gold JAW, Wong KK, Szablewski CM, et al. Characteristics and clinical outcomes of adult patients hospitalized with COVID-19—Georgia, March 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(18):545-550. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32379729.
13. Gross CP, Essien UR, Pasha S, Gross JR, Wang SY, Nunez-Smith M. Racial and ethnic disparities in population-level COVID-19 mortality. *J Gen Intern Med*. 2020;35(10):3097-3099. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32754782.

14. Nayak A, Islam SJ, Mehta A, et al. Impact of social vulnerability on COVID-19 incidence and outcomes in the United States. *medRxiv*. 2020;Preprint. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32511437.

15. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with COVID-19. *N Engl J Med*. 2020;382(26):2534-2543. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32459916.

16. Centers for Disease Control and Prevention. Health equity considerations and racial and ethnic minority groups. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/race-ethnicity.html. Accessed June 20, 2020.

17. Kind AJH, Buckingham WR. Making neighborhood-disadvantage metrics accessible—the neighborhood atlas. *N Engl J Med*. 2018;378(26):2456-2458. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29949490.

18. Walensky RP, Walke HT, Fauci AS. SARS-CoV-2 variants of concern in the United States—challenges and opportunities. *JAMA*. 2021;325(11):1037-1038. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33595644.

19. Wang P, Nair MS, Liu L, et al. Antibody resistance of SARS-CoV-2 variants B.1.351 and B.1.1.7. *Nature*. 2021;593(7857):130-135. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33684923.

20. World Health Organization. Tracking SARS-CoV-2 variants. 2021. Available at: https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/. Accessed July 1, 2021.

21. Leung K, Shum MH, Leung GM, Lam TT, Wu JT. Early transmissibility assessment of the N501Y mutant strains of SARS-CoV-2 in the United Kingdom, October to November 2020. *Euro Surveill*. 2021;26(1). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33413740.

22. Davies NG, Barnard RC, Jarvis CI, et al. Report: continued spread of VOC 202012/01 in England. 2020. Available at: https://cmmid.github.io/topics/covid19/reports/uk-novel-variant/2020_12_31_Transmissibility_and_severity_of_VOC_202012_01_in_England_update_1.pdf.

23. Murugan NA, Javali PA, Pandian CJ, Ali MA, Srivastava V, Jeyaraman J. Computational investigation of increased virulence and pathogenesis of SARS-CoV-2 lineage B.1.1.7. *bioRxiv*. 2021;Preprint. Available at: https://www.biorxiv.org/content/10.1101/2021.01.25.428190v1.

24. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med*. 2020;382(13):1199-1207. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31995857.

25. Lauer SA, Grantz KH, Bi Q, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. *Ann Intern Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32150748.

26. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72,314 cases from the Chinese Center for Disease Control and Prevention. *JAMA*. 2020;323(13):1239-1242. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32091533.

27. Shi H, Han X, Jiang N, et al. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. *Lancet Infect Dis*. 2020;20(4):425-434. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32105637.

28. Liu PP, Blet A, Smyth D, Li H. The science underlying COVID-19: implications for the cardiovascular system. *Circulation*. 2020;142(1):68-78. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32293910.

29. Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O. Potential effects of coronaviruses on the cardiovascular system: a review. *JAMA Cardiol*. 2020;5(7):831-840. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32219363.

30. Sachdeva M, Gianotti R, Shah M, et al. Cutaneous manifestations of COVID-19: report of three cases and a review of literature. *J Dermatol Sci*. 2020;98(2):75-81. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32381430.

31. Henry BM, de Oliveira MHS, Benoit S, Plebani M, Lippi G. Hematologic, biochemical and immune biomarker abnormalities associated with severe illness and mortality in coronavirus disease 2019 (COVID-19): a meta-analysis. *Clin Chem Lab Med*. 2020;58(7):1021-1028. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32286245.

32. Agarwal A, Chen A, Ravindran N, To C, Thuluvath PJ. Gastrointestinal and liver manifestations of COVID-19. *J Clin Exp Hepatol*. 2020;10(3):263-265. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32405183.

33. Whittaker A, Anson M, Harky A. Neurological manifestations of COVID-19: a systematic review and current update. *Acta Neurol Scand*. 2020;142(1):14-22. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32412088.

34. Paniz-Mondolfi A, Bryce C, Grimes Z, et al. Central nervous system involvement by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). *J Med Virol*. 2020;92(7):699-702. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32314810.

35. Pei G, Zhang Z, Peng J, et al. Renal involvement and early prognosis in patients with COVID-19 pneumonia. *J Am Soc Nephrol*. 2020;31(6):1157-1165. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32345702.

36. Su H, Yang M, Wan C, et al. Renal histopathological analysis of 26 postmortem findings of patients with COVID-19 in China. *Kidney Int*. 2020;98(1):219-227. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32327202.

37. Bikdeli B, Madhavan MV, Jimenez D, et al. COVID-19 and thrombotic or thromboembolic disease: Implications for prevention, antithrombotic therapy, and follow-up. *J Am Coll Cardiol*. 2020;75(23):2950-2973. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32311448.

38. Chiotos K, Bassiri H, Behrens EM, et al. Multisystem inflammatory syndrome in children during the coronavirus 2019 pandemic: a case series. *J Pediatric Infect Dis Soc*. 2020;9(3):393-398. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32463092.

39. Belhadjer Z, Meot M, Bajolle F, et al. Acute heart failure in multisystem inflammatory syndrome in children (MIS-C) in the context of global SARS-CoV-2 pandemic. *Circulation*. 2020;142(5):429-436. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32418446.

# Testing for SARS-CoV-2 Infection

*Last Updated: April 21, 2021*

| Summary Recommendations |
|---|
| • To diagnose acute infection of SARS-CoV-2, the COVID-19 Treatment Guidelines Panel (the Panel) recommends using a nucleic acid amplification test (NAAT) with a sample collected from the upper respiratory tract (i.e., a nasopharyngeal, nasal, or oropharyngeal specimen) **(AIII)**.<br>• For intubated and mechanically ventilated adults who are suspected to have COVID-19 but who do not have a confirmed diagnosis:<br>  • The Panel recommends obtaining lower respiratory tract samples to establish a diagnosis of COVID-19 if an initial upper respiratory tract sample is negative **(BII)**.<br>  • The Panel recommends obtaining endotracheal aspirates over bronchial wash or bronchoalveolar lavage samples when collecting lower respiratory tract samples to establish a diagnosis of COVID-19 **(BII)**.<br>• A NAAT should not be repeated in an asymptomatic person within 90 days of a previous SARS-CoV-2 infection, even if the person has had a significant exposure to SARS-CoV-2 **(AIII)**.<br>• SARS-CoV-2 reinfection has been reported in people who have received an initial diagnosis of infection; therefore, a NAAT should be considered for persons who have recovered from a previous infection and who present with symptoms that are compatible with SARS-CoV-2 infection if there is no alternative diagnosis **(BIII)**.<br>• The Panel **recommends against** the use of serologic (i.e., antibody) testing as the sole basis for diagnosis of acute SARS-CoV-2 infection **(AIII)**.<br>• The Panel **recommends against** the use of serologic (i.e., antibody) testing to determine whether a person is immune to SARS-CoV-2 infection **(AIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Diagnostic Testing for SARS-CoV-2 Infection

Everyone who has symptoms that are consistent with COVID-19, as well as people with known high-risk exposures to SARS-CoV-2, should be tested for SARS-CoV-2 infection. Such testing should employ either a nucleic acid amplification test (NAAT) or an antigen test to detect SARS-CoV-2. Ideally, diagnostic testing should also be performed for people who are likely to be at repeated risk of exposure to SARS-CoV-2, such as health care workers and first responders. Testing should also be considered for individuals who spend time in heavily populated environments (e.g., teachers, students, food industry workers) and for travelers. Testing requirements may vary by state, local, and employer policies. Travelers may need evidence of a recent negative test result to enter some states or countries; such documentation may be an acceptable alternative to quarantine upon arrival.

A number of diagnostic tests for SARS-CoV-2 infection (e.g., NAATs, antigen tests) have received Emergency Use Authorizations (EUAs) from the Food and Drug Administration (FDA),[1] but no diagnostic test has been approved by the FDA.

Although nasopharyngeal specimens remain the recommended samples for SARS-CoV-2 diagnostic testing, nasal (anterior nares or mid-turbinate) or oropharyngeal swabs are acceptable alternatives.[2] Lower respiratory tract samples have a higher yield than upper tract samples, but they are often not obtained because of concerns about aerosolization of the virus during sample collection procedures. Some tests that have received EUAs can also be performed on saliva specimens. Studies are currently evaluating the use of other sample types, including stool samples.

Some tests that have received EUAs allow for self-collection of specimens at home, but these specimens must be sent to a laboratory for processing. In addition, some tests allow trained personnel to collect and test specimens in nonclinical settings, such as in the home or in nursing or assisted living facilities. This allows real-time antigen results to be obtained on site.

## Nucleic Acid Amplification Testing for SARS-CoV-2 Infection

Reverse transcriptase polymerase chain reaction (RT-PCR)-based diagnostic tests (which detect viral nucleic acids) are considered the gold standard for detecting current SARS-CoV-2 infection. More recently, NAATs have included a variety of additional platforms (e.g., reverse transcriptase loop-mediated isothermal amplification [RT-LAMP]). Clinically, there may be a window period of up to 5 days after exposure before viral nucleic acids can be detected. Diagnostically, some NAATs may produce false negative results if a mutation occurs in the part of the virus' genome that is assessed by that test.[3] The FDA monitors the potential effects of SARS-CoV-2 genetic variations on NAAT results and issues updates when specific variations could affect the performance of NAATs that have received EUAs. Generally, false negative results are more likely to occur when using NAATs that rely on only one genetic target. Therefore, a single negative test result does not exclude the possibility of SARS-CoV-2 infection in people who have a high likelihood of infection based on their exposure history and/or their clinical presentation.[4]

Many commercial NAATs that use RT-PCR rely on multiple targets to detect the virus, such that even if a mutation impacts one of the targets, the other RT-PCR targets will still work.[5] NAATs that use multiple targets are less likely to be impacted by an increased prevalence of genetic variants. In fact, because each of these tests target multiple locations on the virus' genome, they can be helpful in identifying new genetic variants before they become widespread in the population. For example, the B.1.1.7 variant that has been associated with increased transmission carries many mutations, including a double deletion at positions 69 and 70 on the spike protein gene (S-gene). This mutation appears to impact the detection of the S-gene but does not impact other genetic targets in certain NAATs. If COVID-19 is still suspected after a patient receives a negative test result, clinicians should consider repeating testing; ideally, they should use a NAAT with different genetic targets.[3]

SARS-CoV-2 poses several diagnostic challenges, including potentially discordant shedding of virus from the upper versus the lower respiratory tract. However, due to the high specificity of NAATs, a positive result on a NAAT of an upper respiratory tract sample from a patient with recent onset of SARS-CoV-2-compatible symptoms is sufficient to diagnose COVID-19. In patients with COVID-19, severe acute respiratory syndrome (SARS), and Middle East respiratory syndrome (MERS), lower respiratory tract specimens have a higher viral load and thus a higher yield than upper respiratory tract specimens.[6-12] For intubated or mechanically ventilated patients with clinical signs and symptoms that are consistent with COVID-19 pneumonia, the COVID-19 Treatment Guidelines Panel (the Panel) recommends obtaining lower respiratory tract samples to establish a diagnosis of COVID-19 if an initial upper respiratory tract sample is negative **(BII)**. The Panel recommends obtaining endotracheal aspirates over bronchial wash or bronchoalveolar lavage (BAL) samples when collecting lower respiratory tract samples to establish a diagnosis of COVID-19 **(BII)**.

BAL and sputum induction are aerosol-generating procedures that should be performed only after careful consideration of the risk of exposing staff to infectious aerosols. Endotracheal aspiration appears to carry a lower risk of aerosol-generation than BAL, and some experts consider the sensitivity and specificity of endotracheal aspirates and BAL specimens comparable in detecting SARS-CoV-2.

### *Nucleic Acid Amplification Testing for Individuals With a Previous Positive SARS-CoV-2 Test Result*

NAATs can detect SARS-CoV-2 RNA in specimens obtained weeks to months after the onset of COVID-19 symptoms.[13,14] However, the likelihood of recovering replication-competent virus >10 days from the onset of symptoms in those with mild disease and >20 days in those with severe disease is very low.[15,16] Furthermore, both virologic studies and contact tracing of high-risk contacts show a low risk for SARS-CoV-2 transmission after these intervals.[17,18] Based on these results, the Centers for Disease Control and Prevention (CDC) recommends that NAATs should not be repeated in asymptomatic persons within 90 days of a previous SARS-CoV-2 infection, even if the person has had a significant exposure to SARS-CoV-2 **(AIII)**.[19] If there are concerns that an immunocompromised health care worker may still be infectious >20 days from the onset of SARS-CoV-2 infection, consultation with local employee health services regarding return-to-work testing policies is advised.

SARS-CoV-2 reinfection has been reported in people who have received an initial diagnosis of infection; therefore, a NAAT should be considered for persons who have recovered from a previous infection and who present with symptoms that are compatible with SARS-CoV-2 infection if there is no alternative diagnosis **(BIII)**. However, it should be noted that persons infected with SARS-CoV-2 may have a negative result on an initial NAAT and then have a positive result on a subsequent test due to intermittent detection of viral RNA and not due to reinfection.[13] When the results for an initial and a subsequent test are positive, comparative viral sequence data from both tests are needed to distinguish between the persistent presence of viral fragments and reinfection. In the absence of viral sequence data, the cycle threshold (Ct) value from a positive NAAT result may provide information about whether a newly detected infection is related to the persistence of viral fragments or to reinfection. The Ct value is the number of PCR cycles at which the nucleic acid target in the sample becomes detectable. In general, the Ct value is inversely related to the SARS-CoV-2 viral load. Because the clinical utility of Ct values is an area of active investigation, an expert should be consulted if these values are used to guide clinical decisions.

## Antigen Testing for SARS-CoV-2 Infection

Antigen-based diagnostic tests (which detect viral antigens) are less sensitive than RT-PCR-based tests, but they have similarly high specificity. Antigen tests perform best early in the course of symptomatic SARS-CoV-2 infection, when the viral load is thought to be highest. Advantages of antigen-based tests are their low cost and rapid turnaround time. The availability of immediate results makes them an attractive option for point-of-care testing in high-risk congregate settings where preventing transmission is critical. Antigen-based tests also allow for repeat testing to quickly identify persons with SARS-CoV-2 infection.

Increasingly, data are available to guide the use of antigen tests as screening tests to detect or exclude SARS-CoV-2 infection in asymptomatic persons, or to determine whether a person who was previously confirmed to have SARS-CoV-2 infection is still infectious. The CDC has developed an antigen testing algorithm for persons who have symptoms of COVID-19, those who are asymptomatic and have a close contact with COVID-19, and those who are asymptomatic and have no known exposure to a person with COVID-19.[20]

The CDC testing algorithm recommends additional NAATs when a person who is strongly suspected of having SARS-CoV-2 infection (i.e., a person who is symptomatic) receives a negative result, and when a person who is asymptomatic receives a positive result. Antigen tests can yield false positive results for a variety of reasons, including:

- Incomplete adherence to the instructions for antigen test performance (e.g., reading the results outside the specified time interval or storing test cartridges/cards inappropriately)

- Test interference due to human antibodies (e.g., rheumatoid factor or other nonspecific antibodies)
- Use in communities that have a low prevalence of SARS-CoV-2 infection

## Serologic or Antibody Testing for Diagnosis of SARS-CoV-2 Infection

Unlike NAATs and antigen tests for SARS-CoV-2 that detect the presence of the virus, serologic or antibody tests can detect recent or prior SARS-CoV-2 infection. Because it may take 21 days or longer after symptom onset for seroconversion to occur (i.e., the development of detectable immunoglobulin [Ig] M and/or IgG antibodies to SARS-CoV-2),[21-26] the Panel **does not recommend** serologic testing as the sole basis for diagnosing acute SARS-CoV-2 infection **(AIII)**. Because NAATs and antigen tests for SARS-CoV-2 occasionally yield false negative results, serologic tests have been used in some settings as an additional diagnostic test for patients who are strongly suspected to have SARS-CoV-2 infection. Using a serologic test in combination with a NAAT to detect IgG or total antibodies 3 to 4 weeks after symptom onset maximizes the sensitivity and specificity to detect past infection.

No serologic tests for SARS-CoV-2 are approved by the FDA; some, but not all, commercially available serologic tests for SARS-CoV-2 have received EUAs from the FDA.[1] Several professional societies and federal agencies, including the Infectious Diseases Society of America, the CDC, and the FDA, provide guidance on the use of serologic testing for SARS-CoV-2.

Several factors should be considered when using serologic tests for SARS-CoV-2, including:

- Important performance characteristics of many of the commercially available serologic tests have not been fully characterized, including the sensitivity and specificity of these tests (i.e., the rates of true positive and true negative results). Serologic assays that have FDA EUAs should be used for public health and clinical use. Formal comparisons of serologic tests are in progress.
- Two types of serologic tests have received EUAs from the FDA. The first type are antibody tests that detect the presence of binding antibodies, which bind to a pathogen (e.g., a virus). The second type of tests detect neutralizing antibodies from recent or prior SARS-CoV-2 infection. It is unknown whether one type of test is more clinically meaningful than the other.
- Serologic assays may detect IgM, IgG, IgA, and/or total antibodies, or a combination of IgM and IgG antibodies. Serologic assays that detect IgG and total antibodies have higher specificity to detect past infection than assays that detect IgM and/or IgA antibodies or a combination of IgM and IgG antibodies.
- False positive test results may occur due to cross-reactivity from pre-existing antibodies to other coronaviruses.

## Serologic Testing and Immunity to SARS-CoV-2 Infection

The Panel **recommends against** the use of serologic testing to determine whether a person is immune to SARS-CoV-2 infection **(AIII)**.

If SARS-CoV-2 antibodies are detected during a serologic test, the results should be interpreted with caution for the following reasons:

- It is unclear how long antibodies persist following infection; *and*
- It is unclear whether the presence of antibodies confers protective immunity against future infection.

In communities that have a low prevalence of SARS-CoV-2 infection, the proportion of positive test results that are false positives may be quite high. In these situations, confirmatory testing using a distinct antibody assay, ideally one that uses a different antigenic target (e.g., the nucleocapsid phosphoprotein

if the first assay targeted the spike protein), can substantially improve the probability that persons with positive test results are antibody positive.

Assuming that the test is reliable, serologic tests that identify recent or prior SARS-CoV-2 infection may be used to:

- Differentiate SARS-CoV-2 antibody responses to natural infection from vaccine-induced antibody responses to the SARS-CoV-2 spike protein antigen. Because nucleocapsid protein is not a constituent of vaccines that are currently available through EUAs or in late-stage clinical trials, serologic tests that detect antibodies by recognizing nucleocapsid protein can be used to distinguish antibody responses to natural infection from vaccine-induced antibody responses.
- Determine who may be eligible to donate convalescent plasma
- Estimate the proportion of the population that has been exposed to SARS-CoV-2

Based on current knowledge, serologic tests **should not be used** to **(AIII)**:

- Make decisions about how to group persons in congregate settings (e.g., schools, dormitories, correctional facilities)
- Determine whether persons may return to the workplace
- Assess for prior infection solely to determine whether to vaccinate an individual
- Assess for immunity to SARS-CoV-2 following vaccination, except in clinical trials

## References


1. Food and Drug Administration. Coronavirus disease 2019 (COVID-19) emergency use authorizations for medical devices. 2020. Available at: https://www.fda.gov/medical-devices/emergency-situations-medical-devices/emergency-use-authorizations. Accessed February 4, 2021.
2. Centers for Disease Control and Prevention. Interim guidelines for collecting, handling, and testing clinical specimens from persons for coronavirus disease 2019 (COVID-19). 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/guidelines-clinical-specimens.html. Accessed February 4, 2021.
3. Food and Drug Administration. Genetic variants of SARS-CoV-2 may lead to false negative results with molecular tests for detection of SARS-CoV-2—letter to clinical laboratory staff and health care providers. 2021. Available at: https://www.fda.gov/medical-devices/letters-health-care-providers/genetic-variants-sars-cov-2-may-lead-false-negative-results-molecular-tests-detection-sars-cov-2. Accessed March 15, 2021.
4. Kucirka LM, Lauer SA, Laeyendecker O, Boon D, Lessler J. Variation in false-negative rate of reverse transcriptase polymerase chain reaction-based SARS-CoV-2 tests by time since exposure. *Ann Intern Med*. 2020;173(4):262-267. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32422057.
5. Centers for Disease Control and Prevention. Science brief: emerging SARS-CoV-2 variants. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/more/science-and-research/scientific-brief-emerging-variants.html. Accessed March 15, 2021.
6. Chan PK, To WK, Ng KC, et al. Laboratory diagnosis of SARS. *Emerg Infect Dis*. 2004;10(5):825-831. Available at: https://www.ncbi.nlm.nih.gov/pubmed/15200815.
7. Tang P, Louie M, Richardson SE, et al. Interpretation of diagnostic laboratory tests for severe acute respiratory syndrome: the Toronto experience. *CMAJ*. 2004;170(1):47-54. Available at: https://www.ncbi.nlm.nih.gov/pubmed/14707219.
8. Memish ZA, Al-Tawfiq JA, Makhdoom HQ, et al. Respiratory tract samples, viral load, and genome fraction yield in patients with Middle East respiratory syndrome. *J Infect Dis*. 2014;210(10):1590-1594. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24837403.
9. Centers for Disease Control and Prevention. Overview of testing for SARS-CoV-2 (COVID-19). 2020.

Available at: https://www.cdc.gov/coronavirus/2019-nCoV/hcp/clinical-criteria.html. Accessed February 4, 2021.

10. Centers for Disease Control and Prevention. Interim guidelines for collecting, handling, and testing clinical specimens from persons under investigation (PUIs) for Middle East respiratory syndrome coronavirus (MERS-CoV)–Version 2.1. 2019. Available at: https://www.cdc.gov/coronavirus/mers/guidelines-clinical-specimens.html. Accessed February 4, 2021.
11. Hase R, Kurita T, Muranaka E, Sasazawa H, Mito H, Yano Y. A case of imported COVID-19 diagnosed by PCR-positive lower respiratory specimen but with PCR-negative throat swabs. *Infect Dis (Lond)*. 2020:1-4. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32238024.
12. Wang W, Xu Y, Gao R, et al. Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA*. 2020;323(18):1843-1844. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32159775.
13. Xiao AT, Tong YX, Zhang S. Profile of RT-PCR for SARS-CoV-2: a preliminary study from 56 COVID-19 patients. *Clin Infect Dis*. 2020;71(16):2249-2251. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32306036.
14. Rhee C, Kanjilal S, Baker M, Klompas M. Duration of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infectivity: when is it safe to discontinue isolation? *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33029620.
15. Arons MM, Hatfield KM, Reddy SC, et al. Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *N Engl J Med*. 2020;382(22):2081-2090. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32329971.
16. Bullard J, Dust K, Funk D, et al. Predicting infectious SARS-CoV-2 from diagnostic samples. *Clin Infect Dis*. 2020;71(10):2663-2666. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32442256.
17. Cheng HY, Jian SW, Liu DP, et al. Contact tracing assessment of COVID-19 transmission dynamics in Taiwan and risk at different exposure periods before and after symptom onset. *JAMA Intern Med*. 2020;180(9):1156-1163. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32356867.
18. Korean Disease Control and Prevention Agency. Findings from investigation and analysis of re-positive cases [press release]. 2020. Available at: https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030.
19. Centers for Disease Control and Prevention. Duration of isolation and precautions for adults with COVID-19. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/duration-isolation.html. Accessed January 7, 2021.
20. Centers for Disease Control and Prevention. Interim guidance for antigen testing for SARS-CoV-2. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/resources/antigen-tests-guidelines.html. Accessed January 7, 2021.
21. Guo L, Ren L, Yang S, et al. Profiling early humoral response to diagnose novel coronavirus disease (COVID-19). *Clin Infect Dis.* 2020;71(15):778-785. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32198501.
22. Haveri A, Smura T, Kuivanen S, et al. Serological and molecular findings during SARS-CoV-2 infection: the first case study in Finland, January to February 2020. *Euro Surveill*. 2020;25(11). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32209163.
23. Long QX, Liu BZ, Deng HJ, et al. Antibody responses to SARS-CoV-2 in patients with COVID-19. *Nat Med*. 2020;26(6):845-848. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32350462.
24. Okba NMA, Muller MA, Li W, et al. Severe acute respiratory syndrome coronavirus 2-specific antibody responses in coronavirus disease patients. *Emerg Infect Dis*. 2020;26(7):1478-1488. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32267220.
25. Xiang F, Wang X, He X, et al. Antibody detection and dynamic characteristics in patients with COVID-19. *Clin Infect Dis*. 2020;71(8):1930-1934. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32306047.
26. Zhao J, Yuan Q, Wang H, et al. Antibody responses to SARS-CoV-2 in patients of novel coronavirus disease 2019. *Clin Infect Dis*. 2020;71(16):2027-2034. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32221519.

# Prevention and Prophylaxis of SARS-CoV-2 Infection

*Last Updated: July 8, 2021*

| Summary Recommendations |
| --- |
| • The COVID-19 Treatment Guidelines Panel (the Panel) recommends that health care providers follow recommendations from the Advisory Committee on Immunization Practices when using SARS-CoV-2 vaccines **(AI)**.<br>• The Panel **recommends against** the use of any drugs for SARS-CoV-2 pre-exposure prophylaxis (PrEP), except in a clinical trial **(AIII)**.<br>• The Panel **recommends against** the use of **hydroxychloroquine** for SARS-CoV-2 post-exposure prophylaxis (PEP) **(AI)**.<br>• The Panel **recommends against** the use of other drugs for SARS-CoV-2 PEP, except in a clinical trial **(AIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## General Prevention Measures

Transmission of SARS-CoV-2 is thought to mainly occur through exposure to respiratory droplets transmitted from an infectious person to others within six feet of the person. Less commonly, airborne transmission of small droplets and particles of SARS-CoV-2 to persons further than six feet away can occur; in rare cases, people passing through a room that was previously occupied by an infectious person may become infected. SARS-CoV-2 infection via airborne transmission of small particles tends to occur after prolonged exposure (i.e., >15 minutes) to an infectious person who is in an enclosed space with poor ventilation.[1]

The risk of SARS-CoV-2 transmission can be reduced by covering coughs and sneezes and maintaining a distance of at least six feet from others. When consistent distancing is not possible, face coverings may further reduce the spread of infectious droplets from individuals with SARS-CoV-2 infection to others. Frequent handwashing also effectively reduces the risk of infection.[2] Health care providers should follow the Centers for Disease Control and Prevention (CDC) recommendations for infection control and appropriate use of personal protective equipment (PPE).[3] Another important way to prevent SARS-CoV-2 infection is through vaccination.

## Vaccines

Currently, no SARS-CoV-2 vaccine has been approved by the Food and Drug Administration (FDA). In December 2020, the FDA issued Emergency Use Authorizations (EUAs) for two mRNA vaccines, BNT162b2 (Pfizer-BioNTech)[4] and mRNA-1273 (Moderna).[5] In February 2021, the FDA issued an EUA for a human adenovirus type 26 (Ad26) vectored vaccine, Ad26.COV2.S (Johnson & Johnson/Janssen).[6] BNT162b2 can be administered to individuals aged ≥12 years, whereas mRNA-1273 and Ad26.COV2.S can be given to individuals aged ≥18 years. Clinical trials for these vaccines in younger age groups and clinical trials for other SARS-CoV-2 vaccine candidates are currently ongoing.[7]

In large, placebo-controlled trials, the mRNA-1273 and BNT162b2 vaccines were >90% efficacious for preventing symptomatic, laboratory-confirmed COVID-19 and >95% efficacious for preventing severe COVID-19 after participants completed a two-dose series. The single-dose Ad26.COV2.S vaccine was 66% efficacious in preventing moderate to critical laboratory-confirmed COVID-19. Cases of COVID-19 were confirmed by the presence of symptoms and a positive result on a SARS-CoV-2 nucleic acid amplification test (NAAT).[6,8,9] Newly emerging data indicate that the SARS-CoV-2 vaccines

authorized for use in the United States prevent asymptomatic infection, transmission, and infection by currently circulating or emergent variants of SARS-CoV-2.[10]

Local and systemic adverse events are relatively common with these vaccines, and they are especially common after the second dose of a SARS-CoV-2 mRNA vaccine. Most adverse events that occurred in vaccine trials were mild or moderate in severity (i.e., they did not prevent vaccinated people from engaging in daily activities). There have been a few reports of severe allergic reactions following SARS-CoV-2 vaccination, including rare reports of patients who experienced anaphylaxis after receiving a SARS-CoV-2 mRNA vaccine.[6,11]

Reports of adverse events following the use of the Ad26.COV2.S vaccine under the FDA EUA suggest that there is an increased risk of thrombosis with thrombocytopenia in adults.[6] As of June 7, 2021, thrombosis with thrombocytopenia has been reported to occur at a rate of approximately three people per million people who received this vaccine in the United States.[12] Nearly all reports of this serious condition have been in vaccinated women aged 18 to 49 years. This adverse event is even more rare among women aged ≥50 years and men of all ages.[13] Onset of symptoms typically occurs during the first 3 weeks after vaccination.[14-16] Thrombosis can occur in atypical locations, including the cerebral and abdominal veins; in addition, lower extremity thrombosis and pulmonary emboli may occur. Similar reports from Europe describe thrombocytopenia and venous thrombosis in patients who received the ChAdOx1 nCoV-19 vaccine (Oxford/AstraZeneca), which uses a chimpanzee adenoviral vector. The incidence of cerebral vein thrombosis after vaccination with the ChAdOx1 nCoV-19 vaccine is higher than expected compared to the general population, but lower than the incidence reported for people with COVID-19 (42.8 occurrences per million people).[17,18] The American Society of Hematology and the American Heart Association/American Stroke Association Stroke Council Leadership have published considerations that are relevant to the diagnosis and treatment of the type of thrombosis with thrombocytopenia that occurs in people who receive the Ad26.COV2.S vaccine. These considerations include information on administering a nonheparin anticoagulant and intravenous immunoglobulin to these patients.[19,20] Given the rarity of the syndrome and the unique treatment required, consider consulting a hematologist when treating these patients. Vaccine safety data continue to be collected.

Pregnant and lactating individuals were not included in the initial vaccine trials. A study that used data from three vaccine safety reporting systems in the United States reported that the frequency of adverse events among 35,691 vaccine recipients who identified as pregnant was similar to the frequency observed among nonpregnant patients (see Special Considerations in Pregnancy).[7] The American College of Obstetricians and Gynecologists has published practice guidance on the use of the SARS-CoV-2 mRNA vaccines in pregnant and lactating people, including a guide to assist clinicians during risk and benefit conversations with pregnant patients.[21]

CDC sets the adult and childhood immunization schedules for the United States based on recommendations from the Advisory Committee on Immunization Practices (ACIP). The COVID-19 Treatment Guidelines Panel (the Panel) recommends that health care providers follow recommendations from ACIP when using SARS-CoV-2 vaccines **(AI)**. ACIP considers disease epidemiology, burden of disease, vaccine efficacy and effectiveness, vaccine safety, the quality of the available evidence, and potential vaccination implementation issues. ACIP also sets priorities regarding who receives vaccines in the event of a shortage. ACIP's COVID-19 vaccine recommendations are reviewed by CDC's Director and, if adopted, are published as official CDC recommendations in the *Morbidity and Mortality Weekly Report*.[22]

CDC has provided guidance on resuming activities without wearing a mask or physically distancing for people who are fully vaccinated (people are considered fully vaccinated 2 weeks after completing a two-dose vaccine series or receiving a single-dose vaccine, such as the Ad26.COV2.S vaccine). This

guidance does not apply in places where masks are required by federal, state, local, tribal, or territorial laws, rules, and regulations, and individual businesses or workplaces may have their own mask requirements.[23]

## Pre-Exposure Prophylaxis

- The Panel **recommends against** the use of any drugs for SARS-CoV-2 pre-exposure prophylaxis (PrEP), except in a clinical trial **(AIII)**.

### *Rationale*

At present, there is no known agent that can be administered before exposure to SARS-CoV-2 (i.e., as PrEP) to prevent infection. Clinical trials are investigating several agents, including emtricitabine plus tenofovir alafenamide or tenofovir disoproxil fumarate, hydroxychloroquine, ivermectin, and supplements such as zinc, vitamin C, and vitamin D. Studies of monoclonal antibodies that target SARS-CoV-2 are in development. Please check *ClinicalTrials.gov* for the latest information.

### *Clinical Trial Data*

#### Randomized Controlled Trial of Hydroxychloroquine for SARS-CoV-2 Pre-Exposure Prophylaxis Among Health Care Workers

This double-blind, placebo-controlled randomized trial was designed to determine whether hydroxychloroquine 600 mg per day reduced the frequency of SARS-CoV-2 infection over an 8-week period in hospital-based health care workers. The primary outcome was incidence of SARS-CoV-2 infection (as determined by reverse transcriptase polymerase chain reaction [RT-PCR] assay of nasopharyngeal swabs collected at 4 and 8 weeks) or the occurrence of COVID-19 symptoms.[24]

**Study Population**

- Participants included health care workers at two Philadelphia hospitals who worked ≥20 hours per week in a hospital-based unit, had no known history of SARS-CoV-2 infection, and had no COVID-19-like symptoms in the 2 weeks before enrollment. The study enrolled workers in the emergency department (ED) and in dedicated COVID-19 treatment units.
- The study excluded individuals who were allergic to hydroxychloroquine and those with glucose-6-phosphate dehydrogenase deficiency, retinal disease, or substantial cardiac disease.

**Results**

- The study was based on an assumed 10% infection rate for the planned inclusion of 100 participants per arm.
- Between April 9 and July 14, 2020, community SARS-CoV-2 infection rates declined. At the time of the second interim analysis (when 125 of 132 participants who provided consent were evaluable for the primary endpoint), the Data Safety Monitoring Board recommended early termination of the study for futility.
- Four participants in each arm developed SARS-CoV-2 infection (positivity rate of 6.3% in the hydroxychloroquine arm vs. 6.6% in the placebo arm; $P > 0.99$). Across both arms, six participants developed symptoms of COVID-19, but none required hospitalization.
- Serologic testing for antispike protein immunoglobulin (Ig) M, IgG, and nucleocapsid protein IgG demonstrated more positive results among participants in the hydroxychloroquine arm (four participants [7.4%]) than in the placebo arm (two participants [3.7%]), although the difference was not statistically significant ($P = 0.40$).
- Mild adverse events were more common among participants in the hydroxychloroquine arm (45%)

than in the placebo arm (26%; $P = 0.04$). The greatest difference was the increased frequency of mild diarrhea in the hydroxychloroquine arm.

- The rates of treatment discontinuation were similar in the hydroxychloroquine arm (19%) and the placebo arm (16%).
- There were no cardiac events in either arm, as well as no significant difference in the median frequency of changes in QTc between the study arms ($P = 0.98$).

**Limitations**

- The study was stopped early.
- Due to the low SARS-CoV-2 infection rate among the participants, the study was underpowered to detect a prophylactic benefit of hydroxychloroquine.
- The study population was mostly young, healthy health care workers; therefore, whether the study findings are applicable to other populations is uncertain.

**Interpretation**

There was no clinical benefit of administering hydroxychloroquine 600 mg per day for 8 weeks as PrEP to health care workers who were exposed to patients with COVID-19. Compared to placebo, hydroxychloroquine was associated with an increased risk of mostly mild adverse events.

### Hydroxychloroquine as Pre-Exposure Prophylaxis for COVID-19 in Health Care Workers: A Randomized Trial

COVID PREP was a double-blind, placebo-controlled randomized clinical trial that investigated whether hydroxychloroquine 400 mg given once- or twice-weekly for 12 weeks can prevent SARS-CoV-2 infection in health care workers who were at high risk of exposure. The primary outcome was COVID-19-free survival time. Diagnosis of COVID-19 was defined as having laboratory-confirmed SARS-CoV-2 infection or having cough, shortness of breath, or difficulty breathing or having two or more of the following symptoms: fever, chills, rigors, myalgia, headache, sore throat, or new olfactory and taste disorders. COVID-19-compatible illness was included as a primary outcome even if a SARS-CoV-2 PCR test was not performed or if it was performed and the result was negative.[25]

**Study Population**

- The study participants had to be working in the ED, in the intensive care unit, on a dedicated COVID-19 hospital ward, or as a first responder; alternatively, they had to have a job description that included regularly performing aerosol-generating procedures.
- Participants were recruited via social media platforms. Informed consent was obtained remotely, and the study drug was delivered to the participants by couriers.

**Results**

- The study was powered based on an anticipated 10% event rate of new symptomatic infections. The investigators determined that the study needed to enroll 1,050 participants per arm to have 80% power. However, it became apparent before the first interim analysis that the study would not meet the enrollment target. As a result, enrollment was stopped without unblinding. The investigators attributed the marked decline in enrollment to the negative reports on the safety of hydroxychloroquine, including a warning from the FDA.
- Among the 1,483 participants who were randomized, baseline characteristics were similar across the study arms.
- The number of individuals who met the primary endpoint of confirmed or suspected SARS-CoV-2 infection was 39 (7.9%) in the placebo arm and 29 (5.9%) in both the once- and twice-weekly

hydroxychloroquine arms. Among the 97 participants, only 17 were confirmed to be SARS-CoV-2 PCR positive.

- Compared to placebo, the hazard ratio for the primary endpoint was 0.72 (95% CI, 0.4–1.16; $P$ = 0.18) for the once-weekly hydroxychloroquine arm and 0.74 (95% CI, 0.46–1.19; $P$ = 0.22) for the twice-weekly hydroxychloroquine arm.
- There were no significant differences for any of the secondary efficacy endpoints among the three arms.
- There were significantly more adverse events reported in the once- and twice-weekly hydroxychloroquine arms (adverse events occurred in 31% vs. 36% of participants, respectively; $P < 0.001$ for both arms) than in the placebo arm (21% of participants). The most common adverse events were upset stomach and nausea.
- Drug concentrations were measured in dried whole blood samples from a subset of 180 participants who received hydroxychloroquine. The median hydroxychloroquine concentrations for the twice- and once-weekly hydroxychloroquine arms were 200 ng/mL and 98 ng/mL, respectively; both concentrations are substantially below the in vitro half-maximal effective concentration ($EC_{50}$) of hydroxychloroquine. The investigators noted that the simulations that were used to determine the hydroxychloroquine dose for the study predicted much higher drug concentrations than the observed levels.

**Limitations**

- The study was prematurely halted due to poor enrollment; therefore, the study population was insufficient to detect differences in outcomes among the study arms.
- The study only assessed the SARS-CoV-2 inhibitory activity of two doses of hydroxychloroquine, neither of which achieved concentrations that exceeded the in vitro $EC_{50}$ of the drug.
- Only 17.5% of the participants who met study endpoints had positive SARS-CoV-2 test results; the remainder had COVID-19-compatible symptoms without a confirmatory diagnosis.

**Interpretation**

Hydroxychloroquine 400 mg once- or twice-weekly did not reduce the incidence of documented SARS-CoV-2 infection or COVID-19-compatible symptoms among health care workers who were at high risk of exposure. These findings suggest that hydroxychloroquine was not effective for SARS-CoV-2 PrEP or that the dose used for PrEP was suboptimal.

## Post-Exposure Prophylaxis

- The Panel **recommends against** the use of **hydroxychloroquine** for SARS-CoV-2 post-exposure prophylaxis (PEP) **(AI)**.
- The Panel **recommends against** the use of other drugs for SARS-CoV-2 PEP, except in a clinical trial **(AIII)**.

### *Rationale*

Several randomized controlled trials have evaluated the use of hydroxychloroquine for SARS-CoV-2 PEP.[26-28] None of these studies have reported any evidence of efficacy, and all showed a higher frequency of adverse events among participants who received hydroxychloroquine than among control participants. The results of some of these studies are described below.

A number of agents (e.g., anti-SARS-CoV-2 monoclonal antibodies, hyperimmune gammaglobulin, convalescent plasma, ivermectin, interferons, tenofovir with or without emtricitabine, vitamin D) are

currently being investigated for SARS-CoV-2 PEP. The latest clinical trials for SARS-CoV-2 PEP can be found at *ClinicalTrials.gov*.

## *Clinical Trial Data*

Both chloroquine and hydroxychloroquine have in vitro activity against SARS-CoV and SARS-CoV-2.[29,30] A small cohort study without a control group suggested that hydroxychloroquine might reduce the risk of SARS-CoV-2 transmission to close contacts.[31]

### Household-Randomized, Double-Blind, Controlled Trial of SARS-CoV-2 Post-Exposure Prophylaxis With Hydroxychloroquine

A household-randomized, double-blind, controlled trial evaluated the use of hydroxychloroquine as PEP to prevent SARS-CoV-2 infection. The study was conducted at seven institutions in the United States between March and August 2020. Participants were recruited using online advertising, social media, and referrals from hospitals, health departments, and individuals with laboratory-confirmed SARS-CoV-2 infection.[26]

Households were randomized to receive oral hydroxychloroquine 400 mg once daily for 3 days, followed by hydroxychloroquine 200 mg once daily for an additional 11 days, or oral ascorbic acid 500 mg once daily for 3 days, followed by ascorbic acid 250 mg once daily for 11 days. Mid-turbinate nasal swabs were collected daily during the first 14 days, with the primary endpoint being PCR-confirmed SARS-CoV-2 infection within 14 days after enrollment in those who were not infected at baseline.

**Study Population**

- Eligible participants had close contact with a SARS-CoV-2-infected person, which included household contacts or other close contacts (82%) or health care workers (18%) who cared for an infected person without wearing appropriate PPE. Participants must have come into contact with an index person who had received a diagnosis of SARS-CoV-2 infection within the past 14 days, and high-risk exposure to the index people must have occurred within the previous 96 hours.
- Enrollment included 829 participants from 671 households; 407 participants (in 337 households) received hydroxychloroquine, and 422 participants (in 334 households) received ascorbic acid.

**Results**

- A total of 98 SARS-CoV-2 infections were detected during the first 14 days of follow-up, with an overall cumulative incidence of 14.3% (95% CI, 11.5% to 17%). Fifty-three events (i.e., PCR-confirmed SARS-CoV-2 infection) occurred in the hydroxychloroquine arm, and 45 events occurred in the control arm (aHR 1.10; 95% CI, 0.73–1.66; $P > 0.20$)
- In preplanned analyses, hazard ratios were not significantly different within subgroups based on type of contact, time between the most recent contact and the first dose of the study drug, duration of contact, number of contacts enrolled within the household, quarantine status, index case symptoms, or number of adults or children in the household.
- Adverse events that are associated with the use of hydroxychloroquine, including gastrointestinal symptoms and rash, occurred in 112 participants: 66 participants (16.2%) in the hydroxychloroquine arm and 46 participants (10.9%) in the control arm ($P = 0.026$).

**Limitations**

- There was an average window of 2 days between the time of the most recent exposure to the index people and the time the study drugs were administered. The lapse of time between exposure to SARS-CoV-2 and initiation of hydroxychloroquine may have affected the efficacy of the drug as PEP.

- The primary analysis excluded approximately 10% of enrolled people who were shown to have SARS-CoV-2 infection at baseline.

**Interpretation**

In this study, hydroxychloroquine was ineffective when used as PEP for SARS-CoV-2 infection. Participants who received hydroxychloroquine had a greater risk of adverse events than those who received ascorbic acid.

### Double-Blind Randomized Controlled Trial of Hydroxychloroquine as Post-Exposure Prophylaxis in Contacts With High-Risk or Moderate-Risk Occupational or Household Exposures

This double-blind randomized controlled trial included 821 participants who self-enrolled in the study using an internet-based survey. Participants were randomized to receive either hydroxychloroquine (hydroxychloroquine 800 mg once, followed by hydroxychloroquine 600 mg 6 to 8 hours later, and then hydroxychloroquine 600 mg once daily for 4 additional days) or placebo. Because enrollment was done online, the study drugs were sent to participants by overnight mail; consequently, more than 50% of the participants started the first dose of their assigned treatment 3 to 4 days after exposure to SARS-CoV-2.[28]

**Study Population**

- Participants had a high or moderate risk of occupational exposure (66% of participants) or household exposure (34% of participants) to SARS-CoV-2.
- High-risk exposure was defined as being within six feet of an individual with confirmed SARS-CoV-2 infection for more than 10 minutes while not wearing a face mask or eye shield (87.6% of participants). Moderate-risk exposure was defined as exposure from the same distance and for the same duration while wearing a face mask but no eye shield (12.4% of participants).

**Results**

- A total of 107 participants developed the primary outcome of symptomatic illness. Illness was confirmed by a positive result on a SARS-CoV-2 molecular test. If testing was not available, participants were considered to have symptomatic illness if they developed a compatible COVID-19-related syndrome based on CDC criteria.
- Due to limited access to molecular diagnostic testing, SARS-CoV-2 infection was confirmed in only 16 of the 107 participants (15%). There was no statistically significant difference in the incidence of the primary outcome (symptomatic illness) between the hydroxychloroquine arm and the placebo arm (11.8% vs. 14.3%, respectively; $P = 0.35$).
- There were more adverse events in the hydroxychloroquine arm (mostly nausea, loose stools, and abdominal discomfort), and no serious adverse events or cardiac arrhythmias in either arm.

**Limitations**

- Most participants did not start their assigned therapy until at least 3 days after exposure to SARS-CoV-2.
- Only 15% of participants who reached the primary outcome had SARS-CoV-2 infection confirmed by molecular diagnostics.
- The study participants were young (median age was 40 years) and had a relatively low risk of severe COVID-19.

**Interpretation**

There was no difference in the incidence of observed symptomatic COVID-19 between participants who received hydroxychloroquine 600 mg once daily and those who received placebo. Although hydroxychloroquine 600 mg per day was associated with an increased frequency of adverse events, these

adverse events were mostly mild.

### Cluster-Randomized Trial of SARS-CoV-2 Post-Exposure Prophylaxis With Hydroxychloroquine

This open-label, cluster-randomized trial included 2,314 asymptomatic contacts of 672 COVID-19 cases in Spain.[27] Participants who were epidemiologically linked to a PCR-positive COVID-19 case were defined as study clusters (called rings). All contacts in a ring were simultaneously cluster-randomized in a 1:1 ratio to the control arm (usual care) or the intervention arm (hydroxychloroquine 800 mg once daily for 1 day, followed by hydroxychloroquine 400 mg once daily for 6 days). Participants were informed of their allocated study arm after being randomized to the intervention or control arm and signing a consent form.

The primary outcome was onset of laboratory-confirmed COVID-19, which was defined as a positive result on a SARS-CoV-2 PCR test and at least one of the following symptoms: fever, cough, difficulty breathing, myalgia, headache, sore throat, new olfactory and taste disorders, or diarrhea. A secondary outcome was onset of SARS-CoV-2 infection, which was defined as either a positive SARS-CoV-2 PCR test result or the presence of any of the symptoms compatible with COVID-19. An additional secondary outcome was development of serological positivity at Day 14.

**Study Population**

- Study participants were health care or nursing home workers (60.3%), household contacts (27.1%), or nursing home residents (12.7%) who were documented to have spent >15 minutes within two meters of a PCR-positive COVID-19 case during the 7 days prior to enrollment.
- The baseline characteristics of the participants were similar between the two study arms, including comorbidities, number of days of exposure to SARS-CoV-2 before enrollment and randomization, and type of contact.

**Results**

- A total of 138 study participants (6.0%) developed PCR-confirmed, symptomatic SARS-CoV-2 infection. There was no statistical difference in the incidence of confirmed infection between the hydroxychloroquine and control arms (5.7% vs. 6.2%, respectively; risk ratio 0.86; 95% CI, 0.52–1.42).
- There was no statistical difference between the study arms in the incidence of either PCR-confirmed or symptomatically compatible COVID-19, which was 18.2% overall (18.7% in the hydroxychloroquine arm vs. 17.8% in the control arm; risk ratio 1.03; 95% CI, 0.77–1.38).
- There was no statistical difference between the arms in the rate of positivity for SARS-CoV-2 IgM and/or IgG (14.3% in the hydroxychloroquine arm vs. 8.7% in the control arm; risk ratio 1.57; 95% CI, 0.94–2.62).
- A greater percentage of patients in the hydroxychloroquine arm experienced adverse events (56.1%) than in the control arm (5.9%), although most of the adverse events were mild. Common adverse events included gastrointestinal events, nervous system disorders, myalgia, fatigue, and malaise. No serious adverse events were attributed to the study drug.

**Limitations**

- The study lacked a placebo comparator, which could have had an impact on safety reporting.
- Data regarding the extent of the exposure to the index cases was limited.
- For >50% of the study participants, the time from exposure to the index case to randomization was ≥4 days.

**Interpretation**

The hydroxychloroquine regimen used for PEP in this study did not prevent SARS-CoV-2 infection in healthy individuals who were exposed to a PCR-positive case.

## Ivermectin

High concentrations of ivermectin have been shown to inhibit SARS-CoV-2 replication in vitro.[32,33] Population data also indicate that country-wide mass use of prophylactic chemotherapy for parasitic infections, including the use of ivermectin, is associated with a lower incidence of COVID-19.[34] At this time, few clinical trials have evaluated the safety and efficacy of ivermectin for SARS-CoV-2 PrEP or PEP. Although several studies have reported potentially promising results, the findings are limited by the design of the studies, their small sample sizes, and the lack of details regarding the safety and efficacy of ivermectin. The results of these trials are described below.

In a descriptive, uncontrolled interventional study of 33 contacts of patients with laboratory-confirmed COVID-19, no cases of SARS-CoV-2 infection were identified within 21 days of initiating ivermectin for PEP.[35] An open-label randomized controlled trial investigated ivermectin prophylaxis (plus personal protective measures [PPMs]) in health care workers (as PrEP) or in household contacts (as PEP) exposed to patients with laboratory-confirmed COVID-19. The incidence of SARS-CoV-2 infection was lower among the participants who received ivermectin than among control participants who used only PPMs. However, the study provided no data on the characteristics of the study participants, types of exposures, or how endpoints were defined.[36] Finally, in a small case-control study in SARS-CoV-2-exposed health care workers, 186 participants who became infected were matched with 186 uninfected controls. Of those who received ivermectin after exposure to SARS-CoV-2, 38 were in the infected group and 77 were in the uninfected group, which led the investigators to conclude that ivermectin reduced the incidence of SARS-CoV-2 infection.[37]

Several clinical trials that are evaluating the use of ivermectin for SARS-CoV-2 PrEP or PEP are currently underway or in development. Please see *ClinicalTrials.gov* for the latest information.

## References


1. Centers for Disease Control and Prevention. SARS-CoV-2 Transmission. 2021.Available at: https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/sars-cov-2-transmission.html. Accessed July 2, 2021.
2. Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19): how to protect yourself & others. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html. Accessed June 17, 2021.
3. Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19): infection control guidance for healthcare professionals about coronavirus (COVID-19). 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control.html. Accessed June 17, 2021.
4. Food and Drug Administration. Fact sheet for healthcare providers administering vaccine (vaccination providers): emergency use authorization (EUA) of the Pfizer-BioNTech COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). 2020. Available at: https://www.fda.gov/media/144413/download.
5. Food and Drug Administration. Fact sheet for healthcare providers administering vaccine (vaccination providers): emergency use authorization (EUA) of the Moderna COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). 2020. Available at: https://www.fda.gov/media/144637/download.
6. Food and Drug Administration. Fact sheet for healthcare providers administering vaccine (vaccination providers): emergency use authorization (EUA) of the Janssen COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). 2021/ Available at: https://www.fda.gov/media/146304/download.
7. Shimabukuro TT, Kim SY, Myers TR, et al. Preliminary findings of mRNA COVID-19 vaccine safety in pregnant persons. *N Engl J Med*. 2021;Published online ahead of print. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/33882218.

8. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA COVID-19 vaccine. *N Engl J Med*. 2020;383(27):2603-2615. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33301246.
9. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. *N Engl J Med*. 2021;384(5):403-416. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33378609.
10. Angel Y, Spitzer A, Henig O,et al. Association between vaccination with BNT162b2 and incidence of symptomatic and asymptomatic SARS-CoV-2 infections among health care workers. *JAMA*. 2021;Published online ahead of print. Available at: https://pubmed.ncbi.nlm.nih.gov/33956048/.
11. Centers for Disease Control and Prevention. Interim considerations: preparing for the potential management of anaphylaxis after COVID-19 vaccination. 2020. Available at: https://www.cdc.gov/vaccines/covid-19/info-by-product/pfizer/anaphylaxis-management.html. Accessed June 17, 2021.
12. Centers for Disease Control and Prevention. Reported adverse events. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/adverse-events.html. Accessed June 2, 2021.
13. Centers for Disease Control and Prevention. Safety of COVID-19 vaccines. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/safety-of-vaccines.html. Accessed June 2, 2021.
14. Centers for Disease Control and Prevention. J&J/Janssen update. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/JJUpdate.html#symptoms-list. Accessed June 2, 2021.
15. See I, Su JR, Lale A, et al. U.S. case reports of cerebral venous sinus thrombosis with thrombocytopenia after Ad26.COV2.S aaccination, March 2 to April 21, 2021. *JAMA*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33929487.
16. Greinacher A, Thiele T, Warkentin TE, Weisser K, Kyrle PA,Eichinger S. Thrombotic thrombocytopenia after ChAdOx1 nCov-19 vaccination. *N Engl J Med*. 2021;384(22):2092-2101. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33835769.
17. Pottegard A, Lund LC, Karlstad O, et al. Arterial events, venous thromboembolism, thrombocytopenia, and bleeding after vaccination with Oxford-AstraZeneca ChAdOx1-S in Denmark and Norway: population based cohort study. *BMJ*. 2021. Available at: https://www.bmj.com/content/373/bmj.n1114.
18. Taquet M, Husain M, Geddes JR, Luciano S, Harrison PJ,et al. Cerebral venous thrombosisand portal vein thrombosis: a retrospective cohort study of 537,913 COVID-19 cases. 2021. Available at: https://osf.io/a9jdq/. Accessed June 2, 2021.
19. American Society of Hematology, Bussel JB, Connors JM, et al. Thrombosis with thrombocytopenia syndrome (also termed vaccine-induced thrombotic thrombocytopenia). 2021. Available at: https://www.hematology.org/covid-19/vaccine-induced-immune-thrombotic-thrombocytopenia. Accessed June 2, 2021.
20. American Heart Association, American Stroke Association, Furie KL. Diagnosis and management of cerebral venous sinus thrombosis with vaccine-induced immune thrombotic thrombocytopenia. 2021. Available at: https://www.ahajournals.org/doi/pdf/10.1161/STROKEAHA.121.035564.
21. The American College of Obstetricians and Gynecologists. Practice advisory: vaccinating pregnant and lactating patients against COVID-19. 2020. Available at: https://www.acog.org/clinical/clinical-guidance/practice-advisory/articles/2020/12/vaccinating-pregnant-and-lactating-patients-against-covid-19. Accessed May 26, 2021.
22. Centers for Disease Control and Prevention. Current COVID-19 ACIP vaccine recommendations. 2020. Available at: https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html. Accessed January 6, 2021.
23. Centers for Disease Control and Prevention. When you've been fully vaccinated: how to protect yourself and others. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/fully-vaccinated.html. Accessed April 8, 2021.
24. Abella BS, Jolkovsky EL, Biney BT, et al. Efficacy and safety of hydroxychloroquine vs placebo for pre-exposure SARS-CoV-2 prophylaxis among health care workers: a randomized clinical trial. *JAMA Intern Med*.

2021;181(2):195-202. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33001138.

25. Rajasingham R, Bangdiwala AS, Nicol MR, et al. Hydroxychloroquine as pre-exposure prophylaxis for COVID-19 in healthcare workers: a randomized trial. *Clin Infect Dis*. 2021;72(11):e835-e843. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33068425.
26. Barnabas RV, Brown ER, Bershteyn A, et al. Hydroxychloroquine as postexposure prophylaxis to prevent severe acute respiratory syndrome coronavirus 2 infection: a randomized trial. *Ann Intern Med*. 2021;174(3):344-352. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33284679.
27. Mitjà O, Corbacho-Monné M, Ubals M, et al. A cluster-randomized trial of hydroxychloroquine for prevention of COVID-19. *N Engl J Med*. 2020. Available at: https://www.nejm.org/doi/pdf/10.1056/NEJMoa2021801.
28. Boulware DR, Pullen MF, Bangdiwala AS, et al. A randomized trial of hydroxychloroquine as postexposure prophylaxis for COVID-19. *N Engl J Med*. 2020;383(6):517-525. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32492293.
29. Yao X, Ye F, Zhang M, et al. In vitro antiviral activity and projection of optimized dosing design of hydroxychloroquine for the treatment of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). *Clin Infect Dis*. 2020;71(15):732-739. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32150618.
30. Vincent MJ, Bergeron E, Benjannet S, et al. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. *Virol J*. 2005;2:69. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16115318.
31. Lee SH, Son H,Peck KR. Can post-exposure prophylaxis for COVID-19 be considered as an outbreak response strategy in long-term care hospitals? *Int J Antimicrob Agents*. 2020;55(6):105988. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32305587.
32. Caly L, Druce JD, Catton MG, Jans DA,Wagstaff KM. The FDA-approved drug ivermectin inhibits the replication of SARS-CoV-2 in vitro. *Antiviral Res*. 2020;178:104787. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32251768.
33. Belhadjer Z, Meot M, Bajolle F, et al. Acute heart failure in multisystem inflammatory syndrome in children (MIS-C) in the context of global SARS-CoV-2 pandemic. *Circulation*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32418446.
34. Hellwig MD,Maia A. A COVID-19 prophylaxis? Lower incidence associated with prophylactic administration of ivermectin. *Int J Antimicrob Agents*. 2021;57(1):106248. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33259913.
35. Aguirre Chang G,Figueredo ANT. COVID-19: post-exposure propylaxis with ivermectin in contacts. At homes, places of work, nursing homes, prisons, and others. *ResearchGate*. 2020;Preprint. Available at: https://www.researchgate.net/publication/344781515_COVID-19_POST-EXPOSURE_PROPHYLAXIS_WITH_IVERMECTIN_IN_CONTACTS_At_Homes_Places_of_Work_Nursing_Homes_Prisons_and_Others.
36. Elgazzar A, Hany B, Youssef SA, Hafez M, Moussa H,Eltaweel A. Efficacy and safety of ivermectin for treatment and prophylaxis of COVID-19 pandemic. *Research Square*. 2020;Preprint. Available at: https://www.researchsquare.com/article/rs-100956/v3.
37. Behera P, Patro BK, Singh AK, et al. Role of ivermectin in the prevention of COVID-19 infection among healthcare workers in India: a matched case-control study. *MedRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.29.20222661v1.

# Clinical Spectrum of SARS-CoV-2 Infection

*Last Updated: April 21, 2021*

Patients with SARS-CoV-2 infection can experience a range of clinical manifestations, from no symptoms to critical illness. This section of the Guidelines discusses the clinical presentation of SARS-CoV-2-infected individuals according to illness severity.

In general, adults with SARS-CoV-2 infection can be grouped into the following severity of illness categories. However, the criteria for each category may overlap or vary across clinical guidelines and clinical trials, and a patient's clinical status may change over time.

*Asymptomatic or Presymptomatic Infection:* Individuals who test positive for SARS-CoV-2 using a virologic test (i.e., a nucleic acid amplification test [NAAT] or an antigen test) but who have no symptoms that are consistent with COVID-19.

*Mild Illness:* Individuals who have any of the various signs and symptoms of COVID-19 (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) but who do not have shortness of breath, dyspnea, or abnormal chest imaging.

*Moderate Illness:* Individuals who show evidence of lower respiratory disease during clinical assessment or imaging and who have an oxygen saturation ($SpO_2$) ≥94% on room air at sea level.

*Severe Illness:* Individuals who have $SpO_2$ <94% on room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen ($PaO_2/FiO_2$) <300 mm Hg, respiratory frequency >30 breaths/min, or lung infiltrates >50%.

*Critical Illness:* Individuals who have respiratory failure, septic shock, and/or multiple organ dysfunction.

Patients with certain underlying comorbidities are at a higher risk of progressing to severe COVID-19. These comorbidities include being aged 65 years or older; having cardiovascular disease, chronic lung disease, sickle cell disease, diabetes, cancer, obesity, or chronic kidney disease; being pregnant; being a cigarette smoker; and being a recipient of transplant or immunosuppressive therapy.[1] Health care providers should monitor such patients closely until clinical recovery is achieved.

The optimal pulmonary imaging technique has not yet been defined for people with symptomatic SARS-CoV-2 infection. Initial evaluation for these patients may include chest X-ray, ultrasound, or, if indicated, computed tomography. An electrocardiogram should be performed if indicated. Laboratory testing includes a complete blood count with differential and a metabolic profile, including liver and renal function tests. Although inflammatory markers such as C-reactive protein (CRP), D-dimer, and ferritin are not routinely measured as part of standard care, results from such measurements may have prognostic value.[2-4]

The definitions for the severity of illness categories listed above also apply to pregnant patients. However, the threshold for certain interventions may be different for pregnant patients and nonpregnant patients. For example, oxygen supplementation is recommended for pregnant patients when $SpO_2$ falls below 95% on room air at sea level to accommodate physiologic changes in oxygen demand during pregnancy and to ensure adequate oxygen delivery to the fetus.[5] If laboratory parameters are used for monitoring pregnant patients and making decisions about interventions, clinicians should be aware that normal physiologic changes during pregnancy can alter several laboratory values. In general, leukocyte cell count increases throughout gestation and delivery and peaks during the immediate postpartum period. This increase is mainly due to neutrophilia.[6] D-dimer and CRP levels also increase during pregnancy and are often higher in pregnant patients than nonpregnant patients.[7] Detailed information on treating COVID-19 in pregnant

patients can be found in Special Considerations in Pregnancy and in the pregnancy considerations subsection of each individual section of the Guidelines.

In pediatric patients, radiographic abnormalities are common and, for the most part, should not be the only criteria used to determine the severity of illness. The normal values for respiratory rate also vary with age in children; thus, hypoxia should be the primary criterion used to define severe COVID-19, especially in younger children. In a small number of children and in some young adults, SARS-CoV-2 infection may be followed by a severe inflammatory condition called multisystem inflammatory syndrome in children (MIS-C).[8,9] This syndrome is discussed in detail in Special Considerations in Children.

## Asymptomatic or Presymptomatic Infection

Asymptomatic SARS-CoV-2 infection can occur, although the percentage of patients who remain truly asymptomatic throughout the course of infection is variable and incompletely defined. It is unclear what percentage of individuals who present with asymptomatic infection progress to clinical disease. Some asymptomatic individuals have been reported to have objective radiographic findings that are consistent with COVID-19 pneumonia.[10,11] The availability of widespread virologic testing for SARS-CoV-2 and the development of reliable serologic assays for antibodies to the virus will help determine the true prevalence of asymptomatic and presymptomatic infection. See Therapeutic Management of Nonhospitalized Adults With COVID-19 for recommendations regarding SARS-CoV-2–specific therapy.

## Mild Illness

Patients with mild illness may exhibit a variety of signs and symptoms (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell). They do not have shortness of breath, dyspnea on exertion, or abnormal imaging. Most mildly ill patients can be managed in an ambulatory setting or at home through telemedicine or telephone visits. No imaging or specific laboratory evaluations are routinely indicated in otherwise healthy patients with mild COVID-19. Older patients and those with underlying comorbidities are at higher risk of disease progression; therefore, health care providers should monitor these patients closely until clinical recovery is achieved. See Therapeutic Management of Nonhospitalized Adults With COVID-19 for recommendations regarding SARS-CoV-2-specific therapy.

## Moderate Illness

Moderate illness is defined as evidence of lower respiratory disease during clinical assessment or imaging, with $SpO_2$ ≥94% on room air at sea level. Given that pulmonary disease can progress rapidly in patients with COVID-19, patients with moderate disease should be closely monitored. If bacterial pneumonia or sepsis is suspected, administer empiric antibiotic treatment, re-evaluate the patient daily, and de-escalate or stop antibiotics if there is no evidence of bacterial infection. See Therapeutic Management of Nonhospitalized Adults With COVID-19 for recommendations regarding SARS-CoV-2–specific therapy.

## Severe Illness

Patients with COVID-19 are considered to have severe illness if they have $SpO_2$ <94% on room air at sea level, a respiratory rate >30 breaths/min, $PaO_2/FiO_2$ <300 mm Hg, or lung infiltrates >50%. These patients may experience rapid clinical deterioration. Oxygen therapy should be administered immediately using a nasal cannula or a high-flow oxygen device. See Therapeutic Management of Hospitalized Adults With COVID-19 for recommendations regarding SARS-CoV-2-specific therapy. If secondary bacterial pneumonia or sepsis is suspected, administer empiric antibiotics, re-evaluate the

patient daily, and de-escalate or stop antibiotics if there is no evidence of bacterial infection.

## Critical Illness

Critically ill patients may have acute respiratory distress syndrome, septic shock that may represent virus-induced distributive shock, cardiac dysfunction, an exaggerated inflammatory response, and/or exacerbation of underlying comorbidities. In addition to pulmonary disease, patients with critical illness may also experience cardiac, hepatic, renal, central nervous system, or thrombotic disease.

As with any patient in the intensive care unit (ICU), successful clinical management of a patient with COVID-19 includes treating both the medical condition that initially resulted in ICU admission and other comorbidities and nosocomial complications.

For more information, see Care of Critically Ill Patients With COVID-19.

## SARS-CoV-2 Reinfection

As seen with other viral infections, reinfection with SARS-CoV-2 after recovery from prior infection has been reported.[12] The true prevalence of reinfection is not known, although there are concerns that it may occur with increased frequency with the circulation of new variants.[13] SARS-CoV-2 can often be detected from nasal swab for weeks to months after initial infection, therefore, repeat testing to evaluate for reinfection should be considered only for those who have recovered from initial infection and present with COVID-19-compatible symptoms with no obvious alternate etiology **(AIII)**.[14] Diagnostic testing in this setting is summarized in Testing for SARS-CoV-2 Infection. In addition, if reinfection is suspected, guidelines for the diagnosis and evaluation of suspected SARS-CoV-2 reinfection are provided by the Centers for Disease Control and Prevention (CDC).[15]

It has been speculated that reinfection may occur more frequently in those with a less robust immune response during the initial infection, as is often reported in those with mild illness. Reinfection may also occur as initial immune responses wane over time. Nevertheless, one review noted that SARS-CoV-2 reinfection occurred after previous severe disease in three cases and as early as 3 weeks after diagnosis of the initial infection.[16] A public site posts a variety of published and unpublished reports of reinfection, noting that it has been described to occur from as early as a few weeks to many months after initial infection, and occasionally follows episodes of severe COVID-19.[17] Although data are limited, there is no evidence to suggest that the treatment of highly suspected or documented SARS-CoV-2 reinfection should be different from that for initial infection as outlined in Therapeutic Management of Nonhospitalized Adults With COVID-19 and Therapeutic Management of Hospitalized Adults With COVID-19.

## Persistent Symptoms or Organ Dysfunction After Acute COVID-19

There have been an increasing number of reports of patients who experience persistent symptoms and/or organ dysfunction after acute COVID-19. Data about the incidence, natural history, and etiology of these symptoms are emerging. However, these reports have several limitations, including lack of an agreed-upon case definition and potential bias as most reports included only patients who attended post-COVID-19 clinics and no comparator groups. No specific treatments for the persistent effects of COVID-19 have yet been identified, although this COVID-19 rapid guideline proposes general management strategies.

The nomenclature for this phenomenon is evolving, and there is no established clinical terminology to date. It has been referred to as post-COVID-19 condition or colloquially, “long COVID,” and affected patients have been referred to as “long haulers.” The term “post-acute sequelae of COVID-19” (PASC)

has also been used to describe late sequelae of SARS-CoV-2 infection that include these persistent symptoms, as well as other delayed syndromes such as MIS-C and multisystem inflammatory syndrome in adults (MIS-A). To date, no case definition and no specific time frame have been established to define the syndrome of persistent symptoms and/or organ dysfunction after acute COVID-19. However, CDC recently proposed defining late sequelae as sequelae that extend >4 weeks after initial infection.[18,19] The Patient-Led Research Collaborative for COVID-19 defines long COVID as a collection of symptoms that develop during or following a confirmed or suspected case of COVID-19 and that continue for >28 days.[20] Incidence rates vary widely, from about 10% in some reports to one cohort study in which 87% of patients reported at least one persistent symptom.[21]

Some of the symptoms overlap with the post-intensive care syndrome (PICS) that has been described in patients without COVID-19, but prolonged symptoms and disabilities after COVID-19 have also been reported in patients with milder illness, including outpatients (see General Considerations for information on PICS).[22,23]

Despite limitations of the available descriptive data related to these persistent symptoms, some representative studies have suggested that common findings include fatigue, joint pain, chest pain, palpitations, shortness of breath, cognitive impairment, and worsened quality of life.[24,25]

CDC conducted a telephone survey of a random sample of 292 adult outpatients who had positive polymerase chain reaction results for SARS-CoV-2. Among the 274 respondents who were symptomatic at the time of testing, 35% reported not having returned to their usual state of health 2 weeks or more after testing; 26% among patients aged 18 to 34 years, 32% among those aged 35 to 49 years, and 47% among those aged ≥50 years.[23] An age of ≥50 years and the presence of three or more chronic medical conditions were associated with not returning to usual health within 14 to 21 days. Moreover, one in five individuals aged 18 to 34 years who did not have chronic medical conditions had not returned to baseline health when interviewed at a median of 16 days from the testing date.

In a cohort study from Wuhan, China, 1,733 discharged patients with COVID-19 were evaluated for persistent symptoms at a median of 186 days after symptom onset.[26] The most common symptoms were fatigue or muscle weakness and sleep difficulties (reported among 63% and 26% of participants, respectively). Anxiety or depression was reported among 23% of patients.

In a longitudinal prospective cohort of mostly outpatients with laboratory-confirmed SARS-CoV-2 infection at the University of Washington, 177 participants completed a follow-up questionnaire between 3 and 9 months after illness onset.[27] Overall, 91% of the respondents were outpatients (150 with mild illness and 11 with no symptoms), and only 9.0% had moderate or severe disease requiring hospitalization. Among those reporting symptoms, 33% of the outpatients and 31% of the hospitalized patients reported at least one persistent symptom. Persistent symptoms were reported by 27% of the patients aged 18 to 39 years, 30% aged 40 to 64 years, and 43% aged ≥65 years. The most common persistent symptoms were loss of sense of smell or taste and fatigue (both reported by 14% of participants).

### *Fatigue*

The prevalence of fatigue among 128 individuals from Ireland who had recovered from the acute phase of COVID-19 was examined using the Chalder Fatigue Scale (CFQ11). More than half of patients (67 of 128 patients [52.3%]) reported persistent fatigue at a median of 10 weeks after initial symptoms first appeared. There was no association between illness severity and fatigue.[28] An outpatient service for patients recovering from acute COVID-19 developed in Italy reported that 87% of 143 patients surveyed reported persistent symptoms at a mean of 60 days after symptom onset, with the most common

symptom being fatigue (which occurred in 53.1% of these patients).[21]

### *Cardiopulmonary*

A study from the United Kingdom reported that among 100 hospitalized patients (32 received care in the ICU and 68 received care in hospital wards only), 72% of the ICU patients and 60% of the ward patients experienced fatigue and breathlessness at 4 to 8 weeks after hospital discharge. The authors suggested that posthospital rehabilitation may be necessary for some of these patients.[24] A retrospective study from China found that pulmonary function (as measured by spirometry) was still impaired 1 month after hospital discharge in 31 of 57 patients (54.4%).[29] In a study from Germany that included 100 patients who had recently recovered from COVID-19, cardiac magnetic resonance imaging (MRI) performed a median of 71 days after diagnosis revealed cardiac involvement in 78% of patients and ongoing myocardial inflammation in 60% of patients.[30] A retrospective study from China of 26 patients who had recovered from COVID-19 and who had initially presented with cardiac symptoms found abnormalities on cardiac MRI in 15 patients (58%).[31] The assessment of the prevalence of cardiac abnormalities in people with post-acute COVID-19 syndrome should be viewed with caution, however, as the analysis included only patients with cardiac symptoms.

### *Neuropsychiatric*

Neurologic and psychiatric symptoms have also been reported among patients who have recovered from acute COVID-19. High rates of anxiety and depression have been reported in some patients using self-report scales for psychiatric distress.[25,32] Younger patients have been reported to experience more psychiatric symptoms than patients aged >60 years.[24,25] Patients may continue to experience headaches, vision changes, hearing loss, loss of taste or smell, impaired mobility, numbness in extremities, tremors, myalgia, memory loss, cognitive impairment, and mood changes for up to 3 months after diagnosis of COVID-19.[33-35] One study in the United Kingdom administered cognitive tests to 84,285 participants who had recovered from suspected or confirmed SARS-CoV-2 infection. These participants had worse performances across multiple domains than would be expected for people with the same ages and demographic profiles; this effect was observed even among those who had not been hospitalized.[36] However, the study authors did not report when the tests were administered in relation to the diagnosis of COVID-19.

Persistent symptoms after acute COVID-19 have also been reported in pregnant people.[37] Systematic data on persistent symptoms in children following recovery from the acute phase of COVID-19 are not currently available, although case reports suggest that children may experience long-term effects similar to those experienced by adults after clinical COVID-19.[38,39] MIS-C is discussed in Special Considerations in Children.

More research and more rigorous observational cohort studies are needed to better understand the pathophysiology and clinical course of these post-acute COVID-19 sequelae and to identify management strategies for patients. More information about ongoing studies can be found at *ClinicalTrials.gov*.

## References


1. Centers for Disease Control and Prevention. COVID-19 (coronavirus disease): people with certain medical conditions. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html. Accessed December 7, 2020.
2. Tan C, Huang Y, Shi F, et al. C-reactive protein correlates with computed tomographic findings and predicts severe COVID-19 early. *J Med Virol*. 2020;92(7):856-862. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32281668.

3. Berger JS, Kunichoff D, Adhikari S, et al. Prevalence and outcomes of D-dimer elevation in hospitalized patients with COVID-19. *Arterioscler Thromb Vasc Biol*. 2020;40(10):2539-2547. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32840379.
4. Casas-Rojo JM, Anton-Santos JM, Millan-Nunez-Cortes J, et al. Clinical characteristics of patients hospitalized with COVID-19 in Spain: results from the SEMI-COVID-19 Registry. *Rev Clin Esp*. 2020;220(8):480-494. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32762922.
5. Society for Maternal Fetal Medicine. Management considerations for pregnant patients with COVID-19. 2020. Available at: https://s3.amazonaws.com/cdn.smfm.org/media/2336/SMFM_COVID_Management_of_COVID_pos_preg_patients_4-30-20_final.pdf.
6. Abbassi-Ghanavati M, Greer LG, Cunningham FG. Pregnancy and laboratory studies: a reference table for clinicians. *Obstet Gynecol*. 2009;114(6):1326-1331. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19935037.
7. Anderson BL, Mendez-Figueroa H, Dahlke JD, Raker C, Hillier SL, Cu-Uvin S. Pregnancy-induced changes in immune protection of the genital tract: defining normal. *Am J Obstet Gynecol*. 2013;208(4):321.e1-321.e9. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23313311.
8. Riphagen S, Gomez X, Gonzalez-Martinez C, Wilkinson N, Theocharis P. Hyperinflammatory shock in children during COVID-19 pandemic. *Lancet*. 2020;395(10237):1607-1608. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32386565.
9. Verdoni L, Mazza A, Gervasoni A, et al. An outbreak of severe Kawasaki-like disease at the Italian epicentre of the SARS-CoV-2 epidemic: an observational cohort study. *Lancet*. 2020;395(10239):1771-1778. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32410760.
10. Zhang R, Ouyang H, Fu L, et al. CT features of SARS-CoV-2 pneumonia according to clinical presentation: a retrospective analysis of 120 consecutive patients from Wuhan city. *Eur Radiol*. 2020;30(8):4417-4426. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32279115.
11. Inui S, Fujikawa A, Jitsu M, et al. Chest CT findings in cases from the cruise ship "Diamond Princess" with coronavirus disease 2019 (COVID-19). *Radiology: Cardiothoracic Imaging*. 2020;2(2). Available at: https://pubs.rsna.org/doi/10.1148/ryct.2020200110.
12. Cohen J, Burbelo PD. Reinfection with SARS-CoV-2: implications for vaccines. *Oxford Academic*. 2020. Available at: https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa1866/6041697.
13. Nonaka CKV, Franco MM, Graf T, et al. Genomic evidence of SARS-CoV-2 reinfection case with E484K spike mutation, Brazil. *Emerg Infect Dis*. 2021;27(5). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33605869.
14. Centers for Disease Control and Prevention. Interim guidance on duration of isolation and precautions for adults with COVID-19. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/duration-isolation.html. Accessed March 2, 2021.
15. Centers for Disease Control and Prevention. Investigative criteria for suspected cases of SARS-CoV-2 reinfection (ICR). 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/php/invest-criteria.html. Accessed March 30, 2021.
16. Kim AY, Gandhi RT. Reinfection with severe acute respiratory syndrome coronavirus 2: what goes around may come back around. 2020. Available at: https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa1541/5920338.
17. BNO News. COVID-19 reinfection tracker. 2020. Available at: https://bnonews.com/index.php/2020/08/covid-19-reinfection-tracker/. Accessed March 2, 2021.
18. Datta SD, Talwar A, Lee JT. A proposed framework and timeline of the spectrum of disease due to SARS-CoV-2 infection: illness beyond acute infection and public health implications. *JAMA*. 2020;324(22):2251-2252. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33206133.
19. Greenhalgh T, Knight M, A'Court C, Buxton M, Husain L. Management of post-acute COVID-19 in primary

care. *BMJ*. 2020;370:m3026. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32784198.

20. Sudre CH, Murray B, Varsavsky T, et al. Attributes and predictors of long-COVID: analysis of COVID cases and their symptoms collected by the COVID symptoms study app. *Nat Med*. 2020. Available at: https://www.nature.com/articles/s41591-021-01292-y.
21. Carfi A, Bernabei R, Landi F, Gemelli Against C-P-ACSG. Persistent symptoms in patients after acute COVID-19. *JAMA*. 2020;324(6):603-605. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32644129.
22. Rawal G, Yadav S, Kumar R. Post-intensive care syndrome: an overview. *J Transl Int Med*. 2017;5(2):90-92. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28721340.
23. Tenforde MW, Kim SS, Lindsell CJ, et al. Symptom duration and risk factors for delayed return to usual health among outpatients with COVID-19 in a multistate health care systems network—United States, March–June 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(30):993-998. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32730238.
24. Halpin SJ, McIvor C, Whyatt G, et al. Postdischarge symptoms and rehabilitation needs in survivors of COVID-19 infection: a cross-sectional evaluation. *J Med Virol*. 2021;93(2):1013-1022. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32729939.
25. Cai X, Hu X, Ekumi IO, et al. Psychological distress and its correlates among COVID-19 survivors during early convalescence across age groups. *Am J Geriatr Psychiatry*. 2020;28(10):1030-1039. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32753338.
26. Huang C, Huang L, Wang Y, et al. 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *Lancet*. 2021;397(10270):220-232. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33428867.
27. Logue JK, Franko NM, McCulloch DJ, et al. Sequelae in adults at 6 months after COVID-19 infection. *JAMA Netw Open*. 2021. Available at: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2776560.
28. Townsend L, Dyer AH, Jones K, et al. Persistent fatigue following SARS-CoV-2 infection is common and independent of severity of initial infection. *PLoS One*. 2020;15(11):e0240784. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33166287.
29. Huang Y, Tan C, Wu J, et al. Impact of coronavirus disease 2019 on pulmonary function in early convalescence phase. *Respir Res*. 2020;21(1):163. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32600344.
30. Puntmann VO, Carerj ML, Wieters I, et al. Outcomes of cardiovascular magnetic resonance imaging in patients recently recovered from coronavirus disease 2019 (COVID-19). *JAMA Cardiol*. 2020;5(11):1265-1273. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32730619.
31. Huang L, Zhao P, Tang D, et al. Cardiac involvement in patients recovered from COVID-2019 identified using magnetic resonance imaging. *JACC Cardiovasc Imaging*. 2020;13(11):2330-2339. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32763118.
32. Mazza MG, De Lorenzo R, Conte C, et al. Anxiety and depression in COVID-19 survivors: role of inflammatory and clinical predictors. *Brain Behav Immun*. 2020;89:594-600. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32738287.
33. Lu Y, Li X, Geng D, et al. Cerebral micro-structural changes in COVID-19 patients—an MRI-based 3-month follow-up study. *EClinicalMedicine*. 2020;25:100484. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32838240.
34. Heneka MT, Golenbock D, Latz E, Morgan D, Brown R. Immediate and long-term consequences of COVID-19 infections for the development of neurological disease. *Alzheimers Res Ther*. 2020;12(1):69. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32498691.
35. Lechien JR, Chiesa-Estomba CM, Beckers E, et al. Prevalence and 6-month recovery of olfactory dysfunction: a multicentre study of 1363 COVID-19 patients. *J Intern Med*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33403772.
36. Hampshire A, Trender W, Chamberlain SR, et al. Cognitive deficits in people who have recovered from

COVID-19 relative to controls: an N = 84,285 online study. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.20.20215863v1.

37. Afshar Y, Gaw SL, Flaherman VJ, et al. Clinical presentation of coronavirus disease 2019 (COVID-19) in pregnant and recently pregnant people. *Obstet Gynecol*. 2020;136(6):1117-1125. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33027186.
38. Ludvigsson JF. Case report and systematic review suggest that children may experience similar long-term effects to adults after clinical COVID-19. *Acta Paediatr*. 2021;110(3):914-921. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33205450.
39. Buonsenso D, Munblit D, De Rose C, et al. Preliminary evidence on long COVID in children. *MedRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.01.23.21250375v1.

# Clinical Management Summary

*Last Updated: July 8, 2021*

Two main processes are thought to drive the pathogenesis of COVID-19. Early in the clinical course, the disease is primarily driven by the replication of SARS-CoV-2. Later in the clinical course, the disease appears to be driven by a dysregulated immune/inflammatory response to SARS-CoV-2 that leads to tissue damage. Based on this understanding, it is anticipated that therapies that directly target SARS-CoV-2 would have the greatest effect early in the course of the disease, while immunosuppressive/anti-inflammatory therapies are likely to be more beneficial in the later stages of COVID-19.

The clinical spectrum of SARS-CoV-2 infection includes asymptomatic or presymptomatic infection and mild, moderate, severe, and critical illness. Figure 1 provides guidance for clinicians on the therapeutic management of nonhospitalized adult patients. This includes patients who do not require hospitalization or supplemental oxygen and those who have been discharged from an emergency department or a hospital. Figure 2 provides guidance on the therapeutic management of hospitalized adult patients according to their disease severity and oxygen requirements.

## Figure 1. Therapeutic Management of NonHospitalized Adults with COVID-19

All outpatients with COVID-19 who enter the health care system should have in-person or telehealth follow-up visits. Symptomatic treatments, including hydration, antipyretics, analgesics, and antitussives, can be initiated as needed.

Patients should be counseled about symptoms that warrant re-evaluation by a health care provider (e.g., new onset dyspnea, worsening dyspnea [particularly dyspnea that occurs while the patient is resting or that interferes with daily activities], mental status changes). Home resources should be assessed before patients are discharged from a clinic, urgent care center, ED, or hospital; outpatients should have access to housing, proper nutrition, a caregiver, and a device that is suitable for telehealth. If patients are discharged while they are still receiving oxygen supplementation, they should receive oximetry monitoring and close follow-up soon after discharge.

| PATIENT DISPOSITION | PANEL'S RECOMMENDATIONS |
|---|---|
| **Not Requiring Hospitalization or Supplemental Oxygen, As Determined by a Health Care Provider in ED or an In-Person or Telehealth Visit** | Anti-SARS-CoV-2 monoclonal antibody products are recommended for outpatients with mild to moderate COVID-19 who are at high risk of disease progression, as defined by the EUA criteria (treatments are listed in alphabetical order):[a]<br>• **Casirivimab plus imdevimab**; *or*<br>• **Sotrovimab**<br>At this time, the Panel **recommends against** the use of **bamlanivimab plus etesevimab** in these patients due to an increase in the proportion of potentially resistant variants **(AIII)**.[a] See text for details.<br>The Panel **recommends against** the use of **dexamethasone** or **other systemic glucocorticoids** in the absence of another indication **(AIII)**.[b] |
| **Discharged From Hospital Inpatient Setting in Stable Condition and Does Not Require Supplemental Oxygen** | The Panel **recommends against** continuing the use of **remdesivir (AIIa)**, **dexamethasone (AIIa)**, or **baricitinib (AIIa)** after hospital discharge. |
| **Discharged From Hospital Inpatient Setting and Requires Supplemental Oxygen**<br>*For those who are stable enough for discharge but who still require oxygen*[c] | There is insufficient evidence to recommend either for or against the continued use of remdesivir, dexamethasone, and/or baricitinib. Review the text below when considering the use of any of these agents after hospital discharge. |
| **Discharged From ED Despite New or Increasing Need for Supplemental Oxygen**<br>*When hospital resources are limited, inpatient admission is not possible, and close follow-up is ensured*[d] | The Panel recommends using **dexamethasone** 6 mg PO once daily for the duration of supplemental oxygen (dexamethasone use should not exceed 10 days) with careful monitoring for adverse events **(BIII)**.<br>There is insufficient evidence to recommend either for or against the use of remdesivir. When considering the use of remdesivir, review the text below for further discussion.<br>The Panel **recommends against** the use of **baricitinib** in this setting, except in a clinical trial **(AIII)**. |

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional
**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

[a] In laboratory studies, some SARS-CoV-2 variants of concern or interest harbor certain mutations that are associated with reduced susceptibility to certain agents. Some regimens may be preferred in certain settings based on the degree of reduced susceptibility and the prevalence of these variants in a given region. See Anti-SARS-CoV-2 Monoclonal Antibodies and the Panel's statement on the EUAs for anti-SARS-CoV-2 monoclonal antibodies for more information. Updates on the distribution of bamlanivimab plus etesevimab are available on the HHS Bamlanivimab/Etesevimab website.

[b] There is currently a lack of safety and efficacy data on the use of these agents in outpatients with COVID-19; using systemic glucocorticoids in this setting may cause harm.

[c] These individuals should receive oximetry monitoring and close follow-up through telehealth, visiting nurse services, or in-person clinic visits.

[d] In cases where resources (e.g., inpatient beds, staff members) are scarce, it may be necessary to discharge an adult patient and provide an advanced level of home care, including supplemental oxygen (whether patients are receiving oxygen at home for the first time or are increasing their baseline oxygen requirements), pulse oximetry, and close follow-up through visiting nurse services, telehealth, or in-person clinic visits.

**Key:** ED = emergency department; EUA = Emergency Use Authorization; HHS = Department of Health and Human Services; the Panel = the COVID-19 Treatment Guidelines Panel; PO = orally

## Figure 2. Therapeutic Management of Hospitalized Adults With COVID-19 Based on Disease Severity

| DISEASE SEVERITY | PANEL'S RECOMMENDATIONS |
|---|---|
| **Hospitalized but Does Not Require Supplemental Oxygen** | The Panel **recommends against** the use of **dexamethasone (AIIa)** or other **corticosteroids (AIII)**.[a]<br>There is insufficient evidence to recommend either for or against the routine use of remdesivir. For patients who are at high risk of disease progression, the use of remdesivir may be appropriate. |
| **Hospitalized and Requires Supplemental Oxygen** | Use one of the following options:<br>• **Remdesivir**[b,c] (e.g., for patients who require minimal supplemental oxygen) **(BIIa)**<br>• **Dexamethasone**[d] **plus remdesivir**[b,c] (e.g., for patients who require increasing amounts of supplemental oxygen) **(BIII)**<br>• **Dexamethasone**[d] (when combination therapy with remdesivir cannot be used or is not available) **(BI)** |
| **Hospitalized and Requires Oxygen Delivery Through a High-Flow Device or Noninvasive Ventilation** | Use one of the following options:<br>• **Dexamethasone**[d] **(AI)**<br>• **Dexamethasone**[d] **plus remdesivir**[b,c] **(BIII)**<br>For patients who were recently hospitalized[e] with rapidly increasing oxygen needs and systemic inflammation:<br>• Add either **baricitinib**[f,g] **(BIIa)** or **tocilizumab**[f,h] **(BIIa)** to one of the two options above |
| **Hospitalized and Requires IMV or ECMO** | For most patients:<br>• **Dexamethasone**[d,i] **(AI)**<br>For patients who are within 24 hours of admission to the ICU:<br>• **Dexamethasone**[d,i] **plus tocilizumab**[f,h] **(BIIa)** |

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional
**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

[a] Patients who are receiving dexamethasone or another corticosteroid for other indications should continue therapy for their underlying conditions as directed by their health care provider.
[b] The dose for remdesivir is 200 mg IV for one dose, followed by remdesivir 100 mg IV once daily for 4 days or until hospital discharge (unless the patient is in a health care setting that can provide acute care that is similar to inpatient hospital care). Treatment duration may be extended to up to 10 days if there is no substantial clinical improvement by Day 5.
[c] For patients who are receiving remdesivir but progress to requiring oxygen through a high-flow device, noninvasive ventilation, IMV, or ECMO, remdesivir should be continued until the treatment course is completed.
[d] The dose for dexamethasone is 6 mg IV or PO once daily for 10 days or until hospital discharge. If dexamethasone is not available, equivalent doses of other corticosteroids (e.g., prednisone, methylprednisolone, hydrocortisone) may be used. See the Corticosteroids section for more information.
[e] For example, within 3 days of hospital admission. See the Interleukin-6 Inhibitors section for more information.
[f] As there are no studies that directly compare using baricitinib and tocilizumab as treatments for COVID-19, the Panel has insufficient evidence to recommend one drug over the other. Treatment decisions should be based on local guidance, drug availability, and patient comorbidities.
[g] The dose for baricitinib is 4 mg PO once daily for 14 days or until hospital discharge (refer to Table 4c for dose modifications for patients with renal impairment). Baricitinib should be used in combination with steroids (with or without remdesivir). The combination of baricitinib plus tocilizumab has not been studied, and the Panel **recommends against** the use of this combination, except in a clinical trial **(AIII)**.
[h] The dose for tocilizumab is 8 mg/kg of actual body weight (up to 800 mg) administered as a single IV dose. The combination of tocilizumab plus baricitinib has not been studied, and the use of this combination should be avoided outside of a clinical trial. See the Interleukin-6 Inhibitors section for more information.
[i] The combination of **dexamethasone plus remdesivir** may be considered for patients who have recently been intubated **(CIII)**. The Panel **recommends against** the use of remdesivir monotherapy in these patients.

**Key:** ECMO = extracorporeal membrane oxygenation; ICU = intensive care unit; IMV = invasive mechanical ventilation; IV = intravenous; the Panel = the COVID-19 Treatment Guidelines Panel; PO = orally

# General Management of Nonhospitalized Patients With Acute COVID-19

*Last Updated: July 8, 2021*

| Summary Recommendations |
| --- |
| • Management of nonhospitalized patients with acute COVID-19 should include providing supportive care, taking steps to reduce the risk of SARS-CoV-2 transmission (including isolating the patient), and advising patients on when to contact a health care provider and seek an in-person evaluation **(AIII)**.<br>• When possible, patients with symptoms of COVID-19 should be triaged via telehealth visits before receiving in-person care. Patients with dyspnea should be referred for an in-person evaluation by a health care provider and should be followed closely during the initial days after the onset of dyspnea to assess for worsening respiratory status **(AIII)**.<br>• Management plans should be based on a patient's vital signs, physical exam findings, risk factors for progression to severe illness, and the availability of health care resources **(AIII)**.<br>• See Therapeutic Management of Nonhospitalized Adults With COVID-19 for specific recommendations on using pharmacologic therapy in nonhospitalized patients. |
| **Rating of Recommendations**: A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Introduction

This section of the Guidelines is intended to provide information to health care providers who are caring for nonhospitalized patients with COVID-19. The COVID-19 Treatment Guidelines Panel's (the Panel) recommendations for pharmacologic management can be found in Therapeutic Management of Nonhospitalized Adults With COVID-19. The Panel recognizes that the distinction between outpatient and inpatient care may be less clear during the COVID-19 pandemic. Patients with COVID-19 may receive care outside traditional ambulatory care or hospital settings if there is a shortage of hospital beds, staff, or resources. Settings such as field hospitals and ambulatory surgical centers and programs such as Acute Hospital Care at Home have been implemented to alleviate hospital bed and staffing shortages.[1] Patients may enter an Acute Hospital Care at Home program from either an emergency department (ED) or an inpatient hospital setting. Health care providers should use their judgment when deciding whether the guidance offered in this section applies to individual patients.

This section focuses on the evaluation and management of:

- Adults with COVID-19 in an ambulatory care setting;
- Adults with COVID-19 following discharge from the ED; *and*
- Adults with COVID-19 following inpatient discharge.

Outpatient evaluation and management in each of these settings may include some or all of the following: telemedicine, remote monitoring, in-person visits, and home visits by nurses or other health care providers.

## Managing Patients With COVID-19 in an Ambulatory Care Setting

Approximately 80% of patients with COVID-19 have mild illness that does not warrant medical intervention or hospitalization.[2] Most patients with mild COVID-19 (defined as the absence of viral pneumonia and hypoxemia) can be managed in an ambulatory care setting or at home. Patients with

moderate COVID-19 (those with viral pneumonia but without hypoxemia) or severe COVID-19 (those with dyspnea, hypoxemia, or lung infiltrates >50%) need in-person evaluation and close monitoring, as pulmonary disease can progress rapidly and require hospitalization.[3]

Health care providers should identify patients who may be at high risk for progression to severe COVID-19; these patients may be candidates for anti-SARS-CoV-2 monoclonal antibody treatment (see Figure 1 in Therapeutic Management of Nonhospitalized Adults with COVID-19). Management of COVID-19 patients in the outpatient setting should focus on providing supportive care, taking steps to reduce the risk of SARS-CoV-2 transmission (e.g., wearing a mask, isolating the patient),[4,5] and advising patients on when to seek in-person evaluation.[6] Supportive care includes managing symptoms (as described below), ensuring that patients are receiving the proper nutrition, and paying attention to the risks of social isolation, particularly in older adults.[7] Other unique aspects of care for geriatric patients with COVID-19 include considerations related to cognitive impairment, frailty, fall risk, and polypharmacy. Older patients and those with chronic medical conditions have a higher risk for hospitalization and death; however, SARS-CoV-2 infection may cause severe disease and death in patients of any age, even in the absence of any risk factors. The decision to monitor a patient in the outpatient setting should be made on a case-by-case basis.

## Assessing the Need for In-Person Evaluation

When possible, patients with suspected or laboratory-confirmed COVID-19 should be triaged via telehealth visits before they receive an in-person evaluation. Outpatient management may include the use of patient self-assessment tools. During initial triage, clinic staff should determine which patients are eligible to receive supportive care at home and which patients warrant an in-person evaluation.[8] Local emergency medical services, if called by the patient, may also be of help in deciding whether an in-person evaluation is indicated. Patient management plans should be based on the patient's vital signs, physical exam findings, risk factors for progression to severe illness, and the availability of health care resources **(AIII)**.

All patients with dyspnea, oxygen saturation ($SpO_2$) ≤94% on room air at sea level (if this information is available), or symptoms that suggest higher acuity (e.g., chest pain or tightness, dizziness, confusion or other mental status changes) should be referred for an in-person evaluation by a health care provider. The criteria used to determine the appropriate clinical setting for an in-person evaluation may vary by location and institution; it may also change over time as new data and treatment options emerge. There should be a low threshold for in-person evaluation of older persons and those with medical conditions associated with risk of progression to severe COVID-19. The individual who performs the initial triage should use their clinical judgement to determine whether a patient requires ambulance transport. There are unique considerations for residents of nursing homes and other long-term care facilities who develop acute COVID-19. Decisions about transferring these patients for an in-person evaluation should be a collaborative effort between the resident (or their health care decision maker), a hospital-based specialist (e.g., an emergency physician or geriatrician), and the clinical manager of the facility.[9]

In some settings where clinical evaluation is challenged by geography, health care provider home visits may be used to evaluate patients.[10] Patients who are homeless should be provided with housing where they can adequately self-isolate. Providers should be aware of the potential adverse effects of prolonged social isolation, including depression and anxiety.[7] All outpatients should receive instructions regarding self-care, isolation, and follow-up, and should be advised to contact a health care provider or a local ED for any worsening symptoms.[11,12] Guidance for implementing home care and isolation of outpatients with COVID-19 is provided by the U.S. Centers for Disease Control and Prevention.

## Clinical Considerations When Managing Patients in an Ambulatory Care Setting

Persons who have symptoms that are compatible with COVID-19 should undergo diagnostic SARS-CoV-2 testing (see Prevention and Prophylaxis of SARS-CoV-2 Infection). Patients with SARS-CoV-2 infection may be asymptomatic or experience symptoms that are indistinguishable from other acute viral or bacterial infections (e.g., fever, cough, sore throat, malaise, muscle pain, headache, gastrointestinal symptoms). It is important to consider other possible etiologies of symptoms, including other respiratory viral infections (e.g., influenza), community-acquired pneumonia, congestive heart failure, asthma or chronic obstructive pulmonary disease exacerbations, and streptococcal pharyngitis.

In most adult patients, if dyspnea develops, it tends to occur between 4 and 8 days after symptom onset, although it can also occur after 10 days.[13] While mild dyspnea is common, worsening dyspnea and severe chest pain/tightness suggest the development or progression of pulmonary involvement. In studies of patients who developed acute respiratory distress syndrome, progression occurred a median of 2.5 days after the onset of dyspnea.[14-16] Adult outpatients with dyspnea should be followed closely with telehealth or in-person monitoring, particularly during the first few days following the onset of dyspnea, to monitor for worsening respiratory status **(AIII)**.

If an adult patient has access to a pulse oximeter at home, $SpO_2$ measurements can be used to help assess overall clinical status. Patients should be advised to use pulse oximeters on warm fingers rather than cold fingers for better accuracy. Patients should inform their health care provider if the value is repeatedly below 95% on room air at sea level. Pulse oximetry may not accurately detect occult hypoxemia, especially in Black patients.[3,17,18] Additionally, $SpO_2$ readings obtained through a mobile phone application may not be accurate enough for clinical use.[19-21] Importantly, oximetry should only be interpreted within the context of a patient's entire clinical presentation (i.e., results should be disregarded if a patient is complaining of increasing dyspnea).

## Counseling Regarding the Need for Follow-Up

Health care providers should identify patients who are at high risk for disease progression. These patients may be candidates for anti-SARS-CoV-2 monoclonal antibody treatments, and clinicians should ensure that these patients receive adequate medical follow-up. The frequency and duration of follow-up will depend on the risk for severe disease, the severity of symptoms, and the patient's ability to self-report worsening symptoms. Health care providers should determine whether a patient has access to a phone, computer, or tablet for telehealth; whether they have adequate transportation for clinic visits; and whether they have regular access to food. The clinician should also confirm that the patient has a caregiver who can assist with daily activities if needed.

All patients and/or their family members or caregivers should be counseled about the warning symptoms that should prompt re-evaluation through a telehealth visit or an in-person evaluation in an ambulatory care setting or ED. These symptoms include new onset of dyspnea; worsening dyspnea (particularly if dyspnea occurs while resting or if it interferes with daily activities); dizziness; and mental status changes, such as confusion. Patients should be educated about the time course of these symptoms and the possible respiratory decline that may occur, on average, 1 week after the onset of illness.

## Managing Adults With COVID-19 Following Discharge from the Emergency Department

There are no fixed criteria for admitting patients with COVID-19 to the hospital; criteria may vary by region and hospital facilities. Patients with severe disease are typically admitted to the hospital, but some patients with severe disease may not be admitted due to a high prevalence of infection and limited hospital resources. In addition, patients who could receive appropriate care at home but are

unable to be adequately managed in their usual residential setting are candidates for temporary shelter in supervised facilities, such as a COVID-19 alternative care facility.[22] For example, patients who are living in multigenerational households or who are homeless may not be able to self-isolate and should be provided resources such as dedicated housing units or hotel rooms, when available. Unfortunately, dedicated residential care facilities for COVID-19 patients are not widely available, and community-based solutions for self-care and isolation should be explored.

Treatment with an anti-SARS-CoV-2 monoclonal antibody is recommended for patients with mild to moderate COVID-19 who are not on supplemental oxygen and who have been discharged from the ED but who are at high risk for clinical progression (see Therapeutic Management of Nonhospitalized Adults With COVID-19).

In the cases where institutional resources (e.g., inpatient beds, staff members) are scarce, it may be necessary to discharge an adult patient and provide an advanced level of home care, including supplemental oxygen (if indicated), pulse oximetry, and close follow-up. Although early discharge of those with severe disease is not generally recommended by the Panel, it is recognized that these management strategies are sometimes necessary. In these situations, some institutions are providing frequent telemedicine follow-up visits for these patients or providing a hotline for patients to speak with a clinician when necessary. Home resources should be assessed before a patient is discharged from the ED; outpatients should have a caregiver and access to a device that is suitable for telehealth. Patients and/or their family members or caregivers should be counseled about the warning symptoms that should prompt re-evaluation by a health care provider. Special consideration may be given to using certain therapeutics (e.g., dexamethasone) in this setting. For more information, see Therapeutic Management of Nonhospitalized Adults With COVID-19.

**Anticoagulants** and **antiplatelet therapy** should not be initiated in the ED for the prevention of venous thromboembolism (VTE) or arterial thrombosis if the patient is not being admitted to the hospital, unless the patient has other indications for the therapy or is participating in a clinical trial **(AIII)**. For more information, see Antithrombotic Therapy in Patients With COVID-19. Patients should be encouraged to ambulate, and activity should be increased according to the patient's tolerance.

## Managing Adults With COVID-19 Following Hospital Discharge

Most patients who are discharged from the hospital setting should have a follow-up visit with a health care provider soon after discharge. Whether an in-person or a telehealth visit is most appropriate depends on the clinical and social situation. In some cases, adult patients are deemed to be stable for discharge from the inpatient setting even though they still require supplemental oxygen. Special consideration may be given to using certain therapeutics (e.g., dexamethasone) in this setting. For more information, see Therapeutic Management of Nonhospitalized Adults With COVID-19. When possible, these individuals should receive oximetry monitoring and close follow-up through telehealth visits, visiting nurse services, or in-person clinic visits.

Hospitalized patients with COVID-19 should not be routinely discharged while receiving VTE prophylaxis, unless they have another indication or are participating in a clinical trial **(AIII)**. For more information, see Antithrombotic Therapy in Patients With COVID-19. Patients should be encouraged to ambulate, and activity should be increased according to the patient's tolerance.

## Considerations in Pregnancy

Managing pregnant outpatients with COVID-19 is similar to managing nonpregnant patients (see Special Considerations in Pregnancy). Clinicians should offer supportive care, take steps to reduce the risk of SARS-CoV-2 transmission, and provide guidance on when to seek an in-person evaluation. The

American College of Obstetricians and Gynecologists (ACOG) has developed an algorithm to aid the practitioner in evaluating and managing pregnant outpatients with laboratory-confirmed or suspected COVID-19.[23] ACOG has also published recommendations on how to use telehealth for prenatal care and how to modify routine prenatal care when necessary to decrease the risk of SARS-CoV-2 transmission to patients, caregivers, and staff.

In pregnant patients, $SpO_2$ should be maintained at 95% or above on room air at sea level; therefore, the threshold for monitoring pregnant patients in an inpatient setting may be lower than in nonpregnant patients.[24] In general, there are no changes to fetal monitoring recommendations in the outpatient setting, and fetal management should be similar to the fetal management used for other pregnant patients with medical illness.[25] However, these monitoring strategies can be discussed on a case-by-case basis with an obstetrician. Pregnant and lactating patients should be given the opportunity to participate in clinical trials of outpatients with COVID-19 to help inform decision-making in this population.

## Considerations in Children

Children and adolescents with acute COVID-19 are less likely than adults to require medical intervention or hospitalization, and most can be managed in an ambulatory care setting or at home. In general, the need for ED evaluation or hospitalization should be based on the patient's vital signs, physical exam findings (e.g., dyspnea), and risk factors for progression to severe illness. Certain groups, including young infants, children with risk factors, and those with presentations that overlap with multisystem inflammatory syndrome in children (MIS-C), may require hospitalization for more intensive monitoring. However, this should be determined on a case-by-case basis.

Most children with mild or moderate COVID-19, even those with risk factors, will not progress to more severe illness and will recover without specific therapy (see Special Considerations in Children). There is insufficient evidence for the Panel to recommend either for or against the use of anti-SARS-CoV-2 monoclonal antibody products in nonhospitalized children with COVID-19 who have risk factors for severe disease. The available efficacy data for adults suggests that anti-SARS-CoV-2 monoclonal antibody products may be considered for use in children who meet the Food and Drug Administration Emergency Use Authorization (EUA) criteria, especially those who have more than one risk factor. The decision to use these products in children should be made on a case-by-case basis in consultation with a pediatric infectious disease specialist. The risk factors that predict progression to severe disease in adults can be used to determine the risk of progression in children aged ≥16 years (see the Panel's statement on the EUAs for anti-SARS-CoV-2 monoclonal antibodies).

In general, pediatric patients should not continue receiving remdesivir, dexamethasone, or other COVID-19-directed therapies following discharge from an ED or an inpatient setting. Clinicians should refer to Special Considerations in Children for more information on the management of children with COVID-19.

## References


1. Centers for Medicare & Medicaid Services. CMS announces comprehensive strategy to enhance hospital capacity amid COVID-19 surge. 2020. Available at: https://www.cms.gov/newsroom/press-releases/cms-announces-comprehensive-strategy-enhance-hospital-capacity-amid-covid-19-surge. Accessed March 3, 2021.
2. Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus disease 2019 case surveillance—United States, January 22–May 30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69. Available at: https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6924e2-H.pdf.
3. Centers for Disease Control and Prevention. Interim clinical guidance for management of patients with confirmed coronavirus disease (COVID-19). 2021. Available at:

https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html. Accessed March 3, 2021.

4. Centers for Disease Control and Prevention. COVID-19: how to protect yourself & others. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html. Accessed March 15, 2021.
5. Centers for Disease Control and Prevention. COVID-19: if you are sick or caring for someone. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/. Accessed March 15, 2021.
6. Cheng A, Caruso D, McDougall C. Outpatient management of COVID-19: rapid evidence review. *Am Fam Physician*. 2020;102(8):478-486. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33064422.
7. Morrow-Howell N, Galucia N, Swinford E. Recovering from the COVID-19 pandemic: a focus on older adults. *J Aging Soc Policy*. 2020;32(4-5):526-535. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32336225.
8. Centers for Disease Control and Prevention. Coronavirus self-checker. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/coronavirus-self-checker.html. Accessed March 3, 2021.
9. Burkett E, Carpenter CR, Hullick C, Arendts G, Ouslander JG. It's time: delivering optimal emergency care of residents of aged care facilities in the era of COVID-19. *Emerg Med Australas*. 2021;33(1):131-137. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33131219.
10. Close RM, Stone MJ. Contact tracing for native americans in rural Arizona. *N Engl J Med*. 2020;383(3):e15. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32672426.
11. Centers for Disease Control and Prevention. COVID-19: what to do if you are sick. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/steps-when-sick.html. Accessed March 15, 2021.
12. Centers for Disease Control and Prevention. COVID-19: isolate if you are sick. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/isolation.html. Accessed March 15, 2021.
13. Cohen PA, Hall LE, John JN, Rapoport AB. The early natural history of SARS-CoV-2 infection: clinical observations from an urban, ambulatory COVID-19 clinic. *Mayo Clin Proc*. 2020;95(6):1124-1126. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32451119.
14. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020;323(11):1061-1069. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32031570.
15. Arentz M, Yim E, Klaff L, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington state. *JAMA*. 2020;323(16):1612-1614. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32191259.
16. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. 2020;8(5):475-481. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32105632.
17. Luks AM, Swenson ER. Pulse oximetry for monitoring patients with COVID-19 at home. Potential pitfalls and practical guidance. *Ann Am Thorac Soc*. 2020;17(9):1040-1046. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32521167.
18. Sjoding MW, Dickson RP, Iwashyna TJ, Gay SE, Valley TS. Racial bias in pulse oximetry measurement. *N Engl J Med*. 2020;383(25):2477-2478. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33326721.
19. Modi A, Kiroukas R, Scott JB. Accuracy of smartphone pulse oximeters in patients visiting an outpatient pulmonary function lab for a 6-minute walk test. *Respir Care*. 2019;64(Suppl 10). Available at: http://rc.rcjournal.com/content/64/Suppl_10/3238714.
20. Tarassenko L, Greenhalgh T. Question: should smartphone apps be used clinically as oximeters? Answer: no. 2020. Available at: https://www.cebm.net/covid-19/question-should-smartphone-apps-be-used-as-oximeters-answer-no/. Accessed March 3, 2021.
21. Jordan TB, Meyers CL, Schrading WA, Donnelly JP. The utility of iPhone oximetry apps: a comparison with

standard pulse oximetry measurement in the emergency department. *Am J Emerg Med*. 2020;38(5):925-928. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31471076.

22. Meyer GS, Blanchfield BB, Bohmer RMJ, Mountford MB, Vanderwagen WC. Alternative care sites for the COVID-19 pandemic: the early U.S. and U.K. experience. *NEJM Catalyst*. 2020. Available at: https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0224.
23. The American College of Obstetricians and Gynecologists. Outpatient Assessment and Management for Pregnant Women with Suspected or Confirmed Novel Coronavirus (COVID-19). 2020. Available at: https://www.acog.org/-/media/project/acog/acogorg/files/pdfs/clinical-guidance/practice-advisory/covid-19-algorithm.pdf. Accessed April 2, 2020.
24. The American College of Obstetricians and Gynecologists. COVID-19 FAQs for obstetrician-gynecologists, obstetrics. 2020. Available at: https://www.acog.org/clinical-information/physician-faqs/covid-19-faqs-for-ob-gyns-obstetrics. Accessed February 8, 2021.
25. Society for Maternal-Fetal Medicine. Management considerations for pregnant patients with COVID-19. 2020. Available at: https://s3.amazonaws.com/cdn.smfm.org/media/2336/SMFM_COVID_Management_of_COVID_pos_preg_patients_4-30-20_final.pdf.

# Therapeutic Management of Nonhospitalized Adults With COVID-19

*Last Updated: July 8, 2021*

Figure 1 outlines the COVID-19 Treatment Guidelines Panel's (the Panel) recommendations for using therapeutic interventions outside the hospital inpatient setting. These recommendations differ depending on the patient's disposition.

**Figure 1. Therapeutic Management of NonHospitalized Adults with COVID-19**

All outpatients with COVID-19 who enter the health care system should have in-person or telehealth follow-up visits. Symptomatic treatments, including hydration, antipyretics, analgesics, and antitussives, can be initiated as needed.

Patients should be counseled about symptoms that warrant re-evaluation by a health care provider (e.g., new onset dyspnea, worsening dyspnea [particularly dyspnea that occurs while the patient is resting or that interferes with daily activities], mental status changes). Home resources should be assessed before patients are discharged from a clinic, urgent care center, ED, or hospital; outpatients should have access to housing, proper nutrition, a caregiver, and a device that is suitable for telehealth. If patients are discharged while they are still receiving oxygen supplementation, they should receive oximetry monitoring and close follow-up soon after discharge.

| PATIENT DISPOSITION | PANEL'S RECOMMENDATIONS |
|---|---|
| **Not Requiring Hospitalization or Supplemental Oxygen, As Determined by a Health Care Provider in ED or an In-Person or Telehealth Visit** | Anti-SARS-CoV-2 monoclonal antibody products are recommended for outpatients with mild to moderate COVID-19 who are at high risk of disease progression, as defined by the EUA criteria (treatments are listed in alphabetical order):[a]<br>• **Casirivimab plus imdevimab**; *or*<br>• **Sotrovimab**<br>At this time, the Panel **recommends against** the use of **bamlanivimab plus etesevimab** in these patients due to an increase in the proportion of potentially resistant variants **(AIII)**.[a] See text for details.<br>The Panel **recommends against** the use of **dexamethasone** or **other systemic glucocorticoids** in the absence of another indication **(AIII)**.[b] |
| **Discharged From Hospital Inpatient Setting in Stable Condition and Does Not Require Supplemental Oxygen** | The Panel **recommends against** continuing the use of **remdesivir (AIIa)**, **dexamethasone (AIIa)**, or **baricitinib (AIIa)** after hospital discharge. |
| **Discharged From Hospital Inpatient Setting and Requires Supplemental Oxygen**<br>*For those who are stable enough for discharge but who still require oxygen*[c] | There is insufficient evidence to recommend either for or against the continued use of remdesivir, dexamethasone, and/or baricitinib. Review the text below when considering the use of any of these agents after hospital discharge. |
| **Discharged From ED Despite New or Increasing Need for Supplemental Oxygen**<br>*When hospital resources are limited, inpatient admission is not possible, and close follow-up is ensured*[d] | The Panel recommends using **dexamethasone** 6 mg PO once daily for the duration of supplemental oxygen (dexamethasone use should not exceed 10 days) with careful monitoring for adverse events **(BIII)**.<br>There is insufficient evidence to recommend either for or against the use of remdesivir. When considering the use of remdesivir, review the text below for further discussion.<br>The Panel **recommends against** the use of **baricitinib** in this setting, except in a clinical trial **(AIII)**. |

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional
**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

[a] In laboratory studies, some SARS-CoV-2 variants of concern or interest harbor certain mutations that are associated with reduced susceptibility to certain agents. Some regimens may be preferred in certain settings based on the degree of reduced susceptibility and the prevalence of these variants in a given region. See Anti-SARS-CoV-2 Monoclonal Antibodies and the Panel's statement on the EUAs for anti-SARS-CoV-2 monoclonal antibodies for more information. Updates on the distribution of bamlanivimab plus etesevimab are available on the HHS Bamlanivimab/Etesevimab website.

[b] There is currently a lack of safety and efficacy data on the use of these agents in outpatients with COVID-19; using systemic glucocorticoids in this setting may cause harm.

[c] These individuals should receive oximetry monitoring and close follow-up through telehealth, visiting nurse services, or in-person clinic visits.

[d] In cases where resources (e.g., inpatient beds, staff members) are scarce, it may be necessary to discharge an adult patient and provide an advanced level of home care, including supplemental oxygen (whether patients are receiving oxygen at home for the first time or are increasing their baseline oxygen requirements), pulse oximetry, and close follow-up through visiting nurse services, telehealth, or in-person clinic visits.

**Key:** ED = emergency department; EUA = Emergency Use Authorization; HHS = Department of Health and Human Services; the Panel = the COVID-19 Treatment Guidelines Panel; PO = orally

## Symptom Management

Symptomatic treatment includes using over-the-counter antipyretics, analgesics, or antitussives for fever, headache, myalgias, and cough. Patients with dyspnea may benefit from resting in the prone position rather than the supine position.[1] Health care providers should consider educating patients about breathing exercises, as severe breathlessness may cause anxiety.[2] Patients should be advised to drink fluids regularly to avoid dehydration. Rest is recommended as needed during the acute phase of COVID-19, and ambulation and other forms of activity should be increased according to the patient's tolerance. Patients should be educated about the variability in time to symptom resolution and complete recovery.

## Rationale for the Use of Specific Agents Listed in Figure 1

### *Anti-SARS-CoV-2 Monoclonal Antibodies*

Two combination anti-SARS-CoV-2 monoclonal antibody products (bamlanivimab plus etesevimab and casirivimab plus imdevimab) and a single monoclonal antibody (sotrovimab) have been shown to reduce the risk of hospitalization and death in the outpatient setting in those with mild to moderate COVID-19 symptoms and certain risk factors for disease progression. As a result, these products have received Emergency Use Authorizations (EUAs) from the Food and Drug Administration (FDA) for the treatment of COVID-19 in these individuals, as well as in those with other risk factors for progression that have been identified in population-based studies. There are no comparative data to determine whether there are differences in clinical efficacy or safety between these products.

The Panel recommends using one of the following anti-SARS-CoV-2 monoclonal antibodies to treat outpatients with mild to moderate COVID-19 who are at high risk of clinical progression, as defined by the EUA criteria and the Panel's statement about the EUAs (treatments are listed in alphabetical order):

- **Casirivimab plus imdevimab**; *or*
- **Sotrovimab**

At this time, the Panel **recommends against** the use of **bamlanivimab plus etesevimab (AIII)** because of the increase in the proportion of the variants of concern Gamma (P.1) and Beta (B.1.351), which have reduced susceptibility to both bamlanivimab and etesevimab. See the Centers for Disease Control and Prevention COVID-19 Data Tracker website for the latest information regarding variant proportions by region in the United States. Casirivimab plus imdevimab and sotrovimab remain active against these variants.

Treatment should be started as soon as possible after the patient receives a positive result on a SARS-CoV-2 antigen test or a nucleic acid amplification test (NAAT) and within 10 days of symptom onset. For more details on the available clinical trial data for these antibodies, see Anti-SARS-CoV-2 Monoclonal Antibodies and the Panel's statement on the EUAs for anti-SARS-CoV-2 monoclonal antibodies.

Receipt of a COVID-19 vaccine should be deferred for at least 90 days in those who have received anti-SARS-CoV-2 monoclonal antibodies. This is a precautionary measure, as the antibody treatment may interfere with vaccine-induced immune responses. In people who are vaccinated and then develop COVID-19, prior receipt of a vaccine should not affect treatment decisions, including the use of and timing of treatment with monoclonal antibodies.[3]

### *Dexamethasone*

The Panel **recommends against** the use of **dexamethasone** or **other systemic glucocorticoids** to treat outpatients with mild to moderate COVID-19 who do not require hospitalization or supplemental oxygen **(AIII)**. There is currently a lack of safety and efficacy data on the use of these agents, and

systemic glucocorticoids may cause harm in these patients. Patients who are receiving **dexamethasone** or **another corticosteroid** for other indications should continue therapy for their underlying conditions as directed by their health care providers **(AIII)**.

In RECOVERY, dexamethasone was shown to reduce mortality in hospitalized patients with COVID-19 who required supplemental oxygen. There was no observed benefit of dexamethasone in hospitalized patients who did not receive oxygen support.[4] Nonhospitalized patients who did not require supplemental oxygen were not included in this trial; thus, the safety and efficacy of corticosteroids in this population have not been established. Therefore, the Panel **recommends against** the use of **dexamethasone** or **other systemic glucocorticoids** in this population, as there are no clinical trial data to support their use **(AIII)**. Moreover, the use of corticosteroids can lead to adverse events (e.g., hyperglycemia, neuropsychiatric symptoms, secondary infections), which may be difficult to detect and monitor in an outpatient setting.

Dexamethasone was stopped at the time of hospital discharge during RECOVERY. For hospitalized patients with COVID-19 who do not require supplemental oxygen after discharge, the Panel **recommends against** the continuation of **dexamethasone (AIIa)**.

In some cases, adult patients are deemed to be stable enough to be discharged from the inpatient setting even though they still require supplemental oxygen. The practice of discharging inpatients who still require oxygen was likely uncommon during RECOVERY; therefore, there is insufficient evidence to recommend either for or against the continued use of dexamethasone after hospital discharge in patients who require supplemental oxygen. The data supporting the use of corticosteroids after discharge in such cases are limited, with the main concerns being the lack of monitoring for toxicities, including, but not limited to, blood glucose control and neuropsychiatric impairment. If a patient continues to receive corticosteroids after discharge, consider continuing corticosteroids for the duration of supplemental oxygen. However, the total duration of corticosteroid use should not exceed 10 days (including days during hospitalization). Only patients who showed good tolerance to this therapy prior to discharge should continue to receive corticosteroids after discharge, and these patients should be carefully monitored for adverse events. These individuals should receive oximetry monitoring and close follow-up through telehealth, visiting nurse services, or in-person clinic visits.

In rare cases, patients with COVID-19 who require supplemental oxygen and hospital admission may need to be discharged from the emergency department (ED) due to scarce resources (e.g., in cases where hospital beds or staff are not available). For these patients, the Panel recommends using **dexamethasone** 6 mg PO once daily for the duration of supplemental oxygen (dexamethasone use should not exceed 10 days) with careful monitoring for adverse events **(BIII)**. These patients should receive oximetry monitoring and close follow-up through telehealth, visiting nurse services, or in-person clinic visits.

### *Remdesivir*

Remdesivir is currently the only drug that is approved by the FDA for the treatment of COVID-19. It is recommended for use in hospitalized patients who require supplemental oxygen. The clinical trials that evaluated the safety and efficacy of remdesivir stopped this treatment at the time of discharge from the hospital.[5-7] The Panel **recommends against** the continuation of **remdesivir (AIIa)** in hospitalized patients with COVID-19 who are stable enough for discharge and who do not require supplemental oxygen.

In some cases, adult patients are deemed to be stable enough to be discharged from the inpatient setting even though they still require supplemental oxygen. There is insufficient evidence to recommend either for or against the continued use of remdesivir after hospital discharge in patients who require supplemental oxygen. Since remdesivir can only be administered by intravenous infusion, there may be

logistical issues with providing remdesivir to outpatients. If remdesivir is provided, it should only be administered in health care settings that can provide a similar level of care to an inpatient hospital. These individuals should receive oximetry monitoring and close follow-up through telehealth, visiting nurse services, or in-person clinic visits.

In rare cases, patients with COVID-19 who require supplemental oxygen and hospital admission may need to be discharged from the ED due to scarce resources (i.e., a hospital bed or staff may not be available). There is insufficient evidence to recommend either for or against the routine use of remdesivir in this setting. If remdesivir is provided, it should only be administered in health care settings that can provide a similar level of care to an inpatient hospital. These individuals should receive oximetry monitoring and close follow-up through telehealth, visiting nurse services, or in-person clinic visits.

### *Baricitinib*

The pivotal safety and efficacy trials for baricitinib enrolled hospitalized patients with COVID-19, and treatment was stopped at the time of hospital discharge.[8,9] The Panel **recommends against** the continuation of **baricitinib (AIIa)** in hospitalized patients with COVID-19 who are stable enough for discharge and who do not require supplemental oxygen.

There is insufficient evidence to recommend either for or against the continued use of baricitinib after hospital discharge in patients who have been discharged from the inpatient setting but who still require supplemental oxygen.

There are currently no data that assess the safety and efficacy of using baricitinib in patients who require supplemental oxygen and hospital admission, but who have been discharged from the ED due to scarce resources. Therefore, the Panel **recommends against** the use of **baricitinib** in these patients, except in a clinical trial **(AIII)**.

## Other Agents That Have Been Studied or Are Under Investigation for Use in the Outpatient Management of COVID-19

- The Panel **recommends against** the use of **chloroquine** or **hydroxychloroquine** with or without **azithromycin (AI)**, **lopinavir/ritonavir**, and **other HIV protease inhibitors (AIII)** for outpatient treatment of COVID-19.
- The Panel **recommends against** the use of **antibacterial therapy** (e.g., **azithromycin**, **doxycycline**) for outpatient treatment of COVID-19 in the absence of another indication **(AIII)**.
- Other agents have undergone or are currently undergoing investigation in the outpatient setting. For more information, please refer to the sections of the Guidelines that address:
  - Antiviral agents, such as **ivermectin** and **nitazoxanide**
  - Convalescent plasma
  - Immunomodulators, such as **colchicine** and **fluvoxamine**
  - Supplements, such as **vitamin C**, **vitamin D**, and **zinc**
- **Anticoagulants and antiplatelet therapy** should not be initiated in the outpatient setting for the prevention of venous thromboembolism or arterial thrombosis unless the patient has other indications for the therapy or is participating in a clinical trial **(AIII)**. For more information, see Antithrombotic Therapy in Patients With COVID-19.
- Health care providers should provide information about ongoing clinical trials of investigational therapies to eligible outpatients with COVID-19 so they can make informed decisions about participating in clinical trials **(AIII)**.

## Concomitant Medication Management

In general, a patient's usual medication and/or supplement regimen should be continued after the diagnosis of COVID-19 (see Considerations for Certain Concomitant Medications in Patients With COVID-19). **Angiotensin-converting enzyme inhibitors**, **statin therapy**, **nonsteroidal anti-inflammatory drugs**, and **oral**, **inhaled**, and **intranasal corticosteroids** that are prescribed for comorbid conditions should be continued as directed **(AIII)**. Patients should be advised to avoid the use of nebulized medications in the presence of others to avoid potential aerosolization of SARS-CoV-2.[10] In patients with HIV, antiretroviral therapy should not be switched or adjusted for the purpose of preventing or treating SARS-CoV-2 infection **(AIII)**. For more information, see Special Considerations in People With HIV.

When a patient is receiving an immunomodulating medication, the prescribing clinician should be consulted about the risks and benefits that are associated with a temporary dose reduction or discontinuation; these risks and benefits will depend on the medication's indication and the severity of the underlying condition.

Patients who use a continuous positive airway pressure (CPAP) device or a bilevel positive airway pressure (BiPAP) device to manage obstructive sleep apnea may continue to use their machine. As with nebulizers, patients should be advised to use the device only when they are isolated from others.

## References


1. Caputo ND, Strayer RJ, Levitan R. Early self-proning in awake, non-intubated patients in the emergency department: a single ED's experience during the COVID-19 pandemic. *Acad Emerg Med*. 2020;27(5):375-378. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32320506.
2. National Institute for Health and Care Excellence (NICE) in collaboration with NHS England and NHS Improvement. Managing COVID-19 symptoms (including at the end of life) in the community: summary of NICE guidelines. *BMJ*. 2020;369:m1461. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32312715.
3. Centers for Disease Control and Prevention. Interim clinical considerations for use of COVID-19 vaccines currently authorized in the United States. 2021. Available at: https://www.cdc.gov/vaccines/covid-19/info-by-product/clinical-considerations.html. Accessed July 7, 2021.
4. Recovery Collaborative Group, Horby P, Lim WS, et al. Dexamethasone in hospitalized Patients with COVID-19. *N Engl J Med*. 2021;384(8):693-704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32678530.
5. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the treatment of COVID-19—final report. *N Engl J Med*. 2020;383(19):1813-1826. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32445440.
6. Goldman JD, Lye DCB, Hui DS, et al. Remdesivir for 5 or 10 days in patients with severe COVID-19. *N Engl J Med*. 2020;383(19):1827-1837. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32459919.
7. Spinner CD, Gottlieb RL, Criner GJ, et al. Effect of remdesivir vs standard care on clinical status at 11 days in patients with moderate COVID-19: a randomized clinical trial. *JAMA*. 2020;324(11):1048-1057. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32821939.
8. Kalil AC, Patterson TF, Mehta AK, et al. Baricitinib plus remdesivir for hospitalized adults with COVID-19. *N Engl J Med*. 2021;384(9):795-807. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33306283.
9. Marconi VC, Ramanan AV, de Bono S, et al. Baricitinib plus standard of care for hospitalized adults with COVID-19. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.30.21255934v1.
10. Cazzola M, Ora J, Bianco A, Rogliani P,Matera MG. Guidance on nebulization during the current COVID-19 pandemic. *Respir Med*. 2021;176:106236. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33248363.

# Therapeutic Management of Hospitalized Adults With COVID-19

*Last Updated: July 8, 2021*

## Figure 2. Therapeutic Management of Hospitalized Adults With COVID-19 Based on Disease Severity

| DISEASE SEVERITY | PANEL'S RECOMMENDATIONS |
|---|---|
| **Hospitalized but Does Not Require Supplemental Oxygen** | The Panel **recommends against** the use of **dexamethasone (AIIa)** or other **corticosteroids (AIII)**.[a]<br>There is insufficient evidence to recommend either for or against the routine use of remdesivir. For patients who are at high risk of disease progression, the use of remdesivir may be appropriate. |
| **Hospitalized and Requires Supplemental Oxygen** | Use one of the following options:<br>• **Remdesivir**[b,c] (e.g., for patients who require minimal supplemental oxygen) **(BIIa)**<br>• **Dexamethasone**[d] **plus remdesivir**[b,c] (e.g., for patients who require increasing amounts of supplemental oxygen) **(BIII)**<br>• **Dexamethasone**[d] (when combination therapy with remdesivir cannot be used or is not available) **(BI)** |
| **Hospitalized and Requires Oxygen Delivery Through a High-Flow Device or Noninvasive Ventilation** | Use one of the following options:<br>• **Dexamethasone**[d] **(AI)**<br>• **Dexamethasone**[d] **plus remdesivir**[b,c] **(BIII)**<br>For patients who were recently hospitalized[e] with rapidly increasing oxygen needs and systemic inflammation:<br>• Add either **baricitinib**[f,g] **(BIIa)** or **tocilizumab**[f,h] **(BIIa)** to one of the two options above |
| **Hospitalized and Requires IMV or ECMO** | For most patients:<br>• **Dexamethasone**[d,i] **(AI)**<br>For patients who are within 24 hours of admission to the ICU:<br>• **Dexamethasone**[d,i] **plus tocilizumab**[f,h] **(BIIa)** |

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional
**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

[a] Patients who are receiving dexamethasone or another corticosteroid for other indications should continue therapy for their underlying conditions as directed by their health care provider.
[b] The dose for remdesivir is 200 mg IV for one dose, followed by remdesivir 100 mg IV once daily for 4 days or until hospital discharge (unless the patient is in a health care setting that can provide acute care that is similar to inpatient hospital care). Treatment duration may be extended to up to 10 days if there is no substantial clinical improvement by Day 5.
[c] For patients who are receiving remdesivir but progress to requiring oxygen through a high-flow device, noninvasive ventilation, IMV, or ECMO, remdesivir should be continued until the treatment course is completed.
[d] The dose for dexamethasone is 6 mg IV or PO once daily for 10 days or until hospital discharge. If dexamethasone is not available, equivalent doses of other corticosteroids (e.g., prednisone, methylprednisolone, hydrocortisone) may be used. See the Corticosteroids section for more information.
[e] For example, within 3 days of hospital admission. See the Interleukin-6 Inhibitors section for more information.
[f] As there are no studies that directly compare using baricitinib and tocilizumab as treatments for COVID-19, the Panel has insufficient evidence to recommend one drug over the other. Treatment decisions should be based on local guidance, drug availability, and patient comorbidities.
[g] The dose for baricitinib is 4 mg PO once daily for 14 days or until hospital discharge (refer to Table 4c for dose modifications for patients with renal impairment). Baricitinib should be used in combination with steroids (with or without remdesivir). The combination of baricitinib plus tocilizumab has not been studied, and the Panel **recommends against** the use of this combination, except in a clinical trial **(AIII)**.
[h] The dose for tocilizumab is 8 mg/kg of actual body weight (up to 800 mg) administered as a single IV dose. The combination of tocilizumab plus baricitinib has not been studied, and the use of this combination should be avoided outside of a clinical trial. See the Interleukin-6 Inhibitors section for more information.
[i] The combination of **dexamethasone plus remdesivir** may be considered for patients who have recently been intubated **(CIII)**. The Panel **recommends against** the use of remdesivir monotherapy in these patients.

**Key:** ECMO = extracorporeal membrane oxygenation; ICU = intensive care unit; IMV = invasive mechanical ventilation; IV = intravenous; the Panel = the COVID-19 Treatment Guidelines Panel; PO = orally

## Patients Who Do Not Require Supplemental Oxygen

### *Recommendations*

- The COVID-19 Treatment Guidelines Panel (the Panel) **recommends against** the use of **dexamethasone (AIIa)** or **other corticosteroids (AIII)** for the treatment of COVID-19. Patients who are receiving dexamethasone or another corticosteroid for other indications should continue therapy for their underlying conditions as directed by their health care provider.
- There is insufficient evidence to recommend either for or against the routine use of remdesivir in these patients. The use of remdesivir may be appropriate in patients who have a high risk of disease progression.

### *Rationale for Recommending Against the Use of Dexamethasone or Other Corticosteroids*

In RECOVERY, a multicenter, open-label trial in the United Kingdom, hospitalized patients with COVID-19 were randomized to receive either dexamethasone plus standard of care or standard of care alone (control arm).[1] In the subgroup of participants who did not require supplemental oxygen at enrollment, no survival benefit was observed for dexamethasone: 17.8% of participants in the dexamethasone arm and 14% in the control arm died within 28 days of enrollment (rate ratio 1.19; 95% CI, 0.91–1.55). Please see Table 4a for additional information. Based on these data, the Panel **recommends against** the use of **dexamethasone (AIIa)** or **other corticosteroids (AIII)** for the treatment of COVID-19 in this subgroup, unless the patient has another indication for corticosteroid therapy.

### *Rationale for the Panel's Assessment That There Is Insufficient Evidence to Recommend Either for or Against the Use of Remdesivir*

ACTT-1 was a multinational randomized controlled trial that compared remdesivir to placebo in hospitalized patients with COVID-19. Remdesivir showed no significant benefit in patients with mild to moderate disease, which was defined as oxygen saturation >94% on room air or a respiratory rate <24 breaths/min without supplemental oxygen (rate ratio for recovery 1.29; 95% CI, 0.91–1.83); however, there were only 138 patients in this group.[2]

In a manufacturer-sponsored, open-label randomized trial of 596 patients with moderate COVID-19, patients who received 5 days of remdesivir had higher odds of having a better clinical status on Day 11 (based on distribution on a seven-point ordinal scale) than those who received standard of care (OR 1.65; 95% CI, 1.09–2.48; $P = 0.02$). However, the difference between the arms was of uncertain clinical importance.[3]

The Solidarity trial was a large, multinational, open-label randomized controlled trial in which a 10-day course of remdesivir was compared to standard of care (control arm). About 25% of hospitalized patients in the remdesivir and control arms did not require supplemental oxygen at study entry. The primary outcome of in-hospital mortality occurred in 11 of 661 patients (2%) in the remdesivir arm and in 13 of 664 patients (2.1%) in the control arm (rate ratio 0.90; 99% CI, 0.31–2.58).[4] The open-label design of this study makes it difficult to determine whether remdesivir affects recovery time as determined by duration of hospitalization, because patient discharge may have been delayed in order to complete remdesivir therapy. Please see Table 2a for additional information.

Because these trials produced conflicting results regarding the benefits of remdesivir, the Panel finds the available evidence insufficient to recommend either for or against routine treatment with remdesivir for all hospitalized patients with moderate COVID-19. However, the Panel recognizes that there may be situations in which a clinician judges that remdesivir is an appropriate treatment for a hospitalized patient with moderate disease (e.g., in cases where a person is at a particularly high risk for clinical deterioration).

## Patients Who Require Supplemental Oxygen but Who Do Not Require Oxygen Delivery Through a High-Flow Device, Noninvasive Ventilation, Invasive Mechanical Ventilation, or Extracorporeal Membrane Oxygenation

### *Recommendations*

The Panel recommends one of the following options for these patients:

- **Remdesivir** (e.g., for patients who require minimal supplemental oxygen) **(BIIa)**;
- **Dexamethasone plus remdesivir** (e.g., for patients who require increasing amounts of oxygen) **(BIII)**; *or*
- **Dexamethasone** (when combination therapy with remdesivir cannot be used or is not available) **(BI)**.

### *Additional Considerations*

- If dexamethasone is not available, an alternative corticosteroid such as **prednisone**, **methylprednisolone**, or **hydrocortisone** can be used **(BIII)**. See Corticosteroids for dosing recommendations.
- There is insufficient evidence to determine which patients in this group would benefit from adding baricitinib or tocilizumab to dexamethasone treatment. Some Panel members would add baricitinib or tocilizumab to a patient's dexamethasone treatment in cases where the patient has rapidly increasing oxygen needs and increased markers of inflammation but does not yet require high-flow oxygen or noninvasive ventilation.
- As there are no studies that directly compare using baricitinib and tocilizumab as treatments for COVID-19, the Panel has insufficient evidence to recommend one drug over the other. Treatment decisions should be made based on local guidance, drug availability, and patient comorbidities.

### *Rationale for the Use of Remdesivir*

In ACTT-1, remdesivir was associated with improved time to recovery in the subgroup of participants (n = 435) who required oxygen supplementation but not high-flow oxygen, noninvasive ventilation, or mechanical ventilation (7 days for remdesivir vs. 9 days for placebo; recovery rate ratio 1.45; 95% CI, 1.18–1.79). A lower percentage of patients in the remdesivir arm than in the placebo arm progressed to requiring high-flow oxygen, invasive mechanical ventilation, or extracorporeal membrane oxygenation (ECMO) among those who were not using these methods of oxygen delivery at baseline (17% vs. 24%). In a post hoc analysis of deaths by Day 29, remdesivir appeared to confer a substantial survival benefit in this subgroup (HR for death 0.30; 95% CI, 0.14–0.64).[2]

The Solidarity trial reported no difference in the rate of in-hospital deaths between patients who received remdesivir and those who received standard of care (rate ratio for death in the overall study population 0.95; 95% CI, 0.81–1.11; rate ratio for death in patients who did not require mechanical ventilation at entry 0.86; 99% CI, 0.67–1.11). There was no difference between patients who received remdesivir and those who received standard of care in the percentage of patients who progressed to invasive mechanical ventilation (11.9% vs. 11.5%) or in length of hospital stay.[4] However, an open-label trial like Solidarity is less well-suited to assess time to recovery than a placebo-controlled trial. In Solidarity, because both clinicians and patients knew that remdesivir was being administered, it is possible that hospital discharge was delayed in order to complete the 10-day course of therapy.

Based on the results of ACTT-1, the Panel recommends **remdesivir** (without dexamethasone) as a treatment option for certain patients who require supplemental oxygen (e.g., those who require minimal

supplemental oxygen) **(BIIa)**. In these individuals, the hyperinflammatory state where corticosteroids might be most beneficial may not yet be present or fully developed. For more information, please see Table 2a.

### *Rationale for the Use of Remdesivir Plus Dexamethasone*

The safety and efficacy of using remdesivir plus dexamethasone for the treatment of COVID-19 have not been rigorously evaluated in clinical trials. Despite the lack of clinical trial data, there is a theoretical rationale for combining remdesivir and dexamethasone (see the discussion of clinical trial data for remdesivir above and the discussion for dexamethasone below). Patients with severe COVID-19 may develop a systemic inflammatory response that leads to multiple organ dysfunction syndrome. The potent anti-inflammatory effects of corticosteroids might prevent or mitigate these hyperinflammatory effects. Thus, the combination of an antiviral agent, such as remdesivir, with an anti-inflammatory agent, such as dexamethasone, may treat the viral infection and dampen the potentially injurious inflammatory response that is a consequence of the infection. However, the data on clinical outcomes for patients who received this combination are currently limited.[5]

Based on the theoretical benefits of combining antiviral and anti-inflammatory effects, the Panel recommends the combination of **dexamethasone plus remdesivir** as a treatment option for patients in this group (e.g., those who require increasing amounts of supplemental oxygen) **(BIII)**.

### *Rationale for the Use of Dexamethasone*

In RECOVERY, treatment with dexamethasone conferred a survival benefit among participants who required supplemental oxygen at enrollment. In the dexamethasone group, 23.3% of participants died within 28 days of enrollment compared with 26.2% in the standard of care arm (rate ratio 0.82; 95% CI, 0.72–0.94).[1] However, the amount of supplemental oxygen that participants were receiving and the proportions of participants who required oxygen delivery through a high-flow device or noninvasive ventilation were not reported. It is possible that the benefit of dexamethasone was greatest in those who required more respiratory support. It should be noted that <0.1% of patients in RECOVERY received concomitant remdesivir. For more information, please see the Corticosteroids section.

Some experts prefer not to use dexamethasone monotherapy in this group because of the theoretical concern that corticosteroids might slow viral clearance when they are administered without an antiviral drug. Corticosteroids have been associated with delayed viral clearance and/or worse clinical outcomes in patients with other viral respiratory infections.[6-8] Some studies have suggested that corticosteroids slow SARS-CoV-2 clearance, but the results to date are inconclusive.[9-13]

### *Rationale for the Panel's Assessment That There Is Insufficient Evidence to Determine Which Patients Would Benefit from Dexamethasone Plus Baricitinib or Tocilizumab*

In COV-BARRIER (a multinational, randomized, placebo-controlled trial), 1,525 hospitalized patients with COVID-19 who had evidence of pneumonia, an elevation in one or more inflammatory markers, and an estimated glomerular filtration rate >30 mL/min/1.73 $m^2$ were randomized 1:1 to receive oral baricitinib 4 mg or placebo.[14] The baricitinib dose was adjusted for patients with renal impairment. There was no significant difference between the study arms in the primary endpoint of the trial, which was the proportion of patients who progressed to requiring high-flow oxygen, noninvasive ventilation, or invasive mechanical ventilation or who died by Day 28. In the subgroup of patients who required supplemental oxygen but who did not receive it through a high-flow device or mechanical ventilation (n = 962), the addition of baricitinib resulted in a lower mortality compared to those who received placebo (HR 0.72; 95% CI, 0.45–1.16; $P = 0.11$); however, this difference was not statistically significant.

Early trials that evaluated the use of tocilizumab in patients who were hospitalized with COVID-19 did not show a treatment effect for tocilizumab. These trials included a high proportion of patients who were receiving conventional oxygen therapy; however, many of these trials were underpowered, and only a small proportion of patients were also receiving corticosteroids.[15-19] Although RECOVERY reported a mortality benefit for tocilizumab, the study did not identify a particular subgroup of hospitalized patients on conventional oxygen therapy who benefited most from receiving the drug.[20] Among 21,550 participants who were randomized into the RECOVERY platform trial, only 4,116 of the participants (19%) underwent a second randomization into the tocilizumab intervention arm, suggesting that the study results are generalizable only to a restricted subset of hospitalized patients. The Consolidated Standards of Reporting Trials (CONSORT) flow diagram for RECOVERY suggests that patients with clinical evidence of progressive COVID-19 were preferentially selected for the tocilizumab study.

The Panel recognizes that there may be some hospitalized patients who are receiving conventional oxygen therapy who may have progressive hypoxemia associated with significant systemic inflammation. The addition of baricitinib or tocilizumab to their standard treatment may provide a modest benefit. Nevertheless, there is insufficient evidence to clearly characterize the subgroups within this patient population who would benefit from receiving these interventions. As there are no studies that directly compare using baricitinib and tocilizumab as treatments for COVID-19, the Panel has insufficient evidence to recommend one drug over the other. Treatment decisions should be made based on local guidance, drug availability, and patient comorbidities.

## Patients Who Require Delivery of Oxygen Through a High-Flow Device or Noninvasive Ventilation but Not Invasive Mechanical Ventilation or Extracorporeal Membrane Oxygenation

### *Recommendations*

- The Panel recommends one of the following options for these patients:
  - **Dexamethasone** alone **(AI)**; *or*
  - **Dexamethasone plus remdesivir (BIII)**.
- For recently hospitalized patients (i.e., those who are within 3 days of hospital admission) who have rapidly increasing oxygen needs, require high-flow oxygen or noninvasive ventilation, and have increased markers of inflammation, add **baricitinib (BIIa)** or **tocilizumab (BIIa)** (drugs are listed alphabetically) to one of the two options above.
- The Panel **recommends against** the use of **baricitinib** in combination with **tocilizumab** for the treatment of COVID-19, except in a clinical trial **(AIII)**. Because both baricitinib and tocilizumab are potent immunosuppressants, there is the potential for an additive risk of infection.

### *Additional Considerations*

- Immunosuppressive therapy (e.g., dexamethasone with or without baricitinib or tocilizumab) may increase the risk of opportunistic infections or reactivation of latent infections; however, randomized trials have not demonstrated an increase in the frequency of infections.
- Prophylactic treatment with ivermectin should be considered for patients who are from areas where strongyloidiasis is endemic.

#### Using Corticosteroids

- The combination of dexamethasone and remdesivir has not been rigorously studied in clinical trials. Because there are theoretical reasons for combining these drugs, the Panel considers both dexamethasone alone and the combination of remdesivir and dexamethasone to be acceptable

options for treating COVID-19 in this group of patients.

- The Panel **recommends against** the use of **remdesivir alone** because it is not clear whether remdesivir confers a clinical benefit in this group of patients **(AIIa)**.
- For patients who initially received remdesivir monotherapy and progressed to requiring high-flow oxygen or noninvasive ventilation, add dexamethasone and complete the treatment course of remdesivir.
- If dexamethasone is not available, equivalent doses of other corticosteroids such as **prednisone**, **methylprednisolone**, or **hydrocortisone** may be used **(BIII)**. See Corticosteroids for more information.

#### Using Baricitinib and Tocilizumab

- Baricitinib or tocilizumab should only be given in combination with dexamethasone or another corticosteroid at an equivalent dose. Some clinicians may choose to assess a patient's clinical response to dexamethasone before deciding whether adding baricitinib or tocilizumab is necessary.
- Studies that directly compare using baricitinib and tocilizumab as treatments for COVID-19 are not available. Therefore, the Panel has insufficient evidence to recommend one drug over the other. Treatment decisions should be made based on local guidance, drug availability, and patient comorbidities.
- Although some patients in REMAP-CAP and RECOVERY received a second dose of tocilizumab at the discretion of their treating physicians, there is insufficient evidence to determine which patients, if any, would benefit from an additional dose of the drug.

### *Rationale for the Use of Dexamethasone*

In RECOVERY, treatment with dexamethasone conferred a survival benefit among participants who required supplemental oxygen without invasive mechanical ventilation at enrollment: 23.3% of the participants in the dexamethasone group died within 28 days of enrollment compared with 26.2% in the standard of care arm (rate ratio 0.82; 95% CI, 0.72–0.94).[1]

### *Rationale for the Use of Remdesivir Plus Dexamethasone*

The combination of remdesivir plus dexamethasone has not been rigorously studied in clinical trials; therefore, the safety and efficacy of this combination are unknown. The Panel recognizes that there are theoretical reasons to use this combination, as described above. Based on these theoretical considerations, the Panel considers the combination of dexamethasone plus remdesivir a treatment option for patients in this group.

### *Rationale for Not Recommending Remdesivir Monotherapy*

In ACTT-1, there was no observed difference in time to recovery between the remdesivir and placebo groups (recovery rate ratio 1.09; 95% CI, 0.76–1.57) in the subgroup of participants who required high-flow oxygen or noninvasive ventilation at enrollment (n = 193). A post hoc analysis did not show a survival benefit for remdesivir at Day 29.[2] However, the trial was not powered to detect differences in outcomes within subgroups. The Panel **does not recommend** using remdesivir monotherapy in these patients because there is uncertainty regarding whether remdesivir alone confers a clinical benefit in this subgroup **(AIIa)**. Dexamethasone or remdesivir plus dexamethasone are better treatment options for COVID-19 in this group of patients.

For patients who start remdesivir monotherapy and then progress to requiring oxygen delivery through a high-flow device or noninvasive ventilation, the Panel recommends initiating dexamethasone and

continuing remdesivir until the treatment course is completed. Clinical trials that evaluated the use of remdesivir categorized patients based on their severity of illness at the start of treatment with remdesivir; therefore, patients may benefit from remdesivir even if their clinical course progresses to a severity of illness for which the benefits of remdesivir are less certain.

### *Rationale for Recommending the Use of Baricitinib Plus Dexamethasone in Certain Hospitalized Patients*

In COV-BARRIER, 1,525 hospitalized patients with COVID-19 were randomized 1:1 to receive oral baricitinib 4 mg or placebo in addition to the local standard of care for up to 14 days (or until hospital discharge).[14]

There was no difference in the primary endpoint of progression to high-flow oxygen, noninvasive ventilation, invasive mechanical ventilation, or death by Day 28 between the baricitinib arm (27.8% of patients) and the placebo arm (30.5% of patients; OR 0.85; 95% CI, 0.67–1.08; $P = 0.18$). All-cause mortality by Day 28 was 8.1% of patients in the baricitinib arm and 13.1% in the placebo arm, resulting in a 38.2% reduction in mortality (HR 0.57; 95% CI, 0.41–0.78; nominal $P = 0.002$). Across all the prespecified baseline disease severity subgroups, mortality estimates were numerically lower among those who received baricitinib than among those who received placebo. The difference in mortality was most pronounced in the subgroup of 370 patients who were receiving high-flow oxygen or noninvasive ventilation at baseline (17.5% of patients died in the baricitinib arm vs. 29.4% in the placebo arm; HR 0.52; 95% CI, 0.33–0.80; nominal $P = 0.007$). The occurrence of adverse events, serious adverse events, serious infections, and venous thromboembolic events was comparable in the baricitinib and placebo arms.

ACTT-2 demonstrated that baricitinib used in combination with remdesivir improved time to recovery in hospitalized patients with COVID-19. The effect was most pronounced in patients who were receiving high-flow oxygen or noninvasive ventilation. Although people who were receiving corticosteroids were excluded from ACTT-2, the results of the study support the idea that baricitinib may have a clinical benefit among patients with severe COVID-19 who are not able to receive corticosteroids.[21]

### *Rationale for Recommending the Combination Use of Tocilizumab and Dexamethasone in Certain Hospitalized Patients*

REMAP-CAP and RECOVERY, the two largest randomized controlled tocilizumab trials to date, have both reported a mortality benefit for tocilizumab among patients with rapid respiratory decompensation who require oxygen delivery through a high-flow device or noninvasive ventilation.[20,22] Corticosteroids were given to a majority of patients in both studies. In REMAP-CAP, a narrowly defined population of patients who were admitted to an intensive care unit (ICU) with severe to critical COVID-19 and who were exhibiting rapid respiratory decompensation were randomized to receive open-label tocilizumab or usual care alone. Compared to usual care, the use of tocilizumab reduced in-hospital mortality (28% vs. 36%) and, over 21 days of follow-up, increased the median number of days free of respiratory and cardiovascular organ support (10 days vs. 0 days; OR 1.64; 95% CI, 1.25–2.14). Enrollment occurred within 24 hours of ICU admission and within a median of 1.2 days of hospitalization (IQR 0.8–2.8 days), suggesting that the benefit of tocilizumab occurs specifically in patients who are experiencing rapid respiratory decompensation. In REMAP-CAP, the evidence for therapeutic benefit was strongest among recipients who had recently started receiving oxygen through a high-flow device or noninvasive ventilation; however, the lack of subgroup analyses by oxygen requirement is a notable limitation of this study.

RECOVERY also suggested a mortality benefit for tocilizumab plus dexamethasone in patients who specifically required noninvasive ventilation or high-flow oxygen. In this study, a subset of participants with hypoxemia and C-reactive protein levels ≥75 mg/L were offered enrollment into a second randomization to receive tocilizumab or usual care. Tocilizumab reduced all-cause mortality in these

patients; by Day 28, 29% of participants in the tocilizumab arm had died compared to 33% in the usual care arm (rate ratio 0.86; 95% CI, 0.77–0.96).

The Panel **recommends against** using tocilizumab without concomitant corticosteroids, as multiple trials have reported that the clinical benefit of tocilizumab is seen among patients who are receiving tocilizumab plus a corticosteroid (see Table 4d).

### *Rationale for Recommending Against Using the Combination of Baricitinib and Tocilizumab*

The Panel **recommends against** the use of the combination of baricitinib and tocilizumab for the treatment of COVID-19, except in a clinical trial **(AIII)** because there is insufficient evidence for the use of this combination. Given that both baricitinib and tocilizumab are potent immunosuppressants, there is the potential for an additive risk of infection.

## Patients Who Require Invasive Mechanical Ventilation or Extracorporeal Membrane Oxygenation

### *Recommendations*

- The Panel recommends the use of **dexamethasone** in hospitalized patients with COVID-19 who require invasive mechanical ventilation or ECMO **(AI)**.
- The Panel recommends the use of **dexamethasone plus tocilizumab** for patients who are within 24 hours of admission to the ICU **(BIIa)**.

### *Additional Considerations*

- If dexamethasone is not available, equivalent doses of alternative corticosteroids (e.g., **prednisone**, **methylprednisolone**, **hydrocortisone**) may be used **(BIII)**.
- For patients who initially received remdesivir monotherapy and progressed to requiring invasive mechanical ventilation or ECMO, dexamethasone should be initiated and remdesivir should be continued until the treatment course is completed.
- The Panel **recommends against** the use of **remdesivir monotherapy (AIIa)**.
- Tocilizumab should be given only in combination with dexamethasone (or another corticosteroid at an equivalent dose).
- Although some patients in the REMAP-CAP and RECOVERY trials received a second dose of tocilizumab at the discretion of their treating physicians, there is insufficient evidence to determine which patients, if any, would benefit from an additional dose of the drug.
- The combination of dexamethasone and tocilizumab may increase the risk of opportunistic infections or reactivation of latent infections. Prophylactic treatment with ivermectin should be considered for patients who are from areas where strongyloidiasis is endemic.

### *Rationale for the Use of Dexamethasone Monotherapy*

As the disease progresses in patients with COVID-19, a systemic inflammatory response may lead to multiple organ dysfunction syndrome. The anti-inflammatory effects of corticosteroids mitigate the inflammatory response, and the use of corticosteroids has been associated with improved outcomes in people with COVID-19 and critical illness.

Dexamethasone reduces mortality in critically ill patients with COVID-19 according to a meta-analysis that aggregated seven randomized trials and included data on 1,703 critically ill patients.[23] The largest trial in the meta-analysis was the RECOVERY trial, whose subgroup of mechanically ventilated patients

was included.[1] For details about the meta-analysis and the RECOVERY trial, see the Corticosteroids section. Because the benefits outweigh the potential harms, the Panel recommends the use of **dexamethasone** in hospitalized patients with COVID-19 who require invasive mechanical ventilation or ECMO **(AI)**.

### *Considerations Related to the Use of Dexamethasone Plus Remdesivir Combination Therapy*

Dexamethasone plus remdesivir combination therapy has not been evaluated in controlled studies; therefore, there is insufficient information to make a recommendation either for or against the use of this combination therapy. There is, however, a theoretical reason to administer dexamethasone plus remdesivir to patients who have recently been intubated. Antiviral therapy may prevent a steroid-related delay in viral clearance. This delay has been reported in the setting of other viral infections.[6,7]

Some studies have suggested that corticosteroids slow SARS-CoV-2 clearance, but the studies to date are not definitive. For example, an observational study in people with non-severe COVID-19 suggested that viral clearance was delayed in patients who received corticosteroids,[24] whereas a more recent study in patients with moderate to severe COVID-19 found no relationship between the use of corticosteroids and the rate of viral clearance.[13] Given the conflicting results from observational studies and the absence of clinical trial data, some Panel members would coadminister dexamethasone and remdesivir in patients who have recently been placed on mechanical ventilation **(CIII)** until more conclusive evidence becomes available, based on their concerns about delayed viral clearance in patients who received corticosteroids. Other Panel members would not coadminister these drugs due to uncertainties about the benefit of using remdesivir in critically ill patients.

### *Rationale for Recommending the Use of Tocilizumab Plus Dexamethasone in Patients Within 24 Hours of Admission to the Intensive Care Unit*

The REMAP-CAP and RECOVERY studies, the two largest randomized controlled tocilizumab trials to date, have both reported a mortality benefit for tocilizumab among patients who experienced rapid respiratory decompensation and were recently admitted to the ICU, including those who required invasive mechanical ventilation.[20,22] REMAP-CAP enrolled patients within 24 hours of admission to the ICU. Prior trials that enrolled patients later in the ICU course and/or who received oxygen support >24 hours after ICU admission have failed to show consistent clinical benefits for tocilizumab (see Table 4d). Thus, it is unclear whether there is a clinical benefit for tocilizumab in patients who received invasive mechanical ventilation >24 hours after ICU admission. Findings from RECOVERY suggest a clinical benefit for tocilizumab plus corticosteroids among patients with rapid clinical progression who received invasive mechanical ventilation. See the section above for additional details on the clinical trial data and rationale for using tocilizumab in this situation.

### *Rationale for Recommending Against the Use of Remdesivir Monotherapy*

A clear benefit of remdesivir monotherapy has not been demonstrated in patients who require invasive mechanical ventilation or ECMO. During ACTT-1, remdesivir did not improve the recovery rate in this subgroup of participants (recovery rate ratio 0.98; 95% CI, 0.70–1.36), and in a post hoc analysis of deaths by Day 29, remdesivir did not improve survival among participants in this subgroup (HR 1.13; 95% CI, 0.67–1.89).[2] In the Solidarity trial, there was a trend toward increased mortality among patients who received mechanical ventilation and who were randomized to receive remdesivir rather than standard of care (rate ratio 1.27; 95% CI, 0.99–1.62).[4] Taken together, these results do not demonstrate a clear benefit of remdesivir in critically ill patients.

For patients who start remdesivir monotherapy and then progress to requiring invasive mechanical ventilation or ECMO, the Panel recommends initiating dexamethasone and continuing remdesivir until

the treatment course is completed. Clinical trials that evaluated remdesivir categorized patients based on their severity of illness at the start of treatment with remdesivir; therefore, patients may benefit from receiving remdesivir even if their clinical course progresses to a severity of illness for which the benefits of remdesivir are less certain.

## References


1. RECOVERY Collaborative Group, Horby P, Lim WS, et al. Dexamethasone in hospitalized patients with COVID-19—preliminary report. *N Engl J Med*. 2021;384(8):693-704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32678530.
2. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the treatment of COVID-19—final report. *N Engl J Med*. 2020;383(19):1813-1826. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32445440.
3. Spinner CD, Gottlieb RL, Criner GJ, et al. Effect of remdesivir vs standard care on clinical status at 11 days in patients with moderate COVID-19: a randomized clinical trial. *JAMA*. 2020;324(11):1048-1057. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32821939.
4. WHO Solidarity Trial Consortium, Pan H, Peto R, et al. Repurposed antiviral drugs for COVID-19—interim WHO Solidarity Trial results. *N Engl J Med*. 2021;384(6):497-511.Available at: https://www.ncbi.nlm.nih.gov/pubmed/33264556.
5. Benfield T, Bodilsen J, Brieghel C, et al. Improved survival among hospitalized patients with COVID-19 treated with remdesivir and dexamethasone. a nationwide population-based cohort study. *Clin Infect Dis*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34111274.
6. Arabi YM, Mandourah Y, Al-Hameed F, et al. Corticosteroid therapy for critically ill patients with Middle East respiratory syndrome. *Am J Respir Crit Care Med*. 2018;197(6):757-767. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29161116.
7. Stockman LJ, Bellamy R, Garner P. SARS: systematic review of treatment effects. *PLoS Med*. 2006;3(9):e343. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16968120.
8. Rodrigo C, Leonardi-Bee J, Nguyen-Van-Tam J, Lim WS. Corticosteroids as adjunctive therapy in the treatment of influenza. *Cochrane Database Syst Rev*. 2016;3:CD010406. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26950335.
9. Chen Y, Li L. Influence of corticosteroid dose on viral shedding duration in patients with COVID-19. *Clin Infect Dis*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7454365/.
10. Li S, Hu Z, Song X. High-dose but not low-dose corticosteroids potentially delay viral shedding of patients with COVID-19. *Clin Infect Dis*. 2021;72(7):1297-1298. Available at: https://pubmed.ncbi.nlm.nih.gov/32588877/.
11. Ding C, Feng X, Chen Y, et al. Effect of corticosteroid therapy on the duration of SARS-CoV-2 clearance in patients with mild COVID-19: a retrospective cohort study. *Infect Dis Ther*. 2020;9(4):943-952. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32986226.
12. Liu J, Zhang S, Dong X, et al. Corticosteroid treatment in severe COVID-19 patients with acute respiratory distress syndrome. *J Clin Invest*. 2020;130(12):6417-6428. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33141117.
13. Spagnuolo V, Guffanti M, Galli L, et al. Viral clearance after early corticosteroid treatment in patients with moderate or severe covid-19. *Sci Rep*. 2020;10(1):21291. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33277573.
14. Marconi VC, Ramanan AV, de Bono S, et al. Efficacy and safety of baricitinib in patients with COVID-19 infection: results from the randomised, double-blind, placebo-controlled, parallel-group COV-BARRIER phase 3 trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.30.21255934v2.
15. Veiga VC, Prats J, Farias DLC, et al. Effect of tocilizumab on clinical outcomes at 15 days in patients with

severe or critical coronavirus disease 2019: randomised controlled trial. *BMJ*. 2021;372:n84. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33472855.

16. Salama C, Han J, Yau L, et al. Tocilizumab in patients hospitalized with COVID-19 pneumonia. *N Engl J Med*. 2021;384(1):20-30. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33332779.
17. Stone JH, Frigault MJ, Serling-Boyd NJ, et al. Efficacy of tocilizumab in patients hospitalized with COVID-19. *N Engl J Med*. 2020;383(24):2333-2344. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33085857.
18. Salvarani C, Dolci G, Massari M, et al. Effect of tocilizumab vs standard care on clinical worsening in patients hospitalized with COVID-19 pneumonia: a randomized clinical trial. *JAMA Intern Med*. 2021;181(1):24-31. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33080005.
19. Hermine O, Mariette X, Tharaux PL, et al. Effect of tocilizumab vs usual care in adults hospitalized with COVID-19 and moderate or severe pneumonia: a randomized clinical trial. *JAMA Intern Med*. 2021;181(1):32-40. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33080017.
20. RECOVERY Collaborative Group, Horby PW, Pessoa-Amorim G, et al. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): preliminary results of a randomised, controlled, open-label, platform trial. *Lancet*. 2021;397(10285):1637-1645. Available at: https://pubmed.ncbi.nlm.nih.gov/33933206/.
21. Kalil AC, Patterson TF, Mehta AK, et al. Baricitinib plus remdesivir for hospitalized adults with COVID-19. *N Engl J Med*. 2021;384(9):795-807. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33306283.
22. REMAP-CAP Investigators, Gordon AC, Mouncey PR, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19. *N Engl J Med*. 2021;384(16):1491-1502. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33631065.
23. WHO Rapid Evidence Appraisal for COVID-19 Therapies Working Group, Sterne JAC, Murthy S, et al. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. *JAMA*. 2020;324(13):1330-1341. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876694.
24. Li Q, Li W, Jin Y, et al. Efficacy evaluation of early, low-dose, short-term corticosteroids in adults hospitalized with non-severe COVID-19 pneumonia: a retrospective cohort study. *Infect Dis Ther*. 2020;9(4):823-836. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32880102.

# Care of Critically Ill Adult Patients With COVID-19

*Last Updated: July 8, 2021*

**Summary Recommendations**

**Infection Control**

- For health care workers who are performing aerosol-generating procedures on patients with COVID-19, the COVID-19 Treatment Guidelines Panel (the Panel) recommends using an N95 respirator (or equivalent or higher-level respirator) rather than surgical masks, in addition to other personal protective equipment (PPE) (i.e., gloves, gown, and eye protection such as a face shield or safety goggles) **(AIII)**.
- The Panel recommends minimizing the use of aerosol-generating procedures on intensive care unit patients with COVID-19 and carrying out any necessary aerosol-generating procedures in a negative-pressure room, also known as an airborne infection isolation room, when available **(AIII)**.
- For health care workers who are providing usual care for nonventilated patients with COVID-19, the Panel recommends using an N95 respirator (or equivalent or higher-level respirator) or a surgical mask in addition to other PPE (i.e., gloves, gown, and eye protection such as a face shield or safety goggles) **(AIIa)**.
- For health care workers who are performing non-aerosol-generating procedures on patients with COVID-19 who are on closed-circuit mechanical ventilation, the Panel recommends using an N95 respirator (or equivalent or higher-level respirator) in addition to other PPE (i.e., gloves, gown, and eye protection such as a face shield or safety goggles) because ventilator circuits may become disrupted unexpectedly **(BIII)**.
- The Panel recommends that endotracheal intubation in patients with COVID-19 be performed by health care providers with extensive airway management experience, if possible **(AIII)**.
- The Panel recommends that intubation be performed using video laryngoscopy, if possible **(CIIa)**.

**Hemodynamics**

- For adults with COVID-19 and shock, the Panel recommends using dynamic parameters, skin temperature, capillary refilling time, and/or lactate levels over static parameters to assess fluid responsiveness **(BIIa)**.
- For the acute resuscitation of adults with COVID-19 and shock, the Panel recommends using buffered/balanced crystalloids over unbalanced crystalloids **(BIIa)**.
- For the acute resuscitation of adults with COVID-19 and shock, the Panel **recommends against** the initial use of **albumin** for resuscitation **(BI)**.
- For adults with COVID-19 and shock, the Panel recommends **norepinephrine** as the first-choice vasopressor **(AI)**.
- For adults with COVID-19 and shock, the Panel recommends titrating vasoactive agents to target a mean arterial pressure (MAP) of 60 to 65 mm Hg over higher MAP targets **(BI)**.
- The Panel **recommends against** using **hydroxyethyl starches** for intravascular volume replacement in patients with sepsis or septic shock **(AI)**.
- When norepinephrine is available, the Panel **recommends against** using **dopamine** for patients with COVID-19 and shock **(AI)**.
- As a second line vasopressor, the Panel recommends adding either **vasopressin** (up to 0.03 units/min) **(BIIa)** or **epinephrine (BIIb)** to norepinephrine to raise MAP to target or adding **vasopressin** (up to 0.03 units/min) **(BIIa**) to decrease norepinephrine dosage.
- The Panel **recommends against** using **low-dose dopamine** for renal protection **(AI)**.
- The Panel recommends using **dobutamine** in patients who show evidence of cardiac dysfunction and persistent hypoperfusion despite adequate fluid loading and the use of vasopressor agents **(BIII)**.
- The Panel recommends that all patients who require vasopressors have an arterial catheter placed as soon as practical, if resources are available **(BIII)**.
- For adults with refractory septic shock who have completed a course of corticosteroids to treat their COVID-19, the Panel recommends using low-dose corticosteroid therapy ("shock-reversal") over no corticosteroid therapy **(BIIa)**.

**Oxygenation and Ventilation**

- For adults with COVID-19 and acute hypoxemic respiratory failure despite conventional oxygen therapy, the Panel recommends high-flow nasal cannula (HFNC) oxygen over noninvasive positive pressure ventilation (NIPPV) **(BIIa)**.
- In the absence of an indication for endotracheal intubation, the Panel recommends a closely monitored trial of NIPPV

for adults with COVID-19 and acute hypoxemic respiratory failure and for whom HFNC is not available **(BIIa)**.

- For patients with persistent hypoxemia despite increasing supplemental oxygen requirements in whom endotracheal intubation is not otherwise indicated, the Panel recommends considering a trial of awake prone positioning to improve oxygenation **(CIIa)**.
- The Panel **recommends against** using awake prone positioning as a rescue therapy for refractory hypoxemia to avoid intubation in patients who otherwise meet the indications for intubation and mechanical ventilation **(AIII)**.
- If intubation becomes necessary, the procedure should be performed by an experienced practitioner in a controlled setting due to the enhanced risk of exposing health care practitioners to SARS-CoV-2 during intubation **(AIII)**.
- For mechanically ventilated adults with COVID-19 and acute respiratory distress syndrome (ARDS):
  - The Panel recommends using low tidal volume (VT) ventilation (VT 4–8 mL/kg of predicted body weight) over higher VT ventilation (VT >8 mL/kg) **(AI)**.
  - The Panel recommends targeting plateau pressures of <30 cm $H_2O$ **(AIIa)**.
  - The Panel recommends using a conservative fluid strategy over a liberal fluid strategy **(BIIa)**.
  - The Panel **recommends against** the routine use of **inhaled nitric oxide (AIIa)**.
- For mechanically ventilated adults with COVID-19 and moderate-to-severe ARDS:
  - The Panel recommends using a higher positive end-expiratory pressure (PEEP) strategy over a lower PEEP strategy **(BIIa)**.
  - For mechanically ventilated adults with COVID-19 and refractory hypoxemia despite optimized ventilation, the Panel recommends prone ventilation for 12 to 16 hours per day over no prone ventilation **(BIIa)**.
  - The Panel recommends using, as needed, intermittent boluses of neuromuscular blocking agents (NMBA) or continuous NMBA infusion to facilitate protective lung ventilation **(BIIa)**.
  - In the event of persistent patient-ventilator dyssynchrony, or in cases where a patient requires ongoing deep sedation, prone ventilation, or persistently high plateau pressures, the Panel recommends using a continuous NMBA infusion for up to 48 hours as long as patient anxiety and pain can be adequately monitored and controlled **(BIII)**.
- For mechanically ventilated adults with COVID-19, severe ARDS, and hypoxemia despite optimized ventilation and other rescue strategies:
  - The Panel recommends using recruitment maneuvers rather than not using recruitment maneuvers **(CIIa)**.
  - If recruitment maneuvers are used, the Panel **recommends against** using staircase (incremental PEEP) recruitment maneuvers **(AIIa)**.
  - The Panel recommends using an inhaled pulmonary vasodilator as a rescue therapy; if no rapid improvement in oxygenation is observed, the treatment should be tapered off **(CIII)**.

**Acute Kidney Injury and Renal Replacement Therapy**

- For critically ill patients with COVID-19 who have acute kidney injury and who develop indications for renal replacement therapy, the Panel recommends continuous renal replacement therapy (CRRT), if available **(BIII)**.
- If CRRT is not available or not possible due to limited resources, the Panel recommends prolonged intermittent renal replacement therapy rather than intermittent hemodialysis **(BIII)**.

**Pharmacologic Interventions**

- In patients with COVID-19 and severe or critical illness, there is insufficient evidence for the Panel to recommend either for or against empiric broad-spectrum antimicrobial therapy in the absence of another indication.
- If antimicrobials are initiated, the Panel recommends that their use should be reassessed daily to minimize the adverse consequences of unnecessary antimicrobial therapy **(AIII)**.

**Extracorporeal Membrane Oxygenation**

- There is insufficient evidence for the Panel to recommend either for or against the use of extracorporeal membrane oxygenation for patients with COVID-19 and refractory hypoxemia.

**Rating of Recommendations**: A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

# General Considerations

*Last Updated: April 21, 2021*

Severe cases of COVID-19 may be associated with hypoxemic respiratory failure, acute respiratory distress syndrome (ARDS), septic shock, cardiac dysfunction, elevation in multiple inflammatory cytokines, thromboembolic disease, and/or exacerbation of underlying comorbidities. In addition to pulmonary disease, patients with COVID-19 may also experience cardiac, hepatic, renal, and central nervous system disease. Because patients with critical illness are likely to undergo aerosol-generating procedures, they should be placed in airborne infection isolation rooms, when available.

Guidance on diagnostic testing for SARS-CoV-2 can be found in the Testing for SARS-CoV-2 Infection section.

Most of the recommendations for the management of critically ill patients with COVID-19 are extrapolated from experience with other causes of sepsis.[1] Currently, there is limited information to suggest that the critical care management of patients with COVID-19 should differ substantially from the management of other critically ill patients; however, special precautions to prevent environmental contamination by SARS-CoV-2 are warranted.

As with any patient in the intensive care unit (ICU), successful clinical management of a patient with COVID-19 includes treating both the medical condition that initially resulted in ICU admission and other comorbidities and nosocomial complications.

## Comorbid Conditions

Certain attributes and comorbidities (e.g., older age, cardiovascular disease, diabetes, chronic obstructive pulmonary disease, cancer, renal disease, obesity, sickle cell disease, receipt of a solid organ transplant) are associated with an increased risk of severe illness from COVID-19.[2]

## Bacterial Superinfection of COVID-19-Associated Pneumonia

Limited information exists about the frequency and microbiology of pulmonary coinfections and superinfections in patients with COVID-19, such as hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP). Some studies from China emphasize the lack of bacterial coinfections in patients with COVID-19, while other studies suggest that these patients experience frequent bacterial complications.[3-8] There is appropriate concern about performing pulmonary diagnostic procedures such as bronchoscopy or other airway sampling procedures that require disruption of a closed airway circuit in patients with COVID-19. Thus, while some clinicians do not routinely start empiric broad-spectrum antimicrobial therapy for patients with severe COVID-19 disease, other experienced clinicians routinely use such therapy. However, empiric broad-spectrum antimicrobial therapy is the standard of care for the treatment of shock. Antibiotic stewardship is critical to avoid reflexive or continued courses of antibiotics.

## Inflammatory Response Due to COVID-19

Patients with COVID-19 may express increased levels of pro-inflammatory cytokines and anti-inflammatory cytokines, which has previously been referred to as “cytokine release syndrome” or “cytokine storm,” although these are imprecise terms. However, these terms are misnomers because the magnitude of cytokine elevation in patients with COVID-19 is modest compared to that in patients with many other critical illnesses, such as sepsis and ARDS.[9,10]

Patients with COVID-19 and severe pulmonary involvement are well described to also manifest extrapulmonary disease and to exhibit laboratory markers of acute inflammation. Patients with these manifestations of severe pulmonary disease typically progress to critical illness 10 to 12 days after the

onset of COVID-19 symptoms.

### *Multisystem Inflammatory Syndrome in Adults*

In addition, there are case reports describing patients who had evidence of acute or recent SARS-CoV-2 infection (documented by a nucleic acid amplification test [NAAT] or antigen or antibody testing) with minimal respiratory symptoms, but with laboratory markers of severe inflammation (e.g., elevated C-reactive protein [CRP], ferritin, D-dimer, cardiac enzymes, liver enzymes, and creatinine) and various other symptoms, including fever and shock; and signs of cardiovascular, gastrointestinal, dermatologic, and neurologic disease. This constellation of signs and symptoms has been designated multisystem inflammatory syndrome in adults (MIS-A).[11] To date, most adults in whom MIS-A has been described have survived. This syndrome is similar to a syndrome previously described in children (multisystem inflammatory syndrome in children [MIS-C]).

MIS-A is defined by the following criteria:

1. A severe illness requiring hospitalization in an individual aged ≥21 years;
2. Current or past infection with SARS-CoV-2;
3. Severe dysfunction in one or more extrapulmonary organ systems;
4. Laboratory evidence of elevated inflammatory markers (e.g., CRP, ferritin, D-dimer, interleukin [IL]-6);
5. Absence of severe respiratory illness; *and*
6. Absence of an alternative unifying diagnosis.[11]

Because there is no specific diagnostic test for MIS-A, diagnosis of this inflammatory syndrome is one of exclusion after other causes (e.g., septic shock) have been eliminated. Although there are currently no controlled clinical trial data in patients with MIS-A to guide treatment of the syndrome, case reports have described the use of intravenous immunoglobulin, corticosteroids, or anti-IL-6 therapy.

## COVID-19-Induced Cardiac Dysfunction, Including Myocarditis

A growing body of literature describes cardiac injury or dysfunction in approximately 20% of patients who are hospitalized with COVID-19.[4,6,12-15] COVID-19 may be associated with an array of cardiovascular complications, including acute coronary syndrome, myocarditis, arrythmias, and thromboembolic disease.[16]

## Thromboembolic Events and COVID-19

Critically ill patients with COVID-19 have been observed to have a prothrombotic state, which is characterized by the elevation of certain biomarkers, and there is an apparent increase in the incidence of venous thromboembolic disease in this population. In some studies, thromboemboli have been diagnosed in patients who received chemical prophylaxis with heparinoids.[17-19] Autopsy studies provide additional evidence of both thromboembolic disease and microvascular thrombosis in patients with COVID-19.[20] Some authors have called for routine surveillance of ICU patients for venous thromboembolism.[21] See the Antithrombotic Therapy in Patients with COVID-19 section for a more detailed discussion.

## Renal and Hepatic Dysfunction Due to COVID-19

Although SARS-CoV-2 is primarily a pulmonary pathogen, renal and hepatic dysfunction are consistently described in patients with severe COVID-19.[4] In one case series of patients with critical disease, >15% of the patients required continuous renal replacement therapy.[6] See the Acute Kidney

Injury and Renal Replacement Therapy section for a more detailed discussion.

## Considerations in Children

Several large epidemiologic studies suggest that rates of ICU admission are substantially lower for children with COVID-19 than for adults with the disease. However, severe disease does occur in children.[22-27] The risk factors for severe COVID-19 in children have not yet been established. Data from studies of adults with COVID-19 and extrapolation from data on other pediatric respiratory viruses suggest that children who are severely immunocompromised and those with underlying cardiopulmonary disease may be at higher risk for severe COVID-19.

MIS-C, the postinfectious complication of COVID-19 seen in some children, has been described.[28,29] Certain symptoms of MIS-C often require ICU-level care, including blood pressure and inotropic support. These symptoms include severe abdominal pain, multisystem inflammation, shock, cardiac dysfunction, and, rarely, coronary artery aneurysm. A minority of children with MIS-C meet the criteria for typical or atypical Kawasaki disease. For details on MIS-C clinical features and the treatments that are being investigated, see the Special Considerations in Children section.

## Interactions Between Drugs Used to Treat COVID-19 and Drugs Used to Treat Comorbidities

All ICU patients should be routinely monitored for drug-drug interactions. The potential for drug-drug interactions between investigational medications or medications used off-label to treat COVID-19 and concurrent drugs should be considered.

## Sedation Management in Patients With COVID-19

International guidelines provide recommendations on the prevention, detection, and treatment of pain, sedation, and delirium.[30,31] Sedation management strategies, such as maintaining a light level of sedation (when appropriate) and minimizing sedative exposure, have shortened the duration of mechanical ventilation and the length of stay in the ICU for patients without COVID-19.[32,33]

The Society of Critical Care Medicine's (SCCM's) ICU Liberation Campaign promotes the ICU Liberation Bundle (A-F) to improve post-ICU patient outcomes. The A-F Bundle includes the following elements:

A. Assess, prevent, and manage pain;

B. Both spontaneous awakening and breathing trials;

C. Choice of analgesia and sedation;

D. Delirium: assess, prevent, and manage;

E. Early mobility and exercise; *and*

F. Family engagement and empowerment.

The A-F Bundle also provides frontline staff with practical application strategies for each element.[34] The A-F Bundle should be incorporated using an interprofessional team model. This approach helps standardize communication among team members, improves survival, and reduces long-term cognitive dysfunction of patients.[35] Despite the known benefits of the A-F Bundle, its impact has not been directly assessed in patients with COVID-19; however, the use of the Bundle should be encouraged, when appropriate, to improve ICU patient outcomes. Prolonged mechanical ventilation of COVID-19 patients, coupled with deep sedation and potentially neuromuscular blockade, increases the workload of ICU staff. Additionally, significant drug shortages may force clinicians to use older sedatives with prolonged

durations of action and active metabolites, impeding routine implementation of the PADIS Guidelines. This puts patients at additional risk for ICU and post-ICU complications.

## Post-Intensive Care Syndrome

Patients with COVID-19 are reported to experience prolonged delirium and/or encephalopathy. Risk factors that are associated with delirium include the use of mechanical ventilation; the use of restraints; the use of benzodiazepine, opioid, and vasopressor infusions; and the use of antipsychotics.[36,37] Neurological complications are associated with older age and underlying conditions, such as hypertension and diabetes mellitus.[38] Autopsy studies have reported both macrovascular and microvascular thrombosis, with evidence of hypoxic ischemia.[39] Adequate management requires careful attention to best sedation practices and vigilance in stroke detection.

Post-intensive care syndrome (PICS) is a spectrum of cognitive, psychiatric, and/or physical disability that affects survivors of critical illness and persists after a patient leaves the ICU.[40] Patients with PICS may present with varying levels of impairment; including profound muscle weakness (ICU-acquired weakness); problems with thinking and judgment (cognitive dysfunction); and mental health problems, such as problems sleeping, post-traumatic stress disorder (PTSD), depression, and anxiety. ICU-acquired weakness affects 33% of all patients who receive mechanical ventilation, 50% of patients with sepsis, and ≤50% of patients who remain in the ICU for ≥1 week.[41-43] Cognitive dysfunction affects 30% to 80% of patients discharged from the ICU.[44-46] About 50% of ICU survivors do not return to work within 1 year after discharge.[47] Although no single risk factor has been associated with PICS, there are opportunities to minimize the risk of PICS through medication management (using the A-F Bundle), physical rehabilitation, follow-up clinics, family support, and improved education about the syndrome. PICS also affects family members who participate in the care of their loved ones. In one study, a third of family members who had main decision-making roles experienced mental health problems, such as depression, anxiety, and PTSD.[48]

Early reports suggest that some patients with COVID-19 who have been treated in the ICU express manifestations of PICS.[49] Although specific therapies for COVID-19-induced PICS are not yet available, physicians should maintain a high index of suspicion for cognitive impairment and other related problems in survivors of severe or critical COVID-19 illness.

## Other Intensive Care Unit-Related Complications

Patients who are critically ill with COVID-19 are at risk for nosocomial infections and other complications of critical illness care, such as VAP, HAP, catheter-related bloodstream infections, and venous thromboembolism. When treating patients with COVID-19, clinicians also need to minimize the risk of conventional ICU complications to optimize the likelihood of a successful ICU outcome.

## Advance Care Planning and Goals of Care

The advance care plans and the goals of care for all critically ill patients must be assessed at hospital admission and regularly thereafter. This is an essential element of care for all patients. Information on palliative care for patients with COVID-19 can be found at the National Coalition for Hospice and Palliative Care website.

To guide shared decision-making in cases of serious illness, advance care planning should include identifying existing advance directives that outline a patient's preferences and values. Values and care preferences should be discussed, documented, and revisited regularly for patients with or without prior directives. Specialty palliative care teams can facilitate communication between clinicians and surrogate decision makers, support frontline clinicians, and provide direct patient care services when needed.

Surrogate decision makers should be identified for all critically ill patients with COVID-19 at hospital

admission. Infection-control policies for COVID-19 often create communication barriers for surrogate decision makers, and most surrogates will not be physically present when discussing treatment options with clinicians. Many decision-making discussions will occur via telecommunication.

## Acknowledgments

The Surviving Sepsis Campaign (SSC), an initiative supported by the SCCM and the European Society of Intensive Care Medicine, issued *Guidelines on the Management of Critically Ill Adults with Coronavirus Disease 2019 (COVID-19)* in March 2020.[1] The COVID-19 Treatment Guidelines Panel (the Panel) has based the recommendations in this section on the SSC COVID-19 Guidelines with permission, and the Panel gratefully acknowledges the work of the SSC COVID-19 Guidelines Panel. The Panel also acknowledges the contributions and expertise of Andrew Rhodes, MBBS, MD, of St. George's University Hospitals in London, England, and Waleed Alhazzani, MBBS, MSc, of McMaster University in Hamilton, Canada.

## References

1. Alhazzani W, Moller MH, Arabi YM, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). *Crit Care Med*. 20200;48(6):e440-e469. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32224769.
2. Centers for Disease Control and Prevention. Evidence used to update the list of underlying medical conditions that increase a person's risk of severe illness from COVID-19. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/evidence-table.html. Accessed December 8, 2020.
3. Wu C, Chen X, Cai Y, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. *JAMA Intern Med*. 2020;180(7):934-943. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32167524.
4. Arentz M, Yim E, Klaff L, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington state. *JAMA*. 2020;323(16):1612-1614. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32191259.
5. Bhatraju PK, Ghassemieh BJ, Nichols M, et al. COVID-19 in critically ill patients in the Seattle region—case series. *N Engl J Med*. 2020;382(21):2012-2022. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32227758.
6. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32105632.
7. Chen T, Wu D, Chen H, et al. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. *BMJ*. 2020;368:m1091. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32217556.
8. Du Y, Tu L, Zhu P, et al. Clinical features of 85 fatal cases of COVID-19 from Wuhan: a retrospective observational study. *Am J Respir Crit Care Med*. 2020;201(11):1372-1379. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32242738.
9. Leisman DE, Ronner L, Pinotti R, et al. Cytokine elevation in severe and critical COVID-19: a rapid systematic review, meta-analysis, and comparison with other inflammatory syndromes. *Lancet Respir Med*. 2020;8(12):1233-1244. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33075298.
10. Sinha P, Matthay MA, Calfee CS. Is a "cytokine storm" relevant to COVID-19? *JAMA Intern Med*. 2020;180(9):1152-1154. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32602883.
11. Morris SB, Schwartz NG, Patel P, et al. Case series of multisystem inflammatory syndrome in adults associated with SARS-CoV-2 infection—United Kingdom and United States, March–August 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(40):1450-1456. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33031361.
12. Shi S, Qin M, Shen B, et al. Association of cardiac injury with mortality in hospitalized patients with

COVID-19 in Wuhan, China. *JAMA Cardiol*. 2020;5(7):802-810. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32211816.

13. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497-506. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31986264.
14. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. 2020;395(10229):1054-1062. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32171076.
15. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020;323(11):1061-1069. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32031570.
16. Nishiga M, Wang DW, Han Y, Lewis DB, Wu JC. COVID-19 and cardiovascular disease: from basic mechanisms to clinical perspectives. *Nat Rev Cardiol*. 2020;17(9):543-558. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32690910.
17. Llitjos JF, Leclerc M, Chochois C, et al. High incidence of venous thromboembolic events in anticoagulated severe COVID-19 patients. *J Thromb Haemost*. 2020;18(7):1743-1746. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32320517.
18. Helms J, Tacquard C, Severac F, et al. High risk of thrombosis in patients with severe SARS-CoV-2 infection: a multicenter prospective cohort study. *Intensive Care Med*. 2020;46(6):1089-1098. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32367170.
19. Klok FA, Kruip M, van der Meer NJM, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. *Thromb Res*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32291094.
20. Menter T, Haslbauer JD, Nienhold R, et al. Postmortem examination of COVID-19 patients reveals diffuse alveolar damage with severe capillary congestion and variegated findings in lungs and other organs suggesting vascular dysfunction. *Histopathology*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32364264.
21. Tavazzi G, Civardi L, Caneva L, Mongodi S, Mojoli F. Thrombotic events in SARS-CoV-2 patients: an urgent call for ultrasound screening. *Intensive Care Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32322918.
22. Sun D, Li H, Lu XX, et al. Clinical features of severe pediatric patients with coronavirus disease 2019 in Wuhan: a single center's observational study. *World J Pediatr*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32193831.
23. Dong Y, Mo X, Hu Y, et al. Epidemiology of COVID-19 Among Children in China. *Pediatrics*. 2020;145(6). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32179660.
24. Centers for Disease Control and Prevention. Coronavirus disease 2019 in children—United States, February 12–April 2, 2020. 2020. Available at: https://www.cdc.gov/mmwr/volumes/69/wr/mm6914e4.htm. Accessed January 5, 2021.
25. Chao JY, Derespina KR, Herold BC, et al. Clinical characteristics and outcomes of hospitalized and critically ill children and adolescents with coronavirus disease 2019 (COVID-19) at a tertiary care medical center in New York City. *J Pediatr*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32407719.
26. Zachariah P, Johnson CL, Halabi KC, et al. Epidemiology, clinical features, and disease severity in patients with coronavirus disease 2019 (COVID-19) in a children's hospital in New York City, New York. *JAMA Pediatr*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32492092.
27. DeBiasi RL, Song X, Delaney M, et al. Severe COVID-19 in children and young adults in the Washington, DC metropolitan region. *J Pediatr*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32405091.
28. Whittaker E, Bamford A, Kenny J, et al. Clinical characteristics of 58 children with a pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. *JAMA*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32511692.
29. Verdoni L, Mazza A, Gervasoni A, et al. An outbreak of severe Kawasaki-like disease at the Italian epicentre of

the SARS-CoV-2 epidemic: an observational cohort study. *Lancet*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32410760.

30. Barr J, Fraser GL, Puntillo K, et al. Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit. *Crit Care Med*. 2013;41(1):263-306. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23269131.
31. Devlin JW, Skrobik Y, Gelinas C, et al. Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Crit Care Med*. 2018;46(9):e825-e873. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30113379.
32. Kress JP, Vinayak AG, Levitt J, et al. Daily sedative interruption in mechanically ventilated patients at risk for coronary artery disease. *Crit Care Med*. 2007;35(2):365-371. Available at: https://www.ncbi.nlm.nih.gov/pubmed/17205005.
33. Girard TD, Kress JP, Fuchs BD, et al. Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial): a randomised controlled trial. *Lancet*. 2008;371(9607):126-134. Available at: https://www.ncbi.nlm.nih.gov/pubmed/18191684.
34. Society of Critical Care Medicine. ICU Liberation Bundle (A-F). Available at: https://www.sccm.org/ICULiberation/ABCDEF-Bundles. Accessed January 5, 2021.
35. Barnes-Daly MA, Phillips G, Ely EW. Improving hospital survival and reducing brain dysfunction at seven California community hospitals: implementing PAD guidelines via the ABCDEF bundle in 6,064 patients. *Crit Care Med*. 2017;45(2):171-178. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27861180.
36. Helms J, Kremer S, Merdji H, et al. Neurologic features in severe SARS-CoV-2 infection. *N Engl J Med*. 2020;382(23):2268-2270. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32294339.
37. Pun BT, Badenes R, Heras La Calle G, et al. Prevalence and risk factors for delirium in critically ill patients with COVID-19 (COVID-D): a multicentre cohort study. *Lancet Respir Med*. 2021;9(3):239-250. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33428871.
38. Mao L, Jin H, Wang M, et al. Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. *JAMA Neurol*. 2020;77(6):683-690. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32275288.
39. Solomon IH, Normandin E, Bhattacharyya S, et al. Neuropathological features of COVID-19. *N Engl J Med*. 2020;383(10):989-992. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32530583.
40. Society of Critical Care Medicine. Post-intensive care syndrome. 2013. Available at: https://www.sccm.org/MyICUCare/THRIVE/Post-intensive-Care-Syndrome. Accessed September 22, 2020.
41. Fan E, Dowdy DW, Colantuoni E, et al. Physical complications in acute lung injury survivors: a two-year longitudinal prospective study. *Crit Care Med*. 2014;42(4):849-859. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24247473.
42. De Jonghe B, Sharshar T, Lefaucheur JP, et al. Paresis acquired in the intensive care unit: a prospective multicenter study. *JAMA*. 2002;288(22):2859-2867. Available at: https://www.ncbi.nlm.nih.gov/pubmed/12472328.
43. Ali NA, O'Brien JM, Jr., Hoffmann SP, et al. Acquired weakness, handgrip strength, and mortality in critically ill patients. *Am J Respir Crit Care Med*. 2008;178(3):261-268. Available at: https://www.ncbi.nlm.nih.gov/pubmed/18511703.
44. Pandharipande PP, Girard TD, Jackson JC, et al. Long-term cognitive impairment after critical illness. *N Engl J Med*. 2013;369(14):1306-1316. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24088092.
45. Iwashyna TJ, Ely EW, Smith DM, Langa KM. Long-term cognitive impairment and functional disability among survivors of severe sepsis. *JAMA*. 2010;304(16):1787-1794. Available at: https://www.ncbi.nlm.nih.gov/pubmed/20978258.
46. Mikkelsen ME, Christie JD, Lanken PN, et al. The adult respiratory distress syndrome cognitive outcomes study: long-term neuropsychological function in survivors of acute lung injury. *Am J Respir Crit Care Med*.

2012;185(12):1307-1315. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22492988.

47. Kamdar BB, Sepulveda KA, Chong A, et al. Return to work and lost earnings after acute respiratory distress syndrome: a 5-year prospective, longitudinal study of long-term survivors. *Thorax*. 2018;73(2):125-133. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28918401.
48. Azoulay E, Pochard F, Kentish-Barnes N, et al. Risk of post-traumatic stress symptoms in family members of intensive care unit patients. *Am J Respir Crit Care Med*. 2005;171(9):987-994. Available at: https://www.ncbi.nlm.nih.gov/pubmed/15665319.
49. Carfi A, Bernabei R, Landi F, Gemelli Against C-P-ACSG. Persistent symptoms in patients after acute COVID-19. *JAMA*. 2020;324(6):603-605. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32644129.

# Infection Control

*Last Updated: October 9, 2020*

Health care workers should follow the infection control policies and procedures issued by their health care institutions.

## Recommendation

- For health care workers who are performing aerosol-generating procedures on patients with COVID-19, the COVID-19 Treatment Guidelines Panel (the Panel) recommends using an N95 respirator (or equivalent or higher-level respirator) rather than surgical masks, in addition to other personal protective equipment (PPE) (i.e., gloves, gown, and eye protection such as a face shield or safety goggles) **(AIII)**.
  - Aerosol-generating procedures include endotracheal intubation and extubation, sputum induction, bronchoscopy, mini-bronchoalveolar lavage, open suctioning of airways, manual ventilation, unintentional or intentional ventilator disconnections, noninvasive positive pressure ventilation (NIPPV) (e.g., bilevel positive airway pressure [BiPAP], continuous positive airway pressure [CPAP]), cardiopulmonary resuscitation, and, potentially, nebulizer administration and high-flow oxygen delivery. Caution regarding aerosol generation is appropriate in situations such as tracheostomy and proning, where ventilator disconnections are likely to occur.

## Rationale

During the severe acute respiratory syndrome (SARS) epidemic, aerosol-generating procedures increased the risk of infection among health care workers.[1,2] N95 respirators block 95% to 99% of aerosol particles; however, medical staff must be fit-tested for the type used.[3] Surgical masks block large particles, droplets, and sprays, but are less effective in blocking small particles (<5 μm) and aerosols.[4]

## Recommendation

- The Panel recommends minimizing the use of aerosol-generating procedures on intensive care unit patients with COVID-19 and carrying out any necessary aerosol-generating procedures in a negative-pressure room, also known as an airborne infection isolation room (AIIR), when available **(AIII)**.
  - The Panel recognizes that aerosol-generating procedures are necessary to perform in some patients, and that such procedures can be carried out with a high degree of safety if infection control guidelines are followed.

## Rationale

AIIRs lower the risk of cross-contamination among rooms and lower the risk of infection for staff and patients outside the room when aerosol-generating procedures are performed. AIIRs were effective in preventing virus spread during the SARS epidemic.[2] If an AIIR is not available, a high-efficiency particulate air (HEPA) filter should be used, especially for patients on high-flow nasal cannula or noninvasive ventilation. HEPA filters reduce virus transmission in simulations.[5]

## Recommendations

- For health care workers who are providing usual care for nonventilated patients with COVID-19, the Panel recommends using an N95 respirator (or equivalent or higher-level respirator) or a surgical mask, in addition to other PPE (i.e., gloves, gown, and eye protection such as a face shield

or safety goggles) **(AIIa)**.

- For health care workers who are performing non-aerosol-generating procedures on patients with COVID-19 who are on closed-circuit mechanical ventilation, the Panel recommends using an N95 respirator (or equivalent or higher-level respirator) in addition to other PPE (i.e., gloves, gown, and eye protection such as a face shield or safety goggles) because ventilator circuits may become disrupted unexpectedly **(BIII)**.

## Rationale

There is evidence from studies of viral diseases, including SARS, that both surgical masks and N95 respirators reduce the risk of transmission.[6] Moreover, surgical masks are probably not inferior to N95 respirators for preventing the transmission of respiratory viral infections; a recent systematic review and meta-analysis of randomized controlled trials that compared the protective effects of medical masks and N95 respirators demonstrated that the use of medical masks did not increase the incidence of laboratory-confirmed viral respiratory infections (including coronavirus infections) or clinical respiratory illness.[7]

## Recommendations

- The Panel recommends that endotracheal intubation in patients with COVID-19 be performed by health care providers with extensive airway management experience, if possible **(AIII)**.
- The Panel recommends that intubation be performed using video laryngoscopy, if possible **(CIIa)**.

## Rationale

Practices that maximize the chances of first-pass success and minimize aerosolization should be used when intubating patients with suspected or confirmed COVID-19.[8,9] Thus, the Panel recommends that the health care worker with the most experience and skill in airway management be the first to attempt intubation. The close facial proximity of direct laryngoscopy can expose health care providers to higher concentrations of viral aerosols. It is also important to avoid having unnecessary staff in the room during intubation procedures.

## References


1. Yam LY, Chen RC, Zhong NS. SARS: ventilatory and intensive care. *Respirology*. 2003;8 Suppl:S31-35. Available at: https://www.ncbi.nlm.nih.gov/pubmed/15018131.
2. Twu SJ, Chen TJ, Chen CJ, et al. Control measures for severe acute respiratory syndrome (SARS) in Taiwan. *Emerg Infect Dis*. 2003;9(6):718-720. Available at: https://www.ncbi.nlm.nih.gov/pubmed/12781013.
3. Centers for Disease Control and Prevention. The National Personal Protective Technology Laboratory (NPPTL): respirator trusted-source information. 2020. Available at: https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/respsource1quest2.html. Accessed September 23, 2020.
4. Milton DK, Fabian MP, Cowling BJ, Grantham ML, McDevitt JJ. Influenza virus aerosols in human exhaled breath: particle size, culturability, and effect of surgical masks. *PLoS Pathog*. 2013;9(3):e1003205. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23505369.
5. Qian H, Li Y, Sun H, Nielsen PV, Huang X, Zheng X. Particle removal efficiency of the portable HEPA air cleaner in a simulated hospital ward. *Building Simulation*. 2010;3:215-224. Available at: https://link.springer.com/article/10.1007/s12273-010-0005-4.
6. Offeddu V, Yung CF, Low MSF, Tam CC. Effectiveness of masks and respirators against respiratory infections in halthcare workers: a systematic review and meta-analysis. *Clin Infect Dis*. 2017;65(11):1934-1942. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29140516.
7. Bartoszko JJ, Farooqi MAM, Alhazzani W, Loeb M. Medical masks vs N95 respirators for preventing

COVID-19 in healthcare workers: a systematic review and meta-analysis of randomized trials. *Influenza Other Respir Viruses*. 2020;14(4):365-373. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32246890.

8. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012;7(4):e35797. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22563403.
9. Lewis SR, Butler AR, Parker J, Cook TM, Schofield-Robinson OJ, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation: a Cochrane Systematic Review. *Br J Anaesth*. 2017;119(3):369-383. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28969318.

# Hemodynamics

*Last Updated: July 8, 2021*

Most of the hemodynamic recommendations below are similar to those previously published in the *Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016*. Ultimately, adult patients with COVID-19 who require fluid resuscitation or hemodynamic management of shock should be treated and managed identically to adult patients with septic shock.[1]

## Recommendation

- For adults with COVID-19 and shock, the COVID-19 Treatment Guidelines Panel (the Panel) recommends using dynamic parameters, skin temperature, capillary refilling time, and/or lactate levels over static parameters to assess fluid responsiveness **(BIIa)**.

## Rationale

In a systematic review and meta-analysis of 13 randomized clinical trials in intensive care unit (ICU) patients without COVID-19 (n = 1,652),[2] dynamic assessment to guide fluid therapy reduced mortality (risk ratio 0.59; 95% CI, 0.42–0.83), ICU length of stay (weighted mean difference -1.16 days; 95% CI, -1.97 to -0.36), and duration of mechanical ventilation (weighted mean difference -2.98 hours; 95% CI, -5.08 to -0.89). Dynamic parameters used in these trials included stroke volume variation (SVV), pulse pressure variation (PPV), and stroke volume change with passive leg raise or fluid challenge. Passive leg raising, followed by PPV and SVV, appears to predict fluid responsiveness with the greatest accuracy.[3] The static parameters included components of early goal-directed therapy (e.g., central venous pressure, mean arterial pressure [MAP]).

Resuscitation of patients with shock who do not have COVID-19 based on serum lactate levels has been summarized in a systematic review and meta-analysis of seven randomized clinical trials (n = 1,301). Compared with central venous oxygen saturation-guided therapy, early lactate clearance-directed therapy was associated with a reduction in mortality (relative ratio 0.68; 95% CI, 0.56–0.82), shorter ICU stay (mean difference -1.64 days; 95% CI, -3.23 to -0.05), and shorter duration of mechanical ventilation (mean difference -10.22 hours; 95% CI, -15.94 to -4.50).[4]

## Recommendation

- For the acute resuscitation of adults with COVID-19 and shock, the Panel recommends using buffered/balanced crystalloids over unbalanced crystalloids **(BIIa)**.

## Rationale

A pragmatic randomized trial compared the use of balanced and unbalanced crystalloids for intravenous (IV) fluid administration in critically ill adults without COVID-19 (n = 15,802). The rate of the composite outcome of death, new renal-replacement therapy, or persistent renal dysfunction was lower in the balanced crystalloids group than in the unbalanced crystalloids group (OR 0.90; 95% CI, 0.82–0.99; $P = 0.04$).[5] A secondary analysis compared outcomes in a subset of patients with sepsis (n = 1,641). Compared to treatment with unbalanced crystalloids, treatment with balanced crystalloids resulted in fewer deaths (aOR 0.74; 95% CI, 0.59–0.93; $P = 0.01$) and more vasopressor-free and renal replacement-free days.[6] A subsequent meta-analysis of 21 non-COVID-19 randomized controlled trials (n = 20,213) that included the pragmatic trial cited above compared balanced crystalloids to 0.9% saline for resuscitation of critically ill adults and children. The trial reported nonsignificant differences between the treatment groups in hospital mortality (OR 0.91; 95% CI, 0.83–1.01) and acute kidney injury (OR

0.92; 95% CI, 0.84–1.00).[7]

## Recommendation

- For the acute resuscitation of adults with COVID-19 and shock, the Panel **recommends against** the initial use of **albumin** for resuscitation **(BI)**.

## Rationale

A meta-analysis of 20 non-COVID-19 randomized controlled trials (n = 13,047) that compared the use of albumin or fresh-frozen plasma to crystalloids in critically ill patients found no difference in all-cause mortality between the treatment groups.[8] In contrast, a meta-analysis of 17 non-COVID-19 randomized controlled trials (n = 1,977) that compared the use of albumin to crystalloids specifically in patients with sepsis observed a reduction in mortality among the patients who received albumin (OR 0.82; 95% CI, 0.67–1.0; $P = 0.047$).[9] Given the higher cost of albumin and the lack of a definitive clinical benefit, the Panel **recommends against** the routine use of **albumin** for initial acute resuscitation of patients with COVID-19 and shock **(BI)**.

## Recommendation

- For adults with COVID-19 and shock, the Panel recommends **norepinephrine** as the first-choice vasopressor **(AI)**.

## Rationale

Norepinephrine increases MAP due to its vasoconstrictive effects, with little change in heart rate and less increase in stroke volume compared to dopamine. Dopamine increases MAP and cardiac output, primarily due to an increase in stroke volume and heart rate. Norepinephrine is more potent than dopamine and may be more effective at reversing hypotension in patients with septic shock. Dopamine may be particularly useful in patients with compromised systolic function, but it causes more tachycardia and may be more arrhythmogenic than norepinephrine.[10] It may also influence the endocrine response via the hypothalamic pituitary axis and have immunosuppressive effects.[11] A systematic review and meta-analysis of 11, non-COVID-19 randomized controlled trials that compared vasopressors used to treat patients with septic shock found that norepinephrine use resulted in lower all-cause mortality (RR 0.89; 95% CI, 0.81–0.98) and a lower risk of arrhythmias (RR 0.48; 95% CI, 0.40–0.58) than dopamine use.[12] Although the beta-1 activity of dopamine would be useful in patients with myocardial dysfunction, the greater risk of arrhythmias limits its use.[13,14]

## Recommendation

- For adults with COVID-19 and shock, the Panel recommends titrating vasoactive agents to target a MAP of 60 to 65 mm Hg, over higher MAP targets **(BI)**.

## Rationale

A recent individual patient-data meta-analysis of two, non-COVID-19 randomized controlled trials (n = 894) comparing higher versus lower blood pressure targets for vasopressor therapy in adult patients with shock reported no significant difference between the patients in the higher and lower target groups in 28-day mortality (OR 1.15; 95% CI, 0.87–1.52), 90-day mortality (OR 1.08; 95% CI, 0.84–1.44), myocardial injury (OR 1.47; 95% CI, 0.64–3.56), or limb ischemia (OR 0.92; 95% CI, 0.36–2.10).[15] The risk of arrhythmias was increased in patients allocated to the higher target group (OR 2.50; 95% CI, 1.35–4.77). Similarly, the recently published "65 Trial," a randomized clinical trial in patients without COVID-19 (n = 2,463), reported no significant difference in mortality between patients with

vasopressor therapy guided by a MAP target of 60 to 65 mm Hg and those with treatment guided by a higher, standard of care MAP target (41% vs. 43.8%; RR 0.93; 95% CI, 0.85–1.03).[16] With an indication of improved outcome with lower MAP targets (and no firm indication of harm), the Panel recommends titrating vasoactive agents to a MAP target of 60 to 65 mm Hg **(BI)**.

## Additional Recommendations for Adults With COVID-19 and Shock Based on General Principles of Critical Care

- The Panel **recommends against** using hydroxyethyl starches for intravascular volume replacement in adult patients with COVID-19 and sepsis or septic shock **(AI)**.
- When norepinephrine is available, the Panel **recommends against** using **dopamine** for adult patients with COVID-19 and shock **(AI)**.
- As a second line vasopressor, the Panel recommends adding either **vasopressin** (up to 0.03 units/min) **(BIIa)** or **epinephrine (BIIb)** to norepinephrine to raise MAP to target or adding vasopressin (up to 0.03 units/min) **(BIIa)** to decrease norepinephrine dosage.
- The Panel **recommends against** using **low-dose dopamine** for renal protection **(AI)**.
- The Panel recommends using **dobutamine** in adult patients with COVID-19 who show evidence of cardiac dysfunction and persistent hypoperfusion despite adequate fluid loading and the use of vasopressor agents **(BIII)**.
- The Panel recommends that all adult patients with COVID-19 who require vasopressors have an arterial catheter placed as soon as practical, if resources are available **(BIII)**.
- For adult patients with refractory septic shock who have completed a course of corticosteroids to treat COVID-19, the Panel recommends using low-dose corticosteroid therapy ("shock-reversal") over no corticosteroid therapy **(BIIa)**.
  - A typical corticosteroid regimen in septic shock is hydrocortisone 200 mg IV per day administered either as an infusion or in intermittent doses. The duration of hydrocortisone therapy is usually a clinical decision.
  - Adult patients who are receiving corticosteroids for COVID-19 are receiving sufficient replacement therapy such that they do not require additional hydrocortisone.

## References


1. Rhodes A, Evans LE, Alhazzani W, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock: 2016. *Crit Care Med*. 2017;45(3):486-552. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28098591.
2. Bednarczyk JM, Fridfinnson JA, Kumar A, et al. Incorporating dynamic assessment of fluid responsiveness into goal-directed therapy: a systematic review and meta-analysis. *Crit Care Med*. 2017;45(9):1538-1545. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28817481.
3. Bentzer P, Griesdale DE, Boyd J, MacLean K, Sirounis D, Ayas NT. Will this hemodynamically unstable patient respond to a bolus of intravenous fluids? *JAMA*. 2016;316(12):1298-1309. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27673307.
4. Pan J, Peng M, Liao C, Hu X, Wang A, Li X. Relative efficacy and safety of early lactate clearance-guided therapy resuscitation in patients with sepsis: a meta-analysis. *Medicine (Baltimore)*. 2019;98(8):e14453. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30813144.
5. Semler MW, Self WH, Wanderer JP, et al. Balanced crystalloids versus saline in critically ill adults. *N Engl J Med*. 2018;378(9):829-839. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29485925.
6. Brown RM, Wang L, Coston TD, et al. Balanced crystalloids versus saline in sepsis. a secondary analysis of

the SMART clinical trial. *Am J Respir Crit Care Med*. 2019;200(12):1487-1495. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31454263.

7. Antequera Martin AM, Barea Mendoza JA, Muriel A, et al. Buffered solutions versus 0.9% saline for resuscitation in critically ill adults and children. *Cochrane Database Syst Rev*. 2019;7:CD012247. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31334842.
8. Lewis SR, Pritchard MW, Evans DJ, et al. Colloids versus crystalloids for fluid resuscitation in critically ill people. *Cochrane Database Syst Rev*. 2018;8:CD000567. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30073665.
9. Delaney AP, Dan A, McCaffrey J, Finfer S. The role of albumin as a resuscitation fluid for patients with sepsis: a systematic review and meta-analysis. *Crit Care Med*. 2011;39(2):386-391. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21248514.
10. Regnier B, Rapin M, Gory G, Lemaire F, Teisseire B, Harari A. Haemodynamic effects of dopamine in septic shock. *Intensive Care Med*. 1977;3(2):47-53. Available at: https://www.ncbi.nlm.nih.gov/pubmed/893773.
11. Beck G, Brinkkoetter P, Hanusch C, et al. Clinical review: immunomodulatory effects of dopamine in general inflammation. *Crit Care*. 2004;8(6):485-491. Available at: https://www.ncbi.nlm.nih.gov/pubmed/15566620.
12. Avni T, Lador A, Lev S, Leibovici L, Paul M, Grossman A. Vasopressors for the treatment of septic shock: systematic review and meta-analysis. *PLoS One*. 2015;10(8):e0129305. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26237037.
13. Regnier B, Safran D, Carlet J, Teisseire B. Comparative haemodynamic effects of dopamine and dobutamine in septic shock. *Intensive Care Med*. 1979;5(3):115-120. Available at: https://www.ncbi.nlm.nih.gov/pubmed/500939.
14. De Backer D, Creteur J, Silva E, Vincent JL. Effects of dopamine, norepinephrine, and epinephrine on the splanchnic circulation in septic shock: which is best? *Crit Care Med*. 2003;31(6):1659-1667. Available at: https://www.ncbi.nlm.nih.gov/pubmed/12794401.
15. Lamontagne F, Day AG, Meade MO, et al. Pooled analysis of higher versus lower blood pressure targets for vasopressor therapy septic and vasodilatory shock. *Intensive Care Med*. 2018;44(1):12-21. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29260272.
16. Lamontagne F, Richards-Belle A, Thomas K, et al. Effect of reduced exposure to vasopressors on 90-day mortality in older critically ill patients with vasodilatory hypotension: a randomized clinical trial. *JAMA*. 2020;323(10):938-949. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32049269.

# Oxygenation and Ventilation

*Last Updated: December 17, 2020*

The COVID-19 Treatment Guidelines Panel's (the Panel's) recommendations below emphasize recommendations from the Surviving Sepsis Campaign Guidelines for adult sepsis, pediatric sepsis, and COVID-19.

## Nonmechanically Ventilated Adults With Hypoxemic Respiratory Failure

### *Recommendations*

- For adults with COVID-19 and acute hypoxemic respiratory failure despite conventional oxygen therapy, the Panel recommends high-flow nasal cannula (HFNC) oxygen over noninvasive positive pressure ventilation (NIPPV) **(BIIa)**.
- In the absence of an indication for endotracheal intubation, the Panel recommends a closely monitored trial of NIPPV for adults with COVID-19 and acute hypoxemic respiratory failure and for whom HFNC is not available **(BIIa)**.
- For patients with persistent hypoxemia despite increasing supplemental oxygen requirements in whom endotracheal intubation is not otherwise indicated, the Panel recommends considering a trial of awake prone positioning to improve oxygenation **(CIIa)**.
- The Panel **recommends against** using awake prone positioning as a rescue therapy for refractory hypoxemia to avoid intubation in patients who otherwise meet the indications for intubation and mechanical ventilation **(AIII)**.
- If intubation becomes necessary, the procedure should be performed by an experienced practitioner in a controlled setting due to the enhanced risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) exposure to health care practitioners during intubation **(AIII)**.

### *Rationale*

Severe illness in COVID-19 typically occurs approximately 1 week after the onset of symptoms. The most common symptom is dyspnea, which is often accompanied by hypoxemia. Patients with severe disease typically require supplemental oxygen and should be monitored closely for worsening respiratory status because some patients may progress to acute respiratory distress syndrome (ARDS).

### *Goal of Oxygenation*

The optimal oxygen saturation ($SpO_2$) in adults with COVID-19 is uncertain. However, a target $SpO_2$ of 92% to 96% seems logical considering that indirect evidence from experience in patients without COVID-19 suggests that an $SpO_2$ <92% or >96% may be harmful.

Regarding the potential harm of maintaining an $SpO_2$ <92%, a trial randomly assigned ARDS patients without COVID-19 to either a conservative oxygen strategy (target $SpO_2$ of 88% to 92%) or a liberal oxygen strategy (target $SpO_2$ ≥96%). The trial was stopped early due to futility after enrolling 205 patients, but in the conservative oxygen group there was increased mortality at 90 days (between-group risk difference of 14%; 95% CI, 0.7% to 27%) and a trend toward increased mortality at 28-days (between-group risk difference of 8%; 95% CI, -5% to 21%).[1]

Regarding the potential harm of maintaining an $SpO_2$ >96%, a meta-analysis of 25 randomized trials involving patients without COVID-19 found that a liberal oxygen strategy (median $SpO_2$ of 96%) was associated with an increased risk of in-hospital mortality compared to a lower $SpO_2$ comparator (relative risk 1.21; 95% CI, 1.03–1.43).[2]

### *Acute Hypoxemic Respiratory Failure*

In adults with COVID-19 and acute hypoxemic respiratory failure, conventional oxygen therapy may be insufficient to meet the oxygen needs of the patient. Options for providing enhanced respiratory support include HFNC, NIPPV, intubation and invasive mechanical ventilation, or extracorporeal membrane oxygenation (ECMO).

### *High-Flow Nasal Cannula and Noninvasive Positive Pressure Ventilation*

HFNC is preferred over NIPPV in patients with acute hypoxemic respiratory failure based on data from an unblinded clinical trial in patients without COVID-19 who had acute hypoxemic respiratory failure. Study participants were randomized to HFNC, conventional oxygen therapy, or NIPPV. The patients in the HFNC group had more ventilator-free days (24 days) than those in the conventional oxygen therapy group (22 days) or NIPPV group (19 days) ($P = 0.02$), and 90-day mortality was lower in the HFNC group than in either the conventional oxygen therapy group (HR 2.01; 95% CI, 1.01–3.99) or the NIPPV group (HR 2.50; 95% CI, 1.31–4.78).[3] In the subgroup of more severely hypoxemic patients ($PaO_2/FiO_2$ mm Hg ≤200), the intubation rate was lower for HFNC than for conventional oxygen therapy or NIPPV (HR 2.07 and 2.57, respectively).

The trial's findings were corroborated by a meta-analysis of eight trials with 1,084 patients conducted to assess the effectiveness of oxygenation strategies prior to intubation. Compared to NIPPV, HFNC reduced the rate of intubation (OR 0.48; 95% CI, 0.31–0.73) and ICU mortality (OR 0.36; 95% CI, 0.20–0.63).[4]

NIPPV may generate aerosol spread of SARS-CoV-2 and thus increase nosocomial transmission of the infection.[5,6] It remains unclear whether HFNC results in a lower risk of nosocomial SARS-CoV-2 transmission than NIPPV.

### *Prone Positioning for Nonintubated Patients*

Although prone positioning has been shown to improve oxygenation and outcomes in patients with moderate-to-severe ARDS who are receiving mechanical ventilation,[7,8] there is less evidence regarding the benefit of prone positioning in awake patients who require supplemental oxygen without mechanical ventilation. In a case series of 50 patients with COVID-19 pneumonia who required supplemental oxygen upon presentation to a New York City emergency department, awake prone positioning improved the overall median oxygen saturation of the patients. However, 13 patients still required intubation due to respiratory failure within 24 hours of presentation to the emergency department.[9] Other case series of patients with COVID-19 requiring oxygen or NIPPV have similarly reported that awake prone positioning is well-tolerated and improves oxygenation,[10-12] with some series also reporting low intubation rates after proning.[10,12]

A prospective feasibility study of awake prone positioning in 56 patients with COVID-19 receiving HFNC or NIPPV in a single Italian hospital found that prone positioning for ≤3 hours was feasible in 84% of the patients. There was a significant improvement in oxygenation during prone positioning ($PaO_2/FiO_2$ 181 mm Hg in supine position vs. $PaO_2/FiO_2$ 286 mm Hg in prone position). However, when compared with baseline oxygenation before initiation of prone positioning, this improvement in oxygenation was not sustained ($PaO_2/FiO_2$ of 181 mm Hg and 192 mm Hg at baseline and 1 hour after resupination, respectively). Among patients put in the prone position, there was no difference in intubation rate between patients who maintained improved oxygenation (i.e., responders) and nonresponders.[9]

A prospective, multicenter observational cohort study in Spain and Andorra evaluated the effect of prone positioning on the rate of intubation in COVID-19 patients with acute respiratory failure receiving HFNC. Of the 199 patients requiring HFNC, 55 (27.6%) were treated with prone positioning. Although

the time to intubation was 1 day (IQR 1.0–2.5) in patients receiving HFNC and prone positioning versus 2 days [IQR 1.0–3.0] in patients receiving only HFNC ($P = 0.055$), the use of awake prone positioning did not reduce the risk of intubation (RR 0.87; 95% CI, 0.53–1.43; $P = 0.60$).[13]

Overall, despite promising data, it is unclear which hypoxemic, nonintubated patients with COVID-19 pneumonia benefit from prone positioning, how long prone positioning should be continued, or whether the technique prevents the need for intubation or improves survival.[10]

Appropriate candidates for awake prone positioning are those who can adjust their position independently and tolerate lying prone. Awake prone positioning is **contraindicated** in patients who are in respiratory distress and who require immediate intubation. Awake prone positioning is also **contraindicated** in patients who are hemodynamically unstable, patients who recently had abdominal surgery, and patients who have an unstable spine.[14] Awake prone positioning is acceptable and feasible for pregnant patients and can be performed in the left lateral decubitus position or the fully prone position.[15]

### *Intubation for Invasive Mechanical Ventilation*

It is essential to monitor hypoxemic patients with COVID-19 closely for signs of respiratory decompensation. To ensure the safety of both patients and health care workers, intubation should be performed in a controlled setting by an experienced practitioner.

## Mechanically Ventilated Adults

### *Recommendations*

For mechanically ventilated adults with COVID-19 and ARDS:

- The Panel recommends using low tidal volume (VT) ventilation (VT 4–8 mL/kg of predicted body weight) over higher VT ventilation (VT >8 mL/kg) **(AI)**.
- The Panel recommends targeting plateau pressures of <30 cm $H_2O$ **(AIIa)**.
- The Panel recommends using a conservative fluid strategy over a liberal fluid strategy **(BIIa)**.
- The Panel **recommends against** the routine use of inhaled nitric oxide **(AIIa)**.

### *Rationale*

There is no evidence that ventilator management of patients with hypoxemic respiratory failure due to COVID-19 should differ from ventilator management of patients with hypoxemic respiratory failure due to other causes.

## Positive End-Expiratory Pressure and Prone Positioning in Mechanically Ventilated Adults With Moderate to Severe Acute Respiratory Distress Syndrome

### *Recommendations*

For mechanically ventilated adults with COVID-19 and moderate-to-severe ARDS:

- The Panel recommends using a higher positive end-expiratory pressure (PEEP) strategy over a lower PEEP strategy **(BIIa)**.
- For mechanically ventilated adults with COVID-19 and refractory hypoxemia despite optimized ventilation, the Panel recommends prone ventilation for 12 to 16 hours per day over no prone ventilation **(BIIa)**.

### *Rationale*

PEEP is beneficial in patients with ARDS because it prevents alveolar collapse, improves oxygenation, and minimizes atelectotrauma, a source of ventilator-induced lung injury. A meta-analysis of individual patient data from the three largest trials that compared lower and higher levels of PEEP in patients without COVID-19 found lower rates of ICU mortality and in-hospital mortality with higher PEEP in those with moderate ($PaO_2/FiO_2$ 100–200 mm Hg) and severe ARDS ($PaO_2/FiO_2$ <100 mm Hg).[16]

Although there is no clear standard as to what constitutes a high level of PEEP, one conventional threshold is >10 cm $H_2O$.[17] Recent reports have suggested that, in contrast to patients with non-COVID-19 causes of ARDS, some patients with moderate or severe ARDS due to COVID-19 have normal static lung compliance and thus, in these patients, higher PEEP levels may cause harm by compromising hemodynamics and cardiovascular performance.[18,19] Other studies reported that patients with moderate to severe ARDS due to COVID-19 had low compliance, similar to the lung compliance seen in patients with conventional ARDS.[20-23] These seemingly contradictory observations suggest that COVID-19 patients with ARDS are a heterogeneous population and assessment for responsiveness to higher PEEP should be individualized based on oxygenation and lung compliance. Clinicians should monitor patients for known side effects of higher PEEP, such as barotrauma and hypotension.

## Neuromuscular Blockade in Mechanically Ventilated Adults With Moderate to Severe Acute Respiratory Distress Syndrome

### *Recommendations*

For mechanically ventilated adults with COVID-19 and moderate-to-severe ARDS:

- The Panel recommends using, as needed, intermittent boluses of neuromuscular blocking agents (NMBA) or continuous NMBA infusion to facilitate protective lung ventilation **(BIIa)**.
- In the event of persistent patient-ventilator dyssynchrony, or in cases where a patient requires ongoing deep sedation, prone ventilation, or persistently high plateau pressures, the Panel recommends using a continuous NMBA infusion for up to 48 hours as long as patient anxiety and pain can be adequately monitored and controlled **(BIII)**.

### *Rationale*

The recommendation for intermittent boluses of NMBA or continuous infusion of NMBA to facilitate lung protection may require a health care provider to enter the patient's room frequently for close clinical monitoring. Therefore, in some situations, the risks of SARS-CoV-2 exposure and the need to use personal protective equipment for each entry into a patient's room may outweigh the benefit of NMBA treatment.

## Rescue Therapies for Mechanically Ventilated Adults With Acute Respiratory Distress Syndrome

### *Recommendations*

For mechanically ventilated adults with COVID-19, severe ARDS, and hypoxemia despite optimized ventilation and other rescue strategies:

- The Panel recommends using recruitment maneuvers rather than not using recruitment maneuvers **(CIIa)**.
- If recruitment maneuvers are used, the Panel **recommends against** using staircase (incremental PEEP) recruitment maneuvers **(AIIa)**.

- The Panel recommends using an inhaled pulmonary vasodilator as a rescue therapy; if no rapid improvement in oxygenation is observed, the treatment should be tapered off **(CIII)**.

### *Rationale*

There are no studies to date assessing the effect of recruitment maneuvers on oxygenation in severe ARDS due to COVID-19. However, a systematic review and meta-analysis of six trials of recruitment maneuvers in non-COVID-19 patients with ARDS found that recruitment maneuvers reduced mortality, improved oxygenation 24 hours after the maneuver, and decreased the need for rescue therapy.[24] Because recruitment maneuvers can cause barotrauma or hypotension, patients should be closely monitored during recruitment maneuvers. If a patient decompensates during recruitment maneuvers, the maneuver should be stopped immediately. The importance of properly performing recruitment maneuvers was illustrated by an analysis of eight randomized controlled trials in non-COVID-19 patients (n = 2,544) which found that recruitment maneuvers did not reduce hospital mortality (RR 0.90; 95% CI, 0.78–1.04). Subgroup analysis found that traditional recruitment maneuvers significantly reduced hospital mortality (RR 0.85; 95% CI, 0.75–0.97), whereas incremental PEEP titration recruitment maneuvers increased mortality (RR 1.06; 95% CI, 0.97–1.17).[25]

Although there are no published studies of inhaled nitric oxide in patients with COVID-19, a Cochrane review of 13 trials of inhaled nitric oxide use in patients with ARDS found no mortality benefit.[26] Because the review showed a transient benefit in oxygenation, it is reasonable to attempt inhaled nitric oxide as a rescue therapy in COVID patients with severe ARDS after other options have failed. However, if there is no benefit in oxygenation with inhaled nitric oxide, it should be tapered quickly to avoid rebound pulmonary vasoconstriction that may occur with discontinuation after prolonged use.

## References


1. Barrot L, Asfar P, Mauny F, et al. Liberal or conservative oxygen therapy for acute respiratory distress syndrome. *N Engl J Med*. 2020;382(11):999-1008. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32160661.
2. Chu DK, Kim LH, Young PJ, et al. Mortality and morbidity in acutely ill adults treated with liberal versus conservative oxygen therapy (IOTA): a systematic review and meta-analysis. *Lancet*. 2018;391(10131):1693-1705. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29726345.
3. Frat JP, Thille AW, Mercat A, et al. High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. *N Engl J Med*. 2015;372(23):2185-2196. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25981908.
4. Ni YN, Luo J, Yu H, Liu D, Liang BM, Liang ZA. The effect of high-flow nasal cannula in reducing the mortality and the rate of endotracheal intubation when used before mechanical ventilation compared with conventional oxygen therapy and noninvasive positive pressure ventilation. A systematic review and meta-analysis. *Am J Emerg Med*. 2018;36(2):226-233. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28780231.
5. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012;7(4):e35797. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22563403.
6. Yu IT, Xie ZH, Tsoi KK, et al. Why did outbreaks of severe acute respiratory syndrome occur in some hospital wards but not in others? *Clin Infect Dis*. 2007;44(8):1017-1025. Available at: https://www.ncbi.nlm.nih.gov/pubmed/17366443.
7. Guerin C, Reignier J, Richard JC, et al. Prone positioning in severe acute respiratory distress syndrome. *N Engl J Med*. 2013;368(23):2159-2168. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23688302.
8. Fan E, Del Sorbo L, Goligher EC, et al. An official American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine Clinical Practice guideline: mechanical ventilation in adult

patients with acute respiratory distress syndrome. *Am J Respir Crit Care Med*. 2017;195(9):1253-1263. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28459336.

9. Caputo ND, Strayer RJ, Levitan R. Early self-proning in awake, non-intubated patients in the emergency department: a single ED's experience during the COVID-19 pandemic. *Acad Emerg Med*. 2020;27(5):375-378. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32320506.
10. Sun Q, Qiu H, Huang M, Yang Y. Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. *Ann Intensive Care*. 2020;10(1):33. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32189136.
11. Elharrar X, Trigui Y, Dols AM, et al. Use of prone positioning in nonintubated patients With COVID-19 and hypoxemic acute respiratory failure. *JAMA*;2020;323(22):2336-2338. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32412581.
12. Sartini C, Tresoldi M, Scarpellini P, et al. Respiratory parameters in patients with COVID-19 after using noninvasive ventilation in the prone position outside the intensive care unit. *JAMA*. 2020;323(22):2338-2340. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32412606.
13. Ferrando C, Mellado-Artigas R, Gea A, et al. Awake prone positioning does not reduce the risk of intubation in COVID-19 treated with high-flow nasal oxygen therapy: a multicenter, adjusted cohort study. *Crit Care*. 2020;24(1):597. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33023669.
14. Bamford P, Bentley A, Dean J, Whitmore D, Wilson-Baig N. ICS guidance for prone positioning of the conscious COVID patient. *Intensive Care Society*. 2020. Available at: https://emcrit.org/wp-content/uploads/2020/04/2020-04-12-Guidance-for-conscious-proning.pdf. Accessed December 8, 2020.
15. Society for Maternal Fetal Medicine. Management considerations for pregnant patients with COVID-19. 2020. Available at: https://s3.amazonaws.com/cdn.smfm.org/media/2336/SMFM_COVID_Management_of_COVID_pos_preg_patients_4-30-20_final.pdf. Accessed December 8, 2020.
16. Briel M, Meade M, Mercat A, et al. Higher vs. lower positive end-expiratory pressure in patients with acute lung injury and acute respiratory distress syndrome: systematic review and meta-analysis. *JAMA*. 2010;303(9):865-873. Available at: https://www.ncbi.nlm.nih.gov/pubmed/20197533.
17. Alhazzani W, Moller MH, Arabi YM, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). *Crit Care Med*. 2020;48(6):e440-e469. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32224769.
18. Marini JJ, Gattinoni L. Management of COVID-19 respiratory distress. *JAMA*. 2020;323(22):2329-2330. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32329799.
19. Tsolaki V, Siempos I, Magira E, Kokkoris S, Zakynthinos GE, Zakynthinos S. PEEP levels in COVID-19 pneumonia. *Crit Care*. 2020;24(1):303. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32505186.
20. Bhatraju PK, Ghassemieh BJ, Nichols M, et al. COVID-19 in critically ill patients in the Seattle region - case series. *N Engl J Med*. 2020;382(21):2012-2022. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32227758.
21. Cummings MJ, Baldwin MR, Abrams D, et al. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet*. 2020;395(10239):1763-1770. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32442528.
22. Ziehr DR, Alladina J, Petri CR, et al. Respiratory pathophysiology of mechanically ventilated patients with COVID-19: a cohort study. *Am J Respir Crit Care Med*. 2020;201(12):1560-1564. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32348678.
23. Schenck EJ, Hoffman K, Goyal P, et al. Respiratory mechanics and gas exchange in COVID-19 associated respiratory failure. *Ann Am Thorac Soc*. 2020;17(9):1158-1161. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32432896.
24. Goligher EC, Hodgson CL, Adhikari NKJ, et al. Lung recruitment maneuvers for adult patients with acute respiratory distress syndrome. a systematic review and meta-analysis. *Ann Am Thorac Soc*. 2017;14(Supplement 4):S304-S311. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29043837.

25. Alhazzani W, Moller MH, Arabi YM, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19). *Intensive Care Med*. 2020;46(5):854-887. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32222812.

26. Gebistorf F, Karam O, Wetterslev J, Afshari A. Inhaled nitric oxide for acute respiratory distress syndrome (ARDS) in children and adults. *Cochrane Database Syst Rev*. 2016(6):CD002787. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27347773.

# Acute Kidney Injury and Renal Replacement Therapy

*Last Updated: December 17, 2020*

## Recommendations

- For critically ill adults with COVID-19 who have acute kidney injury (AKI) and who develop indications for renal replacement therapy (RRT), the COVID-19 Treatment Guidelines Panel (the Panel) recommends continuous renal replacement therapy (CRRT), if available **(BIII)**.
- If CRRT is not available or not possible due to limited resources, the Panel recommends prolonged intermittent renal replacement therapy (PIRRT) rather than intermittent hemodialysis (IHD) **(BIII)**.

## Rationale

AKI that requires RRT occurs in approximately 22% of patients with COVID-19 who are admitted to the intensive care unit.[1] Evidence pertaining to RRT in patients with COVID-19 is scarce. Until additional evidence is available, the Panel suggests using the same indications for RRT in patients with COVID-19 as those used for other critically ill patients.[2]

RRT modalities have not been compared in COVID-19 patients; the Panel's recommendations are motivated by the desire to minimize the risk of viral transmission to health care workers. The Panel considers CRRT to be the preferred RRT modality. CRRT is preferable to PIRRT because medication dosing for CRRT is more easily optimized and CRRT does not require nursing staff to enter the patient's room to begin and end dialysis sessions. CRRT and PIRRT are both preferable to IHD because neither requires a dedicated hemodialysis nurse.[3] Peritoneal dialysis has also been used during surge situations in patients with COVID-19.

In situations where there may be insufficient CRRT machines or equipment to meet demand, the Panel advocates performing PIRRT instead of CRRT, and then using the machine for another patient after appropriate cleaning.

## References


1. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5,700 patients hospitalized with COVID-19 in the New York City area. *JAMA*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32320003.
2. American Society of Nephrology. Recommendations on the care of hospitalized patients with COVID-19 and kidney failure requiring renal replacement therapy. 2020. Available at: https://www.asn-online.org/g/blast/files/AKI_COVID-19_Recommendations_Document_03.21.2020.pdf. Accessed November 20, 2020.
3. Centers for Disease Control and Prevention. Coronavirus disease 2019 (COVID-19): considerations for providing hemodialysis to patients with suspected or confirmed COVID-19 in acute care settings. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/dialysis/dialysis-in-acute-care.html. Accessed November 19, 2020.

# Pharmacologic Interventions

*Last Updated: July 8, 2021*

## Therapeutic Management of Adults with COVID-19

See Therapeutic Management of Hospitalized Adults with COVID-19 for the COVID-19 Treatment Guidelines Panel's (the Panel) recommendations on when to use the following drugs alone or in combination: baricitinib, dexamethasone, remdesivir, and tocilizumab.

## Immune-Based Therapy

See the Immunomodulators sections for additional recommendations regarding the use of immunomodulators not listed above.

## Adjunctive Therapy

Recommendations regarding adjunctive therapy in the critical care setting, including antithrombotic therapy and vitamin C, can be found in Antithrombotic Therapy in Patients With COVID-19 and in the Supplements sections.

## Empiric Broad-Spectrum Antimicrobial Therapy

### *Recommendations*

- In patients with severe or critical COVID-19, there is insufficient evidence for the Panel to recommend either for or against empiric broad-spectrum antimicrobial therapy in the absence of another indication.
- If antimicrobials are initiated, the Panel recommends that their use should be reassessed daily to minimize the adverse consequences of unnecessary antimicrobial therapy **(AIII)**.

### *Rationale*

At this time, there are no reliable estimates of the incidence or prevalence of copathogens with SARS-CoV-2.

Some experts routinely administer broad-spectrum antibiotics as empiric therapy for bacterial pneumonia to all patients with COVID-19 and moderate or severe hypoxemia. Other experts administer antibiotics only for specific situations, such as the presence of a lobar infiltrate on a chest X-ray, leukocytosis, an elevated serum lactate level, microbiologic data, or shock.

Gram stain, culture, or other testing of respiratory specimens is often not available due to concerns about aerosolization of SARS-CoV-2 during diagnostic procedures or when processing specimens.

There are no clinical trials that have evaluated the use of empiric antimicrobial agents in patients with COVID-19 or other severe coronavirus infections.

# Extracorporeal Membrane Oxygenation

*Last Updated: December 17, 2020*

## Recommendation

- There is insufficient evidence to recommend either for or against the use of extracorporeal membrane oxygenation (ECMO) in adults with COVID-19 and refractory hypoxemia.

## Rationale

ECMO has been used as a short-term rescue therapy in patients with acute respiratory distress syndrome (ARDS) caused by COVID-19 and refractory hypoxemia. However, there is no conclusive evidence that ECMO is responsible for better clinical outcomes regardless of the cause of hypoxemic respiratory failure.[1-4]

The clinical outcomes for patients with ARDS who are treated with ECMO are variable and depend on multiple factors, including the etiology of hypoxemic respiratory failure, the severity of pulmonary and extrapulmonary illness, the presence of comorbidities, and the ECMO experience of the individual center.[5-7] A recent case series of 83 COVID-19 patients in Paris reported a 60-day mortality of 31% for patients on ECMO.[8] This mortality was similar to the mortality observed in a 2018 study of non-COVID-19 patients with ARDS who were treated with ECMO during the ECMO to Rescue Lung Injury in Severe ARDS (EOLIA) trial; that study reported a mortality of 35% at Day 60.[3]

The Extracorporeal Life Support Organization (ELSO) Registry provides the largest multicenter outcome dataset of patients with confirmed COVID-19 who received ECMO support and whose data were voluntarily submitted. A recent cohort study evaluated ELSO Registry data for 1,035 COVID-19 patients who initiated EMCO between January 16 and May 1, 2020, at 213 hospitals in 36 countries. This study reported an estimated cumulative in-hospital mortality of 37.4% in these patients 90 days after they initiated ECMO (95% CI; 34.4% to 40.4%).[9] Without a controlled trial that evaluates the use of ECMO in patients with COVID-19 and hypoxemic respiratory failure (e.g., ARDS), the benefits of ECMO cannot be clearly defined for this patient population.

Ideally, clinicians who are interested in using ECMO should try to enter their patients into clinical trials or clinical registries so that more informative data can be obtained. The following resources provide more information on the use of ECMO in patients with COVID-19:

- The ELSO ECMO in COVID-19 website
- A list of clinical trials that are evaluating ECMO in patients with COVID-19 on *ClinicalTrials.gov*

## References


1. Peek GJ, Mugford M, Tiruvoipati R, et al. Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial. *Lancet*. 2009;374(9698):1351-1363. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19762075.
2. Pham T, Combes A, Roze H, et al. Extracorporeal membrane oxygenation for pandemic influenza A(H1N1)-induced acute respiratory distress syndrome: a cohort study and propensity-matched analysis. *Am J Respir Crit Care Med*. 2013;187(3):276-285. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23155145.
3. Combes A, Hajage D, Capellier G, et al. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome. *N Engl J Med*. 2018;378(21):1965-1975. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29791822.

4. Munshi L, Walkey A, Goligher E, Pham T, Uleryk EM, Fan E. Venovenous extracorporeal membrane oxygenation for acute respiratory distress syndrome: a systematic review and meta-analysis. *Lancet Respir Med*. 2019;7(2):163-172. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30642776.
5. Bullen EC, Teijeiro-Paradis R, Fan E. How I select which patients with ARDS should be treated with venovenous extracorporeal membrane oxygenation. *Chest*. 2020;158(3):1036-1045. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32330459.
6. Henry BM, Lippi G. Poor survival with extracorporeal membrane oxygenation in acute respiratory distress syndrome (ARDS) due to coronavirus disease 2019 (COVID-19): Pooled analysis of early reports. *J Crit Care*. 2020;58:27-28. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32279018.
7. Mustafa AK, Alexander PJ, Joshi DJ, et al. Extracorporeal membrane oxygenation for patients with COVID-19 in severe respiratory failure. *JAMA Surg*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32780089.
8. Schmidt M, Hajage D, Lebreton G, et al. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome associated with COVID-19: a retrospective cohort study. *Lancet Respir Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32798468.
9. Barbaro RP, MacLaren G, Boonstra PS, et al. Extracorporeal membrane oxygenation support in COVID-19: an international cohort study of the Extracorporeal Life Support Organization registry. *Lancet*. 2020;396(10257):1071-1078. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32987008.

# Antiviral Drugs That Are Approved or Under Evaluation for the Treatment of COVID-19

*Last Updated: July 8, 2021*

| Summary Recommendations |
| --- |
| **Remdesivir is the only Food and Drug Administration-approved drug for the treatment of COVID-19.** In this section, the COVID-19 Treatment Guidelines Panel (the Panel) provides recommendations for using antiviral drugs to treat COVID-19 based on the available data. **As in the management of any disease, treatment decisions ultimately reside with the patient and their health care provider.** For more information on these antiviral agents, see Table 2e.<br><br>**Remdesivir**<br><br>• See Therapeutic Management of Hospitalized Adults with COVID-19 for recommendations on using remdesivir with or without dexamethasone.<br><br>**Ivermectin**<br><br>• There is insufficient evidence for the Panel to recommend either for or against the use of ivermectin for the treatment of COVID-19. Results from adequately powered, well-designed, and well-conducted clinical trials are needed to provide more specific, evidence-based guidance on the role of ivermectin in the treatment of COVID-19.<br><br>**Nitazoxanide**<br><br>• The Panel **recommends against** the use of **nitazoxanide** for the treatment of COVID-19, except in a clinical trial **(BIIa)**.<br><br>**Hydroxychloroquine or Chloroquine and/or Azithromycin**<br><br>• The Panel **recommends against** the use of **chloroquine** or **hydroxychloroquine** and/or **azithromycin** for the treatment of COVID-19 in hospitalized patients **(AI)** and in nonhospitalized patients **(AIIa)**.<br><br>**Lopinavir/Ritonavir and Other HIV Protease Inhibitors**<br><br>• The Panel **recommends against** the use of **lopinavir/ritonavir** and **other HIV protease inhibitors** for the treatment of COVID-19 in hospitalized patients **(AI)** and in nonhospitalized patients **(AIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Antiviral Therapy

Because SARS-CoV-2 replication leads to many of the clinical manifestations of COVID-19, antiviral therapies are being investigated for the treatment of COVID-19. These drugs inhibit viral entry (via the angiotensin-converting enzyme 2 [ACE2] receptor and transmembrane serine protease 2 [TMPRSS2]), viral membrane fusion and endocytosis, or the activity of the SARS-CoV-2 3-chymotrypsin-like protease (3CLpro) and the RNA-dependent RNA polymerase.[1] Because viral replication may be particularly active early in the course of COVID-19, antiviral therapy may have the greatest impact before the illness progresses to the hyperinflammatory state that can characterize the later stages of disease, including critical illness.[2] For this reason, it is necessary to understand the role of antiviral medications in treating mild, moderate, severe, and critical illness in order to optimize treatment for people with COVID-19.

The following sections describe the underlying rationale for using different antiviral medications, provide the COVID-19 Treatment Guidelines Panel's recommendations for using these medications to treat COVID-19, and summarize the existing clinical trial data. Additional antiviral therapies will be added to this section of the Guidelines as new evidence emerges.

## References


1. Sanders JM, Monogue ML, Jodlowski TZ, Cutrell JB. Pharmacologic treatments for Coronavirus Disease 2019 (COVID-19): a review. *JAMA*. 2020;323(18):1824-1836. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32282022.
2. Siddiqi HK, Mehra MR. COVID-19 illness in native and immunosuppressed states: a clinical-therapeutic staging proposal. *J Heart Lung Transplant*. 2020;39(5):405-407. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32362390.

# Remdesivir

*Last Updated: April 21, 2021*

Remdesivir is an intravenous nucleotide prodrug of an adenosine analog. Remdesivir binds to the viral RNA-dependent RNA polymerase and inhibits viral replication through premature termination of RNA transcription. It has demonstrated in vitro activity against SARS-CoV-2.[1] In a rhesus macaque model of SARS-CoV-2 infection, remdesivir treatment was initiated soon after inoculation; the remdesivir-treated animals had lower virus levels in the lungs and less lung damage than the control animals.[2]

Remdesivir is approved by the Food and Drug Administration (FDA) for the treatment of COVID-19 in hospitalized adult and pediatric patients (aged ≥12 years and weighing ≥40 kg). It is also available through an FDA Emergency Use Authorization (EUA) for the treatment of COVID-19 in hospitalized pediatric patients weighing 3.5 kg to <40 kg or aged <12 years and weighing ≥3.5 kg. Remdesivir should be administered in a hospital or a health care setting that can provide a similar level of care to an inpatient hospital.

Remdesivir has been studied in several clinical trials for the treatment of COVID-19. The recommendations from the COVID-19 Treatment Guidelines Panel (the Panel) are based on the results of these studies. See Table 2a for more information.

The safety and efficacy of combination therapy of remdesivir with corticosteroids have not been rigorously studied in clinical trials; however, there are theoretical reasons that combination therapy may be beneficial in some patients with severe COVID-19. For the Panel's recommendations on using remdesivir with or without dexamethasone in certain hospitalized patients, see Therapeutic Management of Hospitalized Adults With COVID-19.

## Monitoring and Adverse Effects

Remdesivir can cause gastrointestinal symptoms (e.g., nausea), elevated transaminase levels, an increase in prothrombin time (without a change in the international normalized ratio), and hypersensitivity reactions.

Liver function tests and prothrombin time should be obtained in all patients before remdesivir is administered and during treatment as clinically indicated. Remdesivir may need to be discontinued if alanine transaminase (ALT) levels increase to >10 times the upper limit of normal and should be discontinued if an increase in ALT level and signs or symptoms of liver inflammation are observed.[3]

## Considerations in Patients With Renal Insufficiency

Each 100 mg vial of remdesivir lyophilized powder contains 3 g of sulfobutylether beta-cyclodextrin sodium (SBECD), whereas each 100 mg/20 mL vial of remdesivir solution contains 6 g of SBECD.[3] SBECD is a vehicle that is primarily eliminated through the kidneys. A patient with COVID-19 who receives a loading dose of remdesivir 200 mg would receive 6 g to 12 g of SBECD, depending on the formulation. This amount of SBECD is within the safety threshold for patients with normal renal function.[4] Accumulation of SBECD in patients with renal impairment may result in liver and renal toxicities. Clinicians may consider preferentially using the lyophilized powder formulation (which contains less SBECD) in patients with renal impairment.

Because both remdesivir formulations contain SBECD, patients with an estimated glomerular filtration rate (eGFR) of <50 mL/min were excluded from some clinical trials of remdesivir; other trials had an eGFR cutoff of <30 mL/min. Remdesivir **is not recommended** for patients with an eGFR <30 mL/

min due to lack of data.[5] Renal function should be monitored before and during remdesivir treatment as clinically indicated.[3]

In two observational studies that evaluated the use of remdesivir in hospitalized patients with COVID-19, no significant differences were reported in the incidences of adverse effects or acute kidney injury between patients with an estimated creatinine clearance (CrCl) <30 mL/min and those with an estimated CrCl ≥30 mL/min.[6,7] One of these studies evaluated patients who primarily received the solution formulation of remdesivir (20 patients had an estimated CrCl <30 mL/min and 115 had an estimated CrCl ≥30 mL/min);[6] the other study evaluated patients who received the lyophilized powder formulation (40 patients had an estimated CrCl <30 mL/min and 307 had an estimated CrCl ≥30 mL/min).[7]

## Drug-Drug Interactions

Clinical drug-drug interaction studies of remdesivir have not been conducted. In vitro, remdesivir is a substrate of cytochrome P450 (CYP) 3A4 and of the drug transporters organic anion-transporting polypeptide (OATP) 1B1 and P-glycoprotein. It is also an inhibitor of CYP3A4, OATP1B1, OATP1B3, and multidrug and toxin extrusion protein 1 (MATE1).[3]

Minimal to no reduction in remdesivir exposure is expected when remdesivir is coadministered with dexamethasone, according to information provided by Gilead Sciences (written communication, July 2020). Chloroquine or hydroxychloroquine may decrease the antiviral activity of remdesivir; coadministration of these drugs **is not recommended**.[3] Remdesivir is not expected to have any significant interactions with oseltamivir or baloxavir, according to information provided by Gilead Sciences (written communications, August and September 2020).

See Table 2e for more information.

## Considerations in Pregnancy

- Pregnant patients were excluded from the clinical trials that evaluated the safety and efficacy of remdesivir for the treatment of COVID-19, but preliminary reports of remdesivir use in pregnant patients from the remdesivir compassionate use program are reassuring.
- Among 86 pregnant and postpartum hospitalized patients with severe COVID-19 who received compassionate use remdesivir, the therapy was well tolerated, with a low rate of serious adverse events.[8]
- Remdesivir should not be withheld from pregnant patients if it is otherwise indicated.

## Considerations in Children

- The safety and effectiveness of using remdesivir to treat COVID-19 have not been evaluated in pediatric patients aged <12 years or weighing <40 kg.
- Remdesivir is available through an FDA EUA for the treatment of COVID-19 in hospitalized pediatric patients weighing 3.5 kg to <40 kg or aged <12 years and weighing ≥3.5 kg.
- A clinical trial is currently evaluating the pharmacokinetics of remdesivir in children (*ClinicalTrials.gov* Identifier NCT04431453).

## Clinical Trials

Several clinical trials that are evaluating the use of remdesivir for the treatment of COVID-19 are currently underway or in development. Please see *ClinicalTrials.gov* for the latest information.

## References


1. Wang M, Cao R, Zhang L, et al. Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. *Cell Res*. 2020;30(3):269-271. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32020029.
2. Williamson BN, Feldmann F, Schwarz B, et al. Clinical benefit of remdesivir in rhesus macaques infected with SARS-CoV-2. *Nature*. 2020;585(7824):273-276. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32516797.
3. Remdesivir (Veklury) [package insert]. Food and Drug Administration. 2020. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2020/214787Orig1s000lbl.pdf.
4. Committee for Human Medicinal Products. Background review for cyclodextrins used as excipients. 2014. Available at: https://www.ema.europa.eu/en/documents/report/background-review-cyclodextrins-used-excipients-context-revision-guideline-excipients-label-package_en.pdf.
5. Adamsick ML, Gandhi RG, Bidell MR, et al. Remdesivir in patients with acute or chronic kidney disease and COVID-19. *J Am Soc Nephrol*. 2020;31(7):1384-1386. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32513665.
6. Pettit NN, Pisano J, Nguyen CT, et al. Remdesivir use in the setting of severe renal impairment: a theoretical concern or real risk? *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33315065.
7. Ackley TW, McManus D, Topal JE, Cicali B,Shah S. A valid warning or clinical lore: an evaluation of safety outcomes of remdesivir in patients with impaired renal function from a multicenter matched cohort. *Antimicrob Agents Chemother*. 2021;65(2). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33229428.
8. Burwick RM, Yawetz S, Stephenson KE, et al. Compassionate use of remdesivir in pregnant women with severe covid-19. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33031500.

# Table 2a. Remdesivir: Selected Clinical Data

*Last Updated: February 11, 2021*

The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing the recommendations for RDV. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Adaptive COVID-19 Treatment Trial (ACTT-1)[1]** | | | |
| Multinational, placebo-controlled, double-blind RCT in hospitalized patients (n = 1,062) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• At least 1 of the following conditions:<br>  • Pulmonary infiltrates, as determined by radiographic imaging<br>  • $SpO_2$ ≤94% on room air<br>  • Required supplemental oxygen<br>  • Required mechanical ventilation<br>  • Required ECMO<br>**Key Exclusion Criteria:**<br>• ALT or AST >5 times ULN<br>• eGFR <30 mL/min<br>• Pregnancy or breastfeeding<br>**Interventions:**<br>• IV RDV 200 mg on Day 1, then 100 mg daily for up to 9 more days<br>• Placebo for 10 days<br>**Primary Endpoint:**<br>• Time to clinical recovery<br>**Ordinal Scale Definitions:**<br>1. Not hospitalized, no limitations<br>2. Not hospitalized, with limitations<br>3. Hospitalized, no active medical problems | **Number of Participants:**<br>• RDV (n = 541) and placebo (n = 521)<br>**Participant Characteristics:**<br>• Median time from symptom onset to randomization was 9 days (IQR 6–12 days).<br>**Outcomes**<br>*Overall Results:*<br>• RDV reduced time to recovery compared to placebo (10 days vs. 15 days; RRR 1.29; 95% CI, 1.12–1.49; $P < 0.001$).<br>• Clinical improvement based on ordinal scale was higher at Day 15 in RDV arm (OR 1.5; 95% CI, 1.2–1.9; $P < 0.001$).<br>• No statistically significant difference in mortality by Day 29 between RDV and placebo arms (HR 0.73; 95% CI, 0.52–1.03; $P = 0.07$).<br>• Benefit of RDV was greatest in patients randomized during the first 10 days after symptom onset.<br>*Results by Disease Severity at Enrollment:*<br>• No difference in median time to recovery between arms among patients who had mild to moderate disease at enrollment.<br>• Benefit of RDV for reducing time to recovery was clearest in patients who required supplemental oxygenation at enrollment (n = 435; RRR 1.45; 95% CI, 1.18–1.79), and RDV appeared to confer | **Limitations:**<br>• Wide range of disease severity; study was not powered to detect differences within subgroups<br>• Powered to detect differences in clinical improvement, not mortality<br>• No data collected on longer-term morbidity<br>**Interpretation:**<br>• In patients with severe COVID-19, RDV reduced time to clinical recovery.<br>• Benefit of RDV was most apparent in hospitalized patients on supplemental oxygen.<br>• No observed benefit in those on high-flow oxygen, noninvasive ventilation, mechanical ventilation, or ECMO, but the study was not powered to detect differences within subgroups.<br>• No observed benefit of RDV in patients with mild or moderate COVID-19, but the number of participants in these categories was relatively small. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Adaptive COVID-19 Treatment Trial (ACTT-1)[1]**, continued | | | |
| | 4. Hospitalized, not on oxygen<br>5. Hospitalized, on oxygen<br>6. Hospitalized, on high-flow oxygen or noninvasive mechanical ventilation<br>7. Hospitalized, on mechanical ventilation or ECMO<br>8. Death | a survival benefit in this subgroup (HR for death by Day 29 0.30; 95% CI, 0.14–0.64).<br>• No observed difference in time to recovery between arms in patients on high-flow oxygen or noninvasive ventilation at enrollment (RRR 1.09; 95% CI, 0.76–1.57). No evidence that RDV affected mortality rate in this subgroup (HR 1.02; 95% CI, 0.54–1.91).<br>• No observed difference in time to recovery between arms in patients on mechanical ventilation or ECMO at enrollment (RRR 0.98; 95% CI, 0.70–1.36). No evidence that RDV affected mortality rate in this subgroup (HR 1.13; 95% CI, 0.67–1.89).<br>*Safety Results:*<br>• Percentages of patients with SAEs were similar between arms (25% vs. 32%).<br>• Transaminase elevations: 6% of RDV recipients, 10.7% of placebo recipients | |
| **Remdesivir Versus Placebo for Severe COVID-19 in China[2]** | | | |
| Multicenter, placebo-controlled, double-blind RCT in hospitalized patients with severe COVID-19 (n = 237) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• Time from symptom onset to randomization <12 days<br>• $SpO_2$ ≤94% on room air or $PaO_2/FiO_2$ <300 mm Hg<br>• Radiographically confirmed pneumonia<br>**Key Exclusion Criteria:**<br>• ALT or AST >5 times ULN<br>• eGFR <30 mL/min<br>• Pregnancy or breastfeeding | **Number of Participants:**<br>• ITT analysis: RDV (n = 158) and placebo (n = 78)<br>• Study stopped before reaching target enrollment of 453 patients due to control of the COVID-19 outbreak in China.<br>**Participant Characteristics:**<br>• Median time from symptom onset to randomization: 9 days for RDV arm, 10 days for placebo arm<br>• Receipt of corticosteroids: 65% of patients in RDV arm, 68% in placebo arm<br>• Receipt of LPV/RTV: 28% of patients in RDV arm, 29% in placebo arm | **Limitations:**<br>• Sample size did not have sufficient power to detect differences in clinical outcomes.<br>• Use of concomitant medications (i.e., corticosteroids, LPV/RTV, IFNs) may have obscured effects of RDV.<br>**Interpretation:**<br>• No difference in time to clinical improvement, 28-day mortality, or rate of SARS-CoV-2 clearance between RDV-treated and placebo-treated patients; |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Remdesivir Versus Placebo for Severe COVID-19 in China[2]**, continued | | | |
| | **Interventions:**<br>• IV RDV 200 mg on Day 1, then 100 mg daily for 9 days<br>• Saline placebo for 10 days<br>**Primary Endpoint:**<br>• Time to clinical improvement, defined as improvement on an ordinal scale or being discharged alive from the hospital | • Receipt of IFN alfa-2b: 29% of patients in RDV arm, 38% in placebo arm<br>**Outcomes:**<br>• No difference in time to clinical improvement between RDV and placebo arms (median time 21 days vs. 23 days; HR 1.23; 95% CI, 0.87–1.75).<br>• For patients who started RDV or placebo within 10 days of symptom onset, faster time to clinical improvement was seen with RDV (median time 18 days vs. 23 days; HR 1.52; 95% CI, 0.95–2.43); however, this was not statistically significant.<br>• 28-day mortality was similar between arms (14% of patients in RDV arm, 13% in placebo arm).<br>• No difference between arms in SARS-CoV-2 viral load at baseline, and rate of decline over time was similar.<br>• Percentage of patients with AEs: 66% in RDV arm, 64% in placebo arm<br>• Discontinuations due to AEs: 12% of patients in RDV arm, 5% in placebo arm | however, study was underpowered to detect differences in these outcomes between arms. |
| **World Health Organization Solidarity Trial[3]** | | | |
| International, open-label, adaptive RCT with multiple treatment arms that enrolled hospitalized patients with COVID-19 (n = 11,330). In 1 arm, patients received RDV. | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Not known to have received any study drug<br>• Not expected to be transferred elsewhere within 72 hours<br>• Physician reported no contraindications to study drugs<br>**Interventions:**<br>• IV RDV 200 mg on Day 0, then 100 mg daily on Days 1–9<br>• Local SOC | **Number of Participants:**<br>• ITT analysis: RDV (n = 2,743) and SOC (n = 2,708)<br>**Participant Characteristics:**<br>• Percentage of patients aged 50–69 years: 47% in RDV arm, 48% in SOC arm<br>• Percentage of patients aged ≥70 years: 18% in RDV arm, 17% in SOC arm<br>• 67% of patients in both arms were on supplemental oxygen at entry.<br>• 9% of patients in both arms were mechanically ventilated at entry. | **Limitations:**<br>• Open-label study design limits the ability to assess time to recovery; clinicians and patients were aware of treatment assignment, so RDV may have been continued to complete the treatment course even if the patient had improved.<br>• No data on time from symptom onset to enrollment<br>• No assessment of outcomes post hospital discharge |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **World Health Organization Solidarity Trial[3]**, continued | | | |
| | **Primary Endpoint:**<br>• In-hospital mortality<br>**Secondary Endpoints:**<br>• Initiation of mechanical ventilation<br>• Duration of hospitalization | • Percentage of patients hospitalized for ≥2 days at entry: 40% in RDV arm, 39% in SOC arm<br>• Percentages of patients with comorbid conditions were similar between RDV and SOC arms: diabetes (26% and 25%), heart disease (21% both groups), and chronic lung disease (6% and 5%).<br>• 48% of patients in both arms received corticosteroids.<br>**Primary Outcomes:**<br>• In-hospital mortality: 301 deaths (11.0%) in RDV arm, 303 deaths (11.2%) in SOC arm<br>• Rate ratios for in-hospital death:<br>  • Overall: 0.95 (95% CI, 0.81–1.11)<br>  • No mechanical ventilation at entry: 0.86 (99% CI, 0.67–1.11)<br>  • Mechanical ventilation at entry: 1.20 (99% CI, 0.80–1.80)<br>**Secondary Outcomes:**<br>• Initiation of mechanical ventilation: 295 patients (10.8%) in RDV arm, 284 patients (10.5%) in SOC arm | **Interpretation:**<br>• RDV did not decrease in-hospital mortality in hospitalized patients when compared to local SOC. |
| **Remdesivir Versus Standard of Care in Hospitalized Patients with Moderate COVID-19[4]** | | | |
| Open-label randomized trial in hospitalized patients (n = 596) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• Moderate pneumonia, defined as radiographic evidence of pulmonary infiltrates and $SpO_2$ >94% on room air<br>**Key Exclusion Criteria:**<br>• ALT or AST >5 times ULN<br>• CrCl <50 mL/min | **Number of Participants:**<br>• 584 patients began treatment: 10-day RDV (n = 193), 5-day RDV (n = 191), and SOC (n = 200)<br>**Participant Characteristics:**<br>• Demographic and baseline disease characteristics were similar across all arms.<br>**Outcomes:**<br>• 5-day RDV had significantly higher odds of better clinical status distribution on Day 11 than SOC (OR 1.65; 95% CI, 1.09–2.48; $P = 0.02$). | **Limitations:**<br>• Open-label design may have affected decisions related to concomitant medication use and hospital discharge.<br>• Greater proportion of patients in SOC arm received HCQ, LPV/RTV, or AZM, which may cause AEs and have not shown clinical benefits in hospitalized patients with COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Remdesivir Versus Standard of Care in Hospitalized Patients with Moderate COVID-19[4]**, continued | | | |
| | **Interventions:**<br>• IV RDV 200 mg on Day 1, then 100 mg daily for 9 days<br>• IV RDV 200 mg on Day 1, then 100 mg daily for 4 days<br>• Local SOC<br>**Primary Endpoint:**<br>• Clinical status on Day 11, as measured by a 7-point ordinal scale | • Clinical status distribution on Day 11 was not significantly different between the 10-day RDV and SOC arms ($P = 0.18$).<br>• By Day 28, there were more hospital discharges among patients who received RDV (89% in 5-day arm and 90% in 10-day arm) than those who received SOC (83%).<br>• Mortality was low in all arms (1% to 2%).<br>• Percentages of patients with AEs in RDV arms vs. SOC arm: nausea (10% vs. 3%), hypokalemia (6% vs. 2%), and headache (5% vs. 3%) | • No data on time to return to activity for discharged patients<br>**Interpretation:**<br>• Hospitalized patients with moderate COVID-19 who received 5 days of RDV had better outcomes than those who received SOC; however, difference between arms was of uncertain clinical importance. |
| **Different Durations of Remdesivir Treatment in Hospitalized Patients[5]** | | | |
| Manufacturer-sponsored, multinational, randomized, open-label trial in hospitalized patients with COVID-19 (n = 402) | **Key Inclusion Criteria:**<br>• Aged ≥12 years<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• Radiographic evidence of pulmonary infiltrates<br>• $SpO_2$ ≤94% on room air or receipt of supplemental oxygen<br>**Key Exclusion Criteria:**<br>• Receipt of mechanical ventilation or ECMO<br>• Multiorgan failure<br>• ALT or AST >5 times ULN<br>• Estimated CrCl <50 mL/min<br>**Interventions:**<br>• IV RDV 200 mg on Day 1, then 100 mg daily for 4 days<br>• IV RDV 200 mg on Day 1, then 100 mg daily for 9 days<br>**Primary Endpoint:**<br>• Clinical status at Day 14, as measured by a 7-point ordinal scale | **Number of Participants:**<br>• 397 participants began treatment: 5-day RDV (n = 200) and 10-day RDV (n = 197)<br>**Participant Characteristics:**<br>• At baseline, patients in 10-day arm had worse clinical status (based on ordinal scale distribution) than those in 5-day arm ($P = 0.02$)<br>**Outcomes:**<br>• After adjusting for imbalances in baseline clinical status, Day 14 distribution in clinical status on the ordinal scale was similar between arms ($P = 0.14$).<br>• Time to achieve clinical improvement of at least 2 levels on the ordinal scale (median day of 50% cumulative incidence) was similar between arms (10 days vs. 11 days).<br>• Median durations of hospitalization among patients discharged on or before Day 14 were similar between 5-day (7 days; IQR 6–10 days) and 10-day arms (8 days; IQR 5–10 days).<br>• Percentages of patients with SAEs: 35% in 10-day arm, 21% in 5-day arm | **Limitations:**<br>• This was an open-label trial without a placebo control arm, so clinical benefit of RDV (compared with no RDV) could not be assessed.<br>• There were baseline imbalances in clinical status of patients in the 5-day and 10-day arms.<br>**Interpretation:**<br>• In hospitalized patients with severe COVID-19 who were not on mechanical ventilation or ECMO, RDV treatment for 5 or 10 days had a similar clinical benefit. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Different Durations of Remdesivir Treatment in Hospitalized Patients[5]**, continued | | | |
| | | • Discontinuations due to AEs: 4% of patients in 5-day arm, 10% in 10-day arm | |

**Key:** AE = adverse effects; ALT = alanine transaminase; AST = aspartate aminotransferase; AZM = azithromycin; CrCl = creatinine clearance; ECMO = extracorporeal membrane oxygenation; eGFR = estimated glomerular filtration rate; HCQ = hydroxychloroquine; IFN = interferon; ITT = intention to treat; IV = intravenous; LPV/RTV = lopinavir/ritonavir; the Panel = the COVID-19 Treatment Guidelines Panel; $PaO_2/FiO_2$ = ratio of arterial partial pressure of oxygen to fraction of inspired oxygen; RCT = randomized controlled trial; RDV = remdesivir; RRR = recovery rate ratio; SAE = serious adverse effects; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; SOC = standard of care; $SpO_2$ = saturation of oxygen; ULN = upper limit of normal

## References


1. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the treatment of COVID-19—final report. *N Engl J Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32445440.
2. Wang Y, Zhang D, Du G, et al. Remdesivir in adults with severe COVID-19: a randomised, double-blind, placebo-controlled, multicentre trial. *Lancet*. 2020;395(10236):1569-1578. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32423584.
3. WHO Solidarity Trial Consortium, Pan H, Peto R, et al. Repurposed antiviral drugs for COVID-19—interim WHO Solidarity Trial results. *N Engl J Med.* 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33264556.
4. Spinner CD, Gottlieb RL, Criner GJ, et al. Effect of remdesivir vs standard care on clinical status at 11 days in patients with moderate COVID-19: a randomized clinical trial. *JAMA*. 2020;324(11):1048-1057. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32821939.
5. Goldman JD, Lye DCB, Hui DS, et al. Remdesivir for 5 or 10 days in patients with severe COVID-19. *N Engl J Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32459919.

# Chloroquine or Hydroxychloroquine and/or Azithromycin

*Last Updated: July 8, 2021*

Chloroquine is an antimalarial drug that was developed in 1934. Hydroxychloroquine, an analogue of chloroquine, was developed in 1946. Hydroxychloroquine is used to treat autoimmune diseases, such as systemic lupus erythematosus and rheumatoid arthritis, in addition to malaria.

Both chloroquine and hydroxychloroquine increase the endosomal pH, which inhibits fusion between SARS-CoV-2 and the host cell membrane.[1] Chloroquine inhibits glycosylation of the cellular angiotensin-converting enzyme 2 (ACE2) receptor, which may interfere with the binding of SARS-CoV to the cell receptor.[2] In vitro studies have suggested that both chloroquine and hydroxychloroquine may block the transport of SARS-CoV-2 from early endosomes to endolysosomes, possibly preventing the release of the viral genome.[3] Both chloroquine and hydroxychloroquine also have immunomodulatory effects, which have been hypothesized to be another potential mechanism of action for the treatment of COVID-19. Azithromycin has antiviral and anti-inflammatory properties. When used in combination with hydroxychloroquine, it has been shown to have a synergistic effect on SARS-CoV-2 in vitro and in molecular modeling studies.[4,5] However, despite demonstrating antiviral activity in some in vitro systems, neither hydroxychloroquine plus azithromycin nor hydroxychloroquine alone reduced upper or lower respiratory tract viral loads or demonstrated clinical efficacy in a rhesus macaque model.[6]

The safety and efficacy of chloroquine or hydroxychloroquine with or without azithromycin and azithromycin alone have been evaluated in randomized clinical trials, observational studies, and/or single-arm studies. Please see Table 2b for more information.

## Recommendation

- The COVID-19 Treatment Guidelines Panel (the Panel) **recommends against** the use of chloroquine or hydroxychloroquine and/or azithromycin for the treatment of COVID-19 in hospitalized patients **(AI)** and in nonhospitalized patients **(AIIa)**.

## Rationale

### *Hospitalized Patients*

In a large randomized controlled platform trial of hospitalized patients in the United Kingdom (RECOVERY), hydroxychloroquine did not decrease 28-day mortality when compared to the usual standard of care. Patients who were randomized to receive hydroxychloroquine had a longer median hospital stay than those who received the standard of care. In addition, among patients who were not on invasive mechanical ventilation at the time of randomization, those who received hydroxychloroquine were more likely to subsequently require intubation or die during hospitalization than those who received the standard of care.[7]

The results from several additional large randomized controlled trials have been published; these trials have failed to show a benefit for hydroxychloroquine with or without azithromycin or azithromycin alone in hospitalized adults with COVID-19. In the Solidarity trial, an international randomized controlled platform trial that enrolled hospitalized patients with COVID-19, the hydroxychloroquine arm was halted for futility. There was no difference in in-hospital mortality between patients in the hydroxychloroquine arm and those in the control arm.[8] Similarly, PETAL, a randomized, placebo-controlled, blinded study, was stopped early for futility. In this study, there was no difference in the median scores on the COVID Outcomes Scale between patients who received hydroxychloroquine and those who received placebo.[9] Data from two additional randomized studies of hospitalized patients

with COVID-19 did not support using hydroxychloroquine plus azithromycin over hydroxychloroquine alone.[10,11] In RECOVERY, azithromycin alone (without hydroxychloroquine) did not improve survival or other clinical outcomes when compared to the usual standard of care.[12]

In addition to these randomized trials, data from large retrospective observational studies do not consistently show evidence of a benefit for hydroxychloroquine with or without azithromycin in hospitalized patients with COVID-19.[13-15] Please see Table 2b or the archived versions of the Guidelines for more information.

Given the lack of a benefit seen in the randomized clinical trials, the Panel **recommends against** using hydroxychloroquine or chloroquine and/or azithromycin to treat COVID-19 in hospitalized patients **(AI)**.

### *Nonhospitalized Patients*

Several randomized trials have not shown a clinical benefit for hydroxychloroquine in nonhospitalized patients with early, asymptomatic, or mild COVID-19.[16,17] In an open-label trial, Mitja et al. randomized 307 nonhospitalized people who were recently confirmed to have COVID-19 to receive hydroxychloroquine or no antiviral treatment. Patients in the hydroxychloroquine arm received hydroxychloroquine 800 mg on Day 1 followed by 400 mg daily for an additional 6 days. The authors reported no difference in the mean reduction in SARS-CoV-2 RNA at Day 3 or the time to clinical improvement between the two arms (see Table 2b for more information). In another trial, treating patients who had asymptomatic or mild COVID-19 with hydroxychloroquine with or without azithromycin did not result in greater rates of virologic clearance (as measured by a negative polymerase chain reaction [PCR] result on Day 6).[18]

An open-label, prospective, randomized trial compared oral azithromycin 500 mg once daily for 3 days plus standard of care to standard of care alone in nonhospitalized, high-risk, older adults who had laboratory-confirmed or suspected COVID-19. No differences were observed between the arms in the primary endpoints of time to first self-reported recovery and hospitalization or death due to COVID-19. These findings remained consistent in an analysis that was restricted to participants with positive SARS-CoV-2 PCR results. The study was ultimately halted due to futility.[19] Similarly, in a preliminary report from ATOMIC-2, adding oral azithromycin 500 mg once daily to standard of care for 14 days did not reduce the risk of hospitalization or death among 292 participants with mild to moderate COVID-19.[20]

While ongoing clinical trials are still evaluating the use of chloroquine, hydroxychloroquine, and azithromycin in outpatients, the existing data suggest that it is unlikely that clinical benefits will be identified for these agents. The Panel **recommends against** the use of chloroquine or hydroxychloroquine and/or azithromycin for the treatment of COVID-19 in nonhospitalized patients **(AIIa)**.

## Adverse Effects

Chloroquine and hydroxychloroquine have similar toxicity profiles, although hydroxychloroquine is better tolerated and has a lower incidence of toxicity than chloroquine. Cardiac adverse events that have been reported in people who received hydroxychloroquine include QTc prolongation, Torsades de Pointes, ventricular arrythmia, and cardiac deaths.[21]

The use of azithromycin has also been associated with QTc prolongation,[22] and using it in combination with hydroxychloroquine has been associated with a higher incidence of QTc prolongation and cardiac adverse events in patients with COVID-19.[23,24]

## Drug-Drug Interactions

Chloroquine and hydroxychloroquine are moderate inhibitors of cytochrome P450 2D6, and these drugs

are also P-glycoprotein inhibitors. Chloroquine and hydroxychloroquine may decrease the antiviral activity of remdesivir; coadministration of these drugs **is not recommended**.[25]

## Drug Availability

Hydroxychloroquine, chloroquine, and azithromycin **are not approved** by the Food and Drug Administration (FDA) for the treatment of COVID-19. Furthermore, the FDA Emergency Use Authorization for hydroxychloroquine and chloroquine was revoked in June 2020.

## References


1. Wang M, Cao R, Zhang L, et al. Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. *Cell Res*. 2020;30(3):269-271. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32020029.
2. Vincent MJ, Bergeron E, Benjannet S, et al. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. *Virol J*. 2005;2:69. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16115318.
3. Liu J, Cao R, Xu M, et al. Hydroxychloroquine, a less toxic derivative of chloroquine, is effective in inhibiting SARS-CoV-2 infection in vitro. *Cell Discov*. 2020;6:16. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32194981.
4. Fantini J, Chahinian H, Yahi N. Synergistic antiviral effect of hydroxychloroquine and azithromycin in combination against SARS-CoV-2: what molecular dynamics studies of virus-host interactions reveal. *Int J Antimicrob Agents*. 2020. Available at: https://pubmed.ncbi.nlm.nih.gov/32405156/.
5. Andreani J, Bideau ML, Duflot I, et al. In vitro testing of combined hydroxychloroquine and azithromycin on SARS-CoV-2 shows synergistic effect. *Microb Pathog*. 2020. Available at: https://pubmed.ncbi.nlm.nih.gov/32344177/.
6. Maisonnasse P, Guedj J, Contreras V, et al. Hydroxychloroquine use against SARS-CoV-2 infection in non-human primates. *Nature*. 2020;585(7826):584-587. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32698191.
7. Recovery Collaborative Group, Horby P, Mafham M, et al. Effect of hydroxychloroquine in hospitalized patients with COVID-19. *N Engl J Med*. 2020;383(21):2030-2040. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33031652.
8. WHO Solidarity Trial Consortium, Pan H, Peto R, et al. Repurposed antiviral drugs for COVID-19—interim WHO Solidarity Trial results. *N Engl J Med*. 2021;384(6):497-511. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33264556.
9. Self WH, Semler MW, Leither LM, et al. Effect of hydroxychloroquine on clinical status at 14 days in hospitalized patients with COVID-19: a randomized clinical trial. *JAMA*. 2020;324(21):2165-2176. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33165621.
10. Furtado RHM, Berwanger O, Fonseca HA, et al. Azithromycin in addition to standard of care versus standard of care alone in the treatment of patients admitted to the hospital with severe COVID-19 in Brazil (COALITION II): a randomised clinical trial. *Lancet*. 2020;396(10256):959-967. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32896292.
11. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without azithromycin in mild-to-moderate COVID-19. *N Engl J Med*. 2020;383(21):2041-2052. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32706953.
12. Recovery Collaborative Group. Azithromycin in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *Lancet*. 2021;397(10274):605-612. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33545096.
13. Rosenberg ES, Dufort EM, Udo T, et al. Association of treatment with hydroxychloroquine or azithromycin with in-hospital mortality in patients with COVID-19 in New York state. *JAMA*. 2020. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/32392282.

14. Geleris J, Sun Y, Platt J, et al. Observational study of hydroxychloroquine in hospitalized patients with COVID-19. *N Engl J Med*. 2020;382(25):2411-2418. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32379955.
15. Arshad S, Kilgore P, Chaudhry ZS, et al. Treatment with hydroxychloroquine, azithromycin, and combination in patients hospitalized with COVID-19. *Int J Infect Dis*. 2020;97:396-403. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32623082.
16. Skipper CP, Pastick KA, Engen NW, et al. Hydroxychloroquine in nonhospitalized adults with early COVID-19: a randomized trial. *Ann Intern Med*. 2020;173(8):623-631. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32673060.
17. Mitja O, Corbacho-Monne M, Ubals M, et al. Hydroxychloroquine for early treatment of adults with mild COVID-19: a randomized-controlled trial. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32674126.
18. Omrani AS, Pathan SA, Thomas SA, et al. Randomized double-blinded placebo-controlled trial of hydroxychloroquine with or without azithromycin for virologic cure of non-severe COVID-19. *EClinicalMedicine*. 2020. Available at: https://pubmed.ncbi.nlm.nih.gov/33251500/.
19. PRINCIPLE Trial Collaborative Group. Azithromycin for community treatment of suspected COVID-19 in people at increased risk of an adverse clinical course in the UK (PRINCIPLE): a randomised, controlled, open-label, adaptive platform trial. *The Lancet*. 2021;397(10279):1063-1074. Available at: https://pubmed.ncbi.nlm.nih.gov/33676597/.
20. Hinks TS, Lucy C, Knight R, et al. A randomised clinical trial of azithromycin versus standard care in ambulatory COVID-19—the ATOMIC2 trial. *MedRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.21.21255807v1.
21. Nguyen LS, Dolladille C, Drici MD, et al. Cardiovascular toxicities associated with hydroxychloroquine and azithromycin: an analysis of the World Health Organization pharmacovigilance database. *Circulation*. 2020;142(3):303-305. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32442023.
22. Azithromycin (Zithromax) [package insert]. Food and Drug Administration. 2013. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2013/050710s039,050711s036,050784s023lbl.pdf.
23. Mercuro NJ, Yen CF, Shim DJ, et al. Risk of QT interval prolongation associated with use of hydroxychloroquine with or without concomitant azithromycin among hospitalized patients testing positive for coronavirus disease 2019 (COVID-19). *JAMA Cardiol*. 2020;5(9):1036-1041. Available at: https://pubmed.ncbi.nlm.nih.gov/32936252/.
24. Chorin E, Wadhwani L, Magnani S, et al. QT interval prolongation and torsade de pointes in patients with COVID-19 treated with hydroxychloroquine/azithromycin. *Heart Rhythm*. 2020;17(9):1425-1433. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32407884.
25. Food and Drug Administration. Remdesivir by Gilead Sciences: FDA warns of newly discovered potential drug interaction that may reduce effectiveness of treatment. 2020. Available at: https://www.fda.gov/safety/medical-product-safety-information/remdesivir-gilead-sciences-fda-warns-newly-discovered-potential-drug-interaction-may-reduce.

# Table 2b. Chloroquine or Hydroxychloroquine and/or Azithromycin: Selected Clinical Data

*Last Updated: July 8, 2021*

The information in this table may include data from preprints or articles that have not been peer reviewed. This section will be updated as new information becomes available. Please see *ClinicalTrials.gov* for more information on clinical trials that are evaluating CQ, HCQ, and/or AZM.

The Panel has reviewed other clinical studies of HCQ with or without AZM, CQ, and AZM for the treatment of COVID-19.[1-19] These studies have limitations that make them less definitive and informative than the studies discussed here. The Panel's summaries and interpretations of some of those studies are available in the archived versions of the COVID-19 Treatment Guidelines.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Solidarity Trial: Hydroxychloroquine in Hospitalized Patients With COVID-19[20]** | | | |
| Open-label randomized controlled platform trial with multiple arms; in 1 arm, hospitalized patients received HCQ (n = 11,330) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Received a diagnosis of COVID-19<br>**Key Exclusion Criteria:**<br>• Already receiving study drug<br>• Expected to be transferred elsewhere within 72 hours<br>**Interventions:**<br>• HCQ plus local SOC. Patients received a loading dose of HCQ 800 mg PO at entry, then HCQ 800 mg PO 6 hours later followed by a daily dose of HCQ 400 mg PO twice daily for 10 days, starting 12 hours after the entry dose.<br>• Local SOC alone | **Number of Participants:**<br>• ITT analysis: HCQ (n = 947) and HCQ control (n = 906)<br>• Enrollment occurred between March 22 and October 4, 2020.<br>**Participant Characteristics:**<br>• 35% of patients enrolled in each arm were aged <50 years; 21% of patients were aged ≥70 years.<br>• 21% to 23% of patients had diabetes mellitus, 20% to 21% had heart disease, and 6.5% to 7% had chronic lung disease.<br>• At entry, 36% to 38% of patients were not on supplemental oxygen, 53% to 55% were receiving supplemental oxygen only, and 9% were receiving IMV.<br>• SOC included corticosteroids for 23% of patients in HCQ arm and 22% of patients in SOC only arm.<br>**Outcomes:**<br>• No significant difference in in-hospital mortality; 104 patients (10.2%) in HCQ arm and 84 patients (8.9%) in SOC arm died by Day 28 (rate ratio 1.19; 95% CI, 0.89–1.59; $P = 0.23$). | **Key Limitations:**<br>• Not blinded<br>• Disease severity varied widely among patients.<br>**Interpretation:**<br>• HCQ does not decrease in-hospital mortality in hospitalized patients with COVID-19 when compared to SOC.<br>• HCQ does not decrease the need for mechanical ventilation when compared to SOC.<br>• There was no evidence of harm in the HCQ arm. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Solidarity Trial: Hydroxychloroquine in Hospitalized Patients With COVID-19[20]**, continued | | | |
| | **Primary Endpoint:**<br>• In-hospital mortality (i.e., death during the original hospitalization; follow-up ended at discharge from the hospital) | • Subgroup analyses based on age or respiratory support at entry reported no significant difference in mortality between the arms.<br>• No difference between the arms in the secondary outcome of initiation of ventilation, and no difference in the composite outcome of in-hospital mortality or initiation of ventilation<br>• The number of deaths due to any cardiac cause during the 14 days after enrollment (the dosing period) was lower in these 2 arms than in the other study arms (the RDV, LPV/RTV, and IFN arms and their respective control arms). | |
| **PETAL Trial: Hydroxychloroquine in Hospitalized Patients With COVID-19[21]** | | | |
| Randomized, placebo-controlled, blinded trial in hospitalized adults (n = 479) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• Symptoms of respiratory illness for <10 days<br>**Key Exclusion Criteria:**<br>• More than 1 dose of HCQ or CQ during the previous 10 days<br>• Prolonged QTc interval (>500 ms)<br>**Interventions:**<br>• HCQ 400 mg PO twice daily for 2 doses, then HCQ 200 mg PO twice daily for 8 doses<br>• Matching placebo<br>**Primary Endpoint:**<br>• Clinical status 14 days after randomization, as measured by a 7-point ordinal scale (the COVID Outcomes Scale) | **Number of Participants:**<br>• Enrollment occurred between April 2 and June 19, 2020.<br>• HCQ (n = 242) and placebo (n = 237)<br>• Planned sample size was 510 participants, but study enrollment was halted early due to futility.<br>**Participant Characteristics:**<br>• Median age was 58 and 57 years in HCQ and placebo arms, respectively; 33% of patients were aged ≥65 years and 24% of patients were Black/African American.<br>• 33% to 36% of patients had diabetes mellitus, 6% to 12% had heart disease, and 7% to 9% had chronic lung disease.<br>• At randomization, 5.4% of patients in HCQ arm and 8% in placebo arm were receiving IMV or ECMO. In both arms, 11% to 12% of patients were receiving noninvasive ventilation or HFNC oxygen, 46% to 48% were receiving low-flow oxygen, and 35% were receiving no respiratory support.<br>• Among the patients who received concomitant medications, 22% received RDV, 19% received AZM, and 18% received corticosteroids. There was no difference in concomitant medication use between the arms. | **Key Limitations:**<br>• It is unclear how the primary outcome of this study (a median COVID Outcomes Scale score) translates to clinical practice.<br>**Interpretation:**<br>• HCQ does not improve patient scores on the COVID Outcomes Scale in hospitalized patients with laboratory-confirmed SARS-CoV-2 infection when compared to placebo.<br>• HCQ did not improve survival or time to discharge in these patients when compared to placebo. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **PETAL Trial: Hydroxychloroquine in Hospitalized Patients With COVID-19[21]**, continued | | | |
| | | **Outcomes:**<br>• Median COVID Outcomes Scale score was 6 in HCQ arm (IQR 4–7) and 6 in placebo arm (IQR 4–7; aOR 1.02; 95% CI, 0.73–1.42).<br>• No difference between the arms in the secondary outcome of all-cause, all-location death at Day 14 and Day 28<br>• No difference between the arms in the number of any of the following systematically collected safety events: cardiac arrest treated with CPR, symptomatic hypoglycemia, ventricular arrhythmia, or seizure<br>• Among patients who had QTc assessed, 5.9% in HCQ arm and 3.3% in placebo arm had a recorded QTc interval >500 ms during the first 5 days of dosing. | |
| **RECOVERY Trial[22]** | | | |
| Open-label, randomized controlled platform trial with multiple arms; in 1 arm, hospitalized patients received HCQ (n = 11,197) | **Key Inclusion Criteria:**<br>• Clinically suspected or laboratory-confirmed SARS-CoV-2 infection<br>**Key Exclusion Criteria:**<br>• Patients with prolonged QTc intervals were excluded from HCQ arm.<br>**Interventions:**<br>• HCQ 800 mg at entry and at 6 hours, then HCQ 400 mg every 12 hours for 9 days or until discharge<br>• Usual SOC<br>**Primary Endpoint:**<br>• All-cause mortality at Day 28 after randomization | **Number of Participants:**<br>• HCQ (n = 1,561) and SOC (n = 3,155)<br>• Study enrollment ended early after investigators and trial-steering committee concluded that the data showed no benefit for HCQ.<br>**Participant Characteristics:**<br>• Mean age was 65 years in both arms; 41% of patients were aged ≥70 years.<br>• 90% of patients had laboratory-confirmed SARS-CoV-2 infection.<br>• 57% of patients had ≥1 major comorbidity: 27% had diabetes mellitus, 26% had heart disease, and 22% had chronic lung disease.<br>• At randomization, 17% of patients were receiving IMV or ECMO, 60% were receiving oxygen only (with or without noninvasive ventilation), and 24% were receiving neither.<br>• Use of AZM or another macrolide during the follow-up period was similar in both arms, as was use of dexamethasone. | **Key Limitations:**<br>• Not blinded<br>• Information on occurrence of new major cardiac arrythmia was not collected throughout the trial.<br>**Interpretation:**<br>• HCQ does not decrease 28-day all-cause mortality when compared to the usual SOC in hospitalized patients with clinically suspected or laboratory-confirmed SARS-CoV-2 infection.<br>• Patients who received HCQ had a longer median length of hospital stay, and those who were not on IMV at the time of randomization were more likely to require intubation or die during hospitalization if they received HCQ. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **RECOVERY Trial[22]**, continued | | | |
| | | **Outcomes:**<br>• No significant difference in 28-day mortality between the 2 arms; 421 patients (26.8%) in HCQ arm and 790 patients (27.0%) in SOC arm had died by Day 28 (rate ratio 1.09; 95% CI, 0.97–1.23; $P = 0.15$).<br>• A similar 28-day mortality for HCQ patients was reported during the post hoc exploratory analysis that was restricted to the 4,266 participants (90.5%) who had a positive SARS-CoV-2 test result.<br>• Patients in HCQ arm were less likely to survive hospitalization and had a longer median time to discharge than patients in SOC arm.<br>• Patients who received HCQ and who were not on IMV at baseline had an increased risk of requiring intubation and an increased risk of death.<br>• At the beginning of the study, the researchers did not record whether a patient developed a major cardiac arrhythmia after study enrollment; however, these data were later collected for 735 patients (47.1%) in HCQ arm and 1,421 patients (45.0%) in SOC arm.<br>• No differences between the arms in the frequency of supraventricular tachycardia, ventricular tachycardia or fibrillation, or instances of AV block that required intervention; 1 case of Torsades de Pointes was reported in HCQ arm. | |
| **Hydroxychloroquine and Hydroxychloroquine Plus Azithromycin for Mild or Moderate COVID-19[23]** | | | |
| Open-label, 3-arm RCT in hospitalized adults (n = 667) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Clinically suspected or laboratory-confirmed SARS-CoV-2 infection<br>• Mild or moderate COVID-19<br>• Duration of symptoms ≤14 days | **Number of Participants:**<br>• mITT analysis included patients with laboratory-confirmed SARS-CoV-2 infection (n = 504).<br>**Participant Characteristics:**<br>• Mean age was 50 years.<br>• 58% of patients were men. | **Key Limitations:**<br>• Not blinded<br>• Follow-up period was restricted to 15 days.<br>**Interpretation:**<br>• Neither HCQ alone nor HCQ plus AZM improved clinical outcomes at Day 15 after randomization among hospitalized patients |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Hydroxychloroquine and Hydroxychloroquine Plus Azithromycin for Mild or Moderate COVID-19[23]**, continued | | | |
| | **Key Exclusion Criteria:**<br>• Need for >4 L of supplemental oxygen or ≥40% $FiO_2$ by face mask<br>• History of ventricular tachycardia<br>• QT interval ≥480 ms<br>**Interventions:**<br>• HCQ 400 mg twice daily for 7 days plus SOC<br>• HCQ 400 mg twice daily plus AZM 500 mg daily for 7 days plus SOC<br>• SOC alone<br>**Primary Endpoint:**<br>• Clinical status at Day 15, as measured by a 7-point ordinal scale among the patients with confirmed SARS-CoV-2 infection<br>**Ordinal Scale Definitions:**<br>1. Not hospitalized, no limitations<br>2. Not hospitalized, with limitations<br>3. Hospitalized, not on oxygen<br>4. Hospitalized, on oxygen<br>5. Hospitalized, oxygen administered by HFNC or noninvasive ventilation<br>6. Hospitalized, on mechanical ventilation<br>7. Death | • At baseline, 58.2% of patients were Ordinal Level 3; 41.8% were Ordinal Level 4.<br>• Median time from symptom onset to randomization was 7 days.<br>• 23.3% to 23.9% of patients received oseltamivir.<br>**Outcomes:**<br>• No significant difference in the odds of worse clinical status at Day 15 between patients in HCQ arm (OR 1.21; 95% CI, 0.69–2.11; $P = 1.00$) and patients in HCQ plus AZM arm (OR 0.99; 95% CI, 0.57–1.73; $P = 1.00$)<br>• No significant differences in secondary outcomes of the 3 arms, including progression to mechanical ventilation during the first 15 days and mean number of days "alive and free of respiratory support"<br>• A greater proportion of patients in HCQ plus AZM arm (39.3%) and HCQ arm (33.7%) experienced AEs than those in SOC arm (22.6%).<br>• QT prolongation was more common in patients who received HCQ plus AZM or HCQ alone than in patients who received SOC alone, but fewer patients in SOC arm had serial electrocardiographic studies performed during the follow-up period. | with mild or moderate COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Hydroxychloroquine in Nonhospitalized Adults With Early COVID-19[24]** | | | |
| Randomized, placebo-controlled trial in nonhospitalized adults (n = 491) | **Key Inclusion Criteria:**<br>• Symptoms that were compatible with COVID-19 and lasted ≤4 days<br>• Either laboratory-confirmed SARS-CoV-2 infection or high-risk exposure within the previous 14 days<br>**Key Exclusion Criteria:**<br>• Aged <18 years<br>• Hospitalized<br>• Receipt of certain medications<br>**Interventions:**<br>• HCQ 800 mg once, then HCQ 600 mg in 6–8 hours, then HCQ 600 mg once daily for 4 days<br>• Placebo<br>**Primary Endpoints:**<br>• Planned primary endpoint was ordinal outcome by Day 14 in 4 categories: not hospitalized, hospitalized, ICU stay, or death.<br>• Because event rates were lower than expected, a new primary endpoint was defined: change in overall symptom severity over 14 days, measured by a 10-point, self-reported, visual analogue scale | **Number of Participants:**<br>• Contributed to primary endpoint data: HCQ (n = 212) and placebo (n = 211)<br>**Participant Characteristics:**<br>• 241 patients were exposed to people with COVID-19 through their position as health care workers (57%), 106 were exposed through household contacts (25%), and 76 had other types of exposure (18%).<br>• Median age was 40 years.<br>• 56% of patients were women.<br>• Only 3% of patients were Black.<br>• Very few patients had comorbidities: 11% had hypertension, 4% had diabetes, and 68% had no chronic medical conditions.<br>• 56% of patients were enrolled on Day 1 of symptom onset.<br>• 341 participants (81%) had either a positive PCR result or a high-risk exposure to a PCR-positive contact.<br>**Outcomes:**<br>• Compared to the placebo recipients, HCQ recipients had a nonsignificant 12% difference in improvement in symptoms between baseline and Day 14 (-2.60 vs. -2.33 points; $P = 0.117$).<br>• Ongoing symptoms were reported by 24% of those in HCQ arm and 30% of those in the placebo arm at Day 14 ($P = 0.21$).<br>• No difference in the incidence of hospitalization between the arms (4 patients in the HCQ arm vs. 10 patients in placebo arm); 2 of 10 placebo participants were hospitalized for reasons that were unrelated to COVID-19<br>• A higher percentage of patients in HCQ arm experienced AEs than patients in placebo arm (43% vs. 22%; $P < 0.001$). | **Key Limitations:**<br>• This study enrolled a highly heterogeneous population.<br>• Only 227 of 423 participants (53.7%) were confirmed PCR-positive for SARS-CoV-2.<br>• Changing the primary endpoint without a new power calculation makes it difficult to assess whether the study is powered to detect differences in outcomes between the study arms.<br>• This study used surveys for screening, symptom assessment, and adherence reporting.<br>• Visual analogue scales are not commonly used, and their ability to assess acute viral respiratory infections in clinical trials has not been validated.<br>**Interpretation:**<br>• The study has some limitations, and it did not find evidence that early administration of HCQ reduced symptom severity in patients with mild COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Hydroxychloroquine in Nonhospitalized Adults With Mild COVID-19[25]** | | | |
| Open-label RCT in nonhospitalized adults (n = 353) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• <5 days of mild COVID-19 symptoms<br>**Key Exclusion Criteria:**<br>• Moderate to severe COVID-19<br>• Severe liver or renal disease<br>• History of cardiac arrhythmia<br>• QT prolongation<br>**Interventions:**<br>• HCQ 800 mg on Day 1, then HCQ 400 mg once daily for 6 days<br>• No antiviral treatment (control arm)<br>**Primary Endpoint:**<br>• Reduction in SARS-CoV-2 viral load, assessed using NP swabs on Days 3 and 7<br>**Secondary Endpoints:**<br>• Disease progression up to Day 28<br>• Time to complete resolution of symptoms | **Number of Participants:**<br>• ITT analysis: HCQ (n = 136) and control (n = 157)<br>• 60 patients were excluded from the ITT analysis due to negative baseline RT-PCR, missing RT-PCR at follow-up visits, or consent withdrawal.<br>**Participant Characteristics:**<br>• Mean age was 41.6 years.<br>• 67% of patients were woman.<br>• Majority of patients were health care workers (87%).<br>• 53% of patients reported chronic health conditions.<br>• Median time from symptom onset to enrollment was 3 days (IQR 2–4 days).<br>• Most common COVID-19 symptoms were fever, cough, and sudden olfactory loss.<br>**Outcomes:**<br>• No significant difference in viral load reduction between control arm and HCQ arm at Day 3<br>• (-1.41 vs. -1.41 $\log_{10}$ copies/mL; difference of 0.01; 95% CI, -0.28 to 0.29), or at Day 7 (-3.37 vs. -3.44 log10 copies/mL; difference of -0.07; 95% CI, -0.44 to 0.29).<br>• No difference in the risk of hospitalization between control arm and HCQ arm (7.1% vs. 5.9%; risk ratio 0.75; 95% CI, 0.32–1.77)<br>• No difference in the median time from randomization to the resolution of COVID-19 symptoms between the 2 arms (12.0 days in control arm vs. 10.0 days in HCQ arm; $P = 0.38$)<br>• A higher percentage of participants in the HCQ arm than in the control arm experienced AEs during the 28-day follow-up period (72% vs. 9%). Most common AEs were GI disorders and "nervous system disorders."<br>• SAEs were reported in 12 patients in control arm and 8 patients in HCQ arm. SAEs that occurred among patients in HCQ arm were not deemed to be related to the drug. | **Key Limitations:**<br>• Open-label, non-placebo-controlled trial<br>• Study design allowed for the possibility of dropouts in control arm and over-reporting of AEs in HCQ arm.<br>• The intervention changed during the study; the authors initially planned to include HCQ plus DRV/COBI.<br>• The majority of the participants were relatively young health care workers.<br>**Interpretation:**<br>• Early administration of HCQ to patients with mild COVID-19 did not result in improvement in virologic clearance, a lower risk of disease progression, or a reduced time to symptom improvement. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Observational Study on Hydroxychloroquine With or Without Azithromycin[26]** | | | |
| Retrospective, multicenter, observational study in a random sample of hospitalized adults with COVID-19 from the New York Department of Health (n = 1,438) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>**Interventions:**<br>• HCQ plus AZM<br>• HCQ alone<br>• AZM alone<br>• Neither drug<br>**Primary Endpoint:**<br>• In-hospital mortality<br>**Secondary Endpoint:**<br>• Cardiac arrest and arrhythmia or QT prolongation on an ECG | **Number of Participants:**<br>• HCQ plus AZM (n = 735), HCQ alone (n = 271), AZM alone (n = 211), and neither drug (n = 221)<br>Participant Characteristics:<br>• Patients in the treatment arms had more severe disease at baseline than those who received neither drug.<br>**Outcomes:**<br>• In adjusted analyses, patients who received 1 of the 3 treatment regimens did not show a decreased in-hospital mortality rate when compared with those who received neither drug.<br>• Patients who received HCQ plus AZM had a greater risk of cardiac arrest than patients who received neither drug (OR 2.13; 95% CI, 1.12–4.05). | **Key Limitations:**<br>• This study has the inherent limitations of an observational study, including residual confounding from confounding variables that were unrecognized and/or unavailable for analysis.<br>**Interpretation:**<br>• Despite the limitations discussed above, these findings suggest that although HCQ and AZM are not associated with an increased risk of in-hospital death, the combination of HCQ and AZM may be associated with an increased risk of cardiac arrest. |
| **Observational Study of Hydroxychloroquine Versus No Hydroxychloroquine in New York City[27]** | | | |
| Observational study in hospitalized adults with COVID-19 at a large medical center (n = 1,376) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>**Key Exclusion Criteria:**<br>• Intubation, death, or transfer to another facility within 24 hours of arriving at the emergency department<br>**Interventions:**<br>• HCQ 600 mg twice daily on Day 1, then HCQ 400 mg once daily for 4 days<br>• No HCQ<br>**Primary Endpoint:**<br>• Time from study baseline (24 hours after patients arrived at the ED) to intubation or death | **Number of Participants:**<br>• Received HCQ (n = 811) and did not receive HCQ (n = 565)<br>**Participant Characteristics:**<br>• HCQ recipients were more severely ill at baseline than those who did not receive HCQ.<br>**Outcomes:**<br>• Using propensity scores to adjust for major predictors of respiratory failure and inverse probability weighting, the study demonstrated that HCQ use was not associated with intubation or death (HR 1.04; 95% CI, 0.82–1.32).<br>• No association between concomitant use of AZM and the composite endpoint of intubation or death (HR 1.03; 95% CI, 0.81–1.31) | **Key Limitations:**<br>• This study has the inherent limitations of an observational study, including residual confounding from confounding variables that were unrecognized and/or unavailable for analysis.<br>**Interpretation:**<br>• The use of HCQ for treatment of COVID-19 was not associated with harm or benefit in a large observational study. |

**Key:** AE = adverse event; AV = atrioventricular; AZM = azithromycin; CPR = cardiopulmonary resuscitation; CQ = chloroquine; DRV/COBI = darunavir/cobicistat; ECG = electrocardiogram; ECMO = extracorporeal membrane oxygenation; ED = emergency department, $FiO_2$ = fraction of inspired oxygen; GI = gastrointestinal; HCQ = hydroxychloroquine; HFNC = high-flow nasal cannula; ICU = intensive care unit; IFN = interferon; IMV = invasive mechanical ventilation; ITT = intention-to-treat; LPV/RTV = lopinavir/ritonavir; mITT = modified intention-to-treat; NP = nasopharyngeal; the Panel = the COVID-19 Treatment Guidelines Panel; PCR = polymerase chain reaction; PO = orally; RCT = randomized controlled trial; RDV = remdesivir; RT-PCR = reverse transcription polymerase chain reaction; SAE = serious adverse event; SOC = standard of care

## References


1. Chorin E, Dai M, Shulman E, et al. The QT interval in patients with COVID-19 treated with hydroxychloroquine and azithromycin. *Nat Med*. 2020;26(6):808-809. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32488217.
2. Gautret P, Lagier JC, Parola P, et al. Clinical and microbiological effect of a combination of hydroxychloroquine and azithromycin in 80 COVID-19 patients with at least a six-day follow up: A pilot observational study. *Travel Med Infect Dis*. 2020:101663. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32289548.
3. Gautret P, Lagier JC, Parola P, et al. Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial. *Int J Antimicrob Agents*. 2020:105949. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32205204.
4. Huang M, Tang T, Pang P, et al. Treating COVID-19 with chloroquine. *J Mol Cell Biol*. 2020;12(4):322-325. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32236562.
5. Magagnoli J, Narendran S, Pereira F, et al. Outcomes of hydroxychloroquine usage in United States veterans hospitalized with COVID-19. *Med (N Y)*. 2020;1(1):114-127.e3. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32838355.
6. Molina JM, Delaugerre C, Le Goff J, et al. No evidence of rapid antiviral clearance or clinical benefit with the combination of hydroxychloroquine and azithromycin in patients with severe COVID-19 infection. *Med Mal Infect*. 2020;50(4):384. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32240719.
7. Satlin MJ, Goyal P, Magleby R, et al. Safety, tolerability, and clinical outcomes of hydroxychloroquine for hospitalized patients with coronavirus 2019 disease. *PLoS One*. 2020;15(7):e0236778. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32701969.
8. Mikami T, Miyashita H, Yamada T, et al. Risk factors for mortality in patients with COVID-19 in New York City. *J Gen Intern Med*. 2021;36(1):17-26. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32607928.
9. Catteau L, Dauby N, Montourcy M, et al. Low-dose hydroxychloroquine therapy and mortality in hospitalised patients with COVID-19: a nationwide observational study of 8075 participants. *Int J Antimicrob Agents*. 2020:106144. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32853673.
10. COVID-19 RISK and Treatments (CORIST) Collaboration. Use of hydroxychloroquine in hospitalised COVID-19 patients is associated with reduced mortality: findings from the observational multicentre Italian CORIST study. *Eur J Intern Med*. 2020;82:38-47. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32859477.
11. Furtado RHM, Berwanger O, Fonseca HA, et al. Azithromycin in addition to standard of care versus standard of care alone in the treatment of patients admitted to the hospital with severe COVID-19 in Brazil (COALITION II): a randomised clinical trial. *Lancet*. 2020;396(10256):959-967. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32896292.
12. Tang W, Cao Z, Han M, et al. Hydroxychloroquine in patients with mainly mild to moderate coronavirus disease 2019: open label, randomised

controlled trial. *BMJ*. 2020;369:m1849. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32409561.

13. Borba MGS, Val FFA, Sampaio VS, et al. Effect of high vs low doses of chloroquine diphosphate as adjunctive therapy for patients hospitalized with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection: a randomized clinical trial. *JAMA Netw Open*. 2020;3(4):e208857. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32339248.
14. Mahevas M, Tran VT, Roumier M, et al. Clinical efficacy of hydroxychloroquine in patients with COVID-19 pneumonia who require oxygen: observational comparative study using routine care data. *BMJ*. 2020;369:m1844. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32409486.
15. Arshad S, Kilgore P, Chaudhry ZS, et al. Treatment with hydroxychloroquine, azithromycin, and combination in patients hospitalized with COVID-19. *Int J Infect Dis*. 2020;97:396-403. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32623082.
16. Recovery Collaborative Group. Azithromycin in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *Lancet*. 2021;397(10274):605-612. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33545096.
17. Omrani AS, Pathan SA, Thomas SA, et al. Randomized double-blinded placebo-controlled trial of hydroxychloroquine with or without azithromycin for virologic cure of non-severe COVID-19. *EClinicalMedicine*. 2020;29:100645. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33251500.
18. Principle Trial Collaborative Group. Azithromycin for community treatment of suspected COVID-19 in people at increased risk of an adverse clinical course in the UK (PRINCIPLE): a randomised, controlled, open-label, adaptive platform trial. *Lancet*. 2021;397(10279):1063-1074. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33676597.
19. Hinks TSC, Cureton L, Knight R, et al. A randomised clinical trial of azithromycin versus standard care in ambulatory COVID-19–the ATOMIC2 trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.21.21255807v1.
20. WHO Solidarity Trial Consortium, Pan H, Peto R, et al. Repurposed antiviral drugs for COVID-19—interim WHO Solidarity Trial results. *N Engl J Med*. 2021;384(6):497-511. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33264556.
21. Self WH, Semler MW, Leither LM, et al. Effect of hydroxychloroquine on clinical status at 14 days in hospitalized patients with COVID-19: a randomized clinical trial. *JAMA*. 2020;324(21):2165-2176. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33165621.
22. Recovery Collaborative Group, Horby P, Mafham M, et al. Effect of hydroxychloroquine in hospitalized patients with COVID-19. *N Engl J Med*. 2020;383(21):2030-2040. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33031652.
23. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without azithromycin in mild-to-moderate COVID-19. *N Engl J Med*. 2020;383(21):2041-2052. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32706953.
24. Skipper CP, Pastick KA, Engen NW, et al. Hydroxychloroquine in nonhospitalized adults with early COVID-19: a randomized trial. *Ann Intern Med*. 2020;173(8):623-631. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32673060.
25. Mitja O, Corbacho-Monne M, Ubals M, et al. Hydroxychloroquine for early treatment of adults with mild COVID-19: a randomized-controlled trial. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32674126.
26. Rosenberg ES, Dufort EM, Udo T, et al. Association of treatment with hydroxychloroquine or azithromycin with in-hospital mortality in patients with COVID-19 in New York state. *JAMA*. 2020;323(24):2493-2502. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32392282.
27. Geleris J, Sun Y, Platt J, et al. Observational study of hydroxychloroquine in hospitalized patients with COVID-19. *N Engl J Med*. 2020;382(25):2411-2418. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32379955.

# Ivermectin

*Last Updated: February 11, 2021*

Ivermectin is a Food and Drug Administration (FDA)-approved antiparasitic drug that is used to treat several neglected tropical diseases, including onchocerciasis, helminthiases, and scabies.[1] It is also being evaluated for its potential to reduce the rate of malaria transmission by killing mosquitoes that feed on treated humans and livestock.[2] For these indications, ivermectin has been widely used and is generally well tolerated.[1,3] Ivermectin is not approved by the FDA for the treatment of any viral infection.

## Proposed Mechanism of Action and Rationale for Use in Patients With COVID-19

Reports from in vitro studies suggest that ivermectin acts by inhibiting the host importin alpha/beta-1 nuclear transport proteins, which are part of a key intracellular transport process that viruses hijack to enhance infection by suppressing the host's antiviral response.[4,5] In addition, ivermectin docking may interfere with the attachment of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spike protein to the human cell membrane.[6] Ivermectin is thought to be a host-directed agent, which may be the basis for its broad-spectrum activity in vitro against the viruses that cause dengue, Zika, HIV, and yellow fever.[4,7-9] Despite this in vitro activity, no clinical trials have reported a clinical benefit for ivermectin in patients with these viruses. Some studies of ivermectin have also reported potential anti-inflammatory properties, which have been postulated to be beneficial in people with COVID-19.[10-12]

Some observational cohorts and clinical trials have evaluated the use of ivermectin for the prevention and treatment of COVID-19. Data from some of these studies can be found in Table 2c.

## Recommendation

- There is insufficient evidence for the COVID-19 Treatment Guidelines Panel (the Panel) to recommend either for or against the use of ivermectin for the treatment of COVID-19. Results from adequately powered, well-designed, and well-conducted clinical trials are needed to provide more specific, evidence-based guidance on the role of ivermectin in the treatment of COVID-19.

## Rationale

Ivermectin has been shown to inhibit the replication of SARS-CoV-2 in cell cultures.[13] However, pharmacokinetic and pharmacodynamic studies suggest that achieving the plasma concentrations necessary for the antiviral efficacy detected in vitro would require administration of doses up to 100-fold higher than those approved for use in humans.[14,15] Even though ivermectin appears to accumulate in the lung tissue, predicted systemic plasma and lung tissue concentrations are much lower than 2 µM, the half-maximal inhibitory concentration ($IC_{50}$) against SARS-CoV-2 in vitro.[16-19] Subcutaneous administration of ivermectin 400 µg/kg had no effect on SARS-CoV-2 viral loads in hamsters. However, there was a reduction in olfactory deficit (measured using a food-finding test) and a reduction in the interleukin (IL)-6:IL-10 ratio in lung tissues.[20]

Since the last revision of this section of the Guidelines, the results of several randomized trials and retrospective cohort studies of ivermectin use in patients with COVID-19 have been published in peer-reviewed journals or have been made available as manuscripts ahead of peer review. Some clinical studies showed no benefits or worsening of disease after ivermectin use,[21-24] whereas others reported shorter time to resolution of disease manifestations that were attributed to COVID-19,[25-27] greater reduction in inflammatory marker levels,[26] shorter time to viral clearance,[21] or lower mortality rates in patients who received ivermectin than in patients who received comparator drugs or placebo.[21,27]

However, most of these studies had incomplete information and significant methodological limitations, which make it difficult to exclude common causes of bias. These limitations include:

- The sample size of most of the trials was small.
- Various doses and schedules of ivermectin were used.
- Some of the randomized controlled trials were open-label studies in which neither the participants nor the investigators were blinded to the treatment arms.
- Patients received various concomitant medications (e.g., doxycycline, hydroxychloroquine, azithromycin, zinc, corticosteroids) in addition to ivermectin or the comparator drug. This confounded the assessment of the efficacy or safety of ivermectin.
- The severity of COVID-19 in the study participants was not always well described.
- The study outcome measures were not always clearly defined.

Table 2c includes summaries of key studies. Because most of these studies have significant limitations, the Panel cannot draw definitive conclusions on the clinical efficacy of ivermectin for the treatment of COVID-19. Results from adequately powered, well-designed, and well-conducted clinical trials are needed to provide further guidance on the role of ivermectin in the treatment of COVID-19.

## Monitoring, Adverse Effects, and Drug-Drug Interactions

- Ivermectin is generally well tolerated. Adverse effects may include dizziness, pruritis, nausea, or diarrhea.
- Neurological adverse effects have been reported with the use of ivermectin for the treatment of onchocerciasis and other parasitic diseases, but it is not clear whether these adverse effects were caused by ivermectin or the underlying conditions.[28]
- Ivermectin is a minor cytochrome P 3A4 substrate and a p-glycoprotein substrate.
- Ivermectin is generally given on an empty stomach with water; however, administering ivermectin with food increases its bioavailability.
- The FDA issued a warning in April 2020 that ivermectin intended for use in animals **should not be used** to treat COVID-19 in humans.
- Please see Table 2c for additional information.

## Considerations in Pregnancy

In animal studies, ivermectin was shown to be teratogenic when given in doses that were maternotoxic. These results raise concerns about administering ivermectin to people who are in the early stages of pregnancy (prior to 10 weeks gestation).[29] A 2020 systematic review and meta-analysis reviewed the incidence of poor maternal and fetal outcomes after ivermectin was used for its antiparasitic properties during pregnancy. However, the study was unable to establish a causal relationship between ivermectin use and poor maternal or fetal outcomes due to the quality of evidence. There are numerous reports of inadvertent ivermectin use in early pregnancy without apparent adverse effects.[30-32] Therefore, there is insufficient evidence to establish the safety of using ivermectin in pregnant people, especially those in the later stages of pregnancy.

One study reported that the ivermectin concentrations secreted in breastmilk after a single oral dose were relatively low. No studies have evaluated the ivermectin concentrations in breastmilk in patients who received multiple doses.

## Considerations in Children

Ivermectin is used in children weighing >15 kg for the treatment of helminthic infections, pediculosis, and scabies. The safety of using ivermectin in children weighing <15 kg has not been well established. Ivermectin is generally well tolerated in children, with a side effect profile similar to the one seen in adults. Currently, there are no available pediatric data from clinical trials to inform the use of ivermectin for the treatment or prevention of COVID-19 in children.

## Clinical Trials

Several clinical trials that are evaluating the use of ivermectin for the treatment of COVID-19 are currently underway or in development. Please see *ClinicalTrials.gov* for the latest information.

## References


1. Omura S, Crump A. Ivermectin: panacea for resource-poor communities? *Trends Parasitol*. 2014;30(9):445-455. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25130507.
2. Fritz ML, Siegert PY, Walker ED, Bayoh MN, Vulule JR, Miller JR. Toxicity of bloodmeals from ivermectin-treated cattle to Anopheles gambiae s.l. *Ann Trop Med Parasitol*. 2009;103(6):539-547. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19695159.
3. Kircik LH, Del Rosso JQ, Layton AM, Schauber J. Over 25 years of clinical experience with ivermectin: an overview of safety for an increasing number of indications. *J Drugs Dermatol*. 2016;15(3):325-332. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26954318.
4. Yang SNY, Atkinson SC, Wang C, et al. The broad spectrum antiviral ivermectin targets the host nuclear transport importin alpha/beta1 heterodimer. *Antiviral Res*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32135219.
5. Arévalo AP, Pagotto R, Pórfido J, et al. Ivermectin reduces coronavirus infection in vivo: a mouse experimental model. *bioRxiv*. 2020;Preprint. Available at: https://www.biorxiv.org/content/10.1101/2020.11.02.363242v1.
6. Lehrer S, Rheinstein PH. Ivermectin docks to the SARS-CoV-2 spike receptor-binding domain attached to ACE2. *In Viv*o. 2020;34(5):3023-3026. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32871846.
7. Tay MY, Fraser JE, Chan WK, et al. Nuclear localization of dengue virus (DENV) 1-4 non-structural protein 5; protection against all 4 DENV serotypes by the inhibitor ivermectin. *Antiviral Res*. 2013;99(3):301-306. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23769930.
8. Wagstaff KM, Sivakumaran H, Heaton SM, Harrich D, Jans DA. Ivermectin is a specific inhibitor of importin alpha/beta-mediated nuclear import able to inhibit replication of HIV-1 and dengue virus. *Biochem J*. 2012;443(3):851-856. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22417684.
9. Barrows NJ, Campos RK, Powell ST, et al. A screen of FDA-approved drugs for inhibitors of Zika virus infection. *Cell Host Microbe*. 2016;20(2):259-270. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27476412.
10. Zhang X, Song Y, Ci X, et al. Ivermectin inhibits LPS-induced production of inflammatory cytokines and improves LPS-induced survival in mice. *Inflamm Res*. 2008;57(11):524-529. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19109745.
11. DiNicolantonio JJ, Barroso J, McCarty M. Ivermectin may be a clinically useful anti-inflammatory agent for late-stage COVID-19. *Open Heart*. 2020;7(2). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32895293.
12. Ci X, Li H, Yu Q, et al. Avermectin exerts anti-inflammatory effect by downregulating the nuclear transcription factor kappa-B and mitogen-activated protein kinase activation pathway. *Fundam Clin Pharmacol*. 2009;23(4):449-455. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19453757.
13. Caly L, Druce JD, Catton MG, Jans DA, Wagstaff KM. The FDA-approved drug ivermectin inhibits the

replication of SARS-CoV-2 in vitro. *Antiviral Res*. 2020;178:104787. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32251768.

14. Chaccour C, Hammann F, Ramon-Garcia S, Rabinovich NR. Ivermectin and COVID-19: keeping rigor in times of urgency. *Am J Trop Med Hyg*. 2020;102(6):1156-1157. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32314704.
15. Guzzo CA, Furtek CI, Porras AG, et al. Safety, tolerability, and pharmacokinetics of escalating high doses of ivermectin in healthy adult subjects. *J Clin Pharmacol*. 2002;42(10):1122-1133. Available at: https://www.ncbi.nlm.nih.gov/pubmed/12362927.
16. Arshad U, Pertinez H, Box H, et al. Prioritization of anti-SARS-CoV-2 drug repurposing opportunities based on plasma and target site concentrations derived from their established human pharmacokinetics. *Clin Pharmacol Ther*. 2020;108(4):775-790. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32438446.
17. Bray M, Rayner C, Noel F, Jans D, Wagstaff K. Ivermectin and COVID-19: a report in antiviral research, widespread interest, an FDA warning, two letters to the editor and the authors' responses. *Antiviral Res*. 2020;178:104805. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32330482.
18. Momekov G, Momekova D. Ivermectin as a potential COVID-19 treatment from the pharmacokinetic point of view: antiviral levels are not likely attainable with known dosing regimens. *Biotechnology & Biotechnological Equipment*. 2020;34(1):469-474. Available at: https://www.tandfonline.com/doi/full/10.1080/13102818.2020.1775118.
19. Jermain B, Hanafin PO, Cao Y, Lifschitz A, Lanusse C, Rao GG. Development of a minimal physiologically-based pharmacokinetic model to simulate lung exposure in humans following oral administration of ivermectin for COVID-19 drug repurposing. *J Pharm Sci*. 2020;109(12):3574-3578. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32891630.
20. de Melo GD, Lazarini F, Larrous F, et al. Anti-COVID-19 efficacy of ivermectin in the golden hamster. *bioRxiv*. 2020;Preprint. Available at: https://www.biorxiv.org/content/10.1101/2020.11.21.392639v1.
21. Ahmed S, Karim MM, Ross AG, et al. A five-day course of ivermectin for the treatment of COVID-19 may reduce the duration of illness. *Int J Infect Dis*. 2020;103:214-216. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33278625.
22. Chachar AZK, Khan KA, Asif M, Tanveer K, Khaqan A, Basri R. Effectiveness of ivermectin in SARS-COV-2/COVID-19 Patients. *Int J of Sci*. 2020;9:31-35. Available at: https://www.ijsciences.com/pub/article/2378.
23. Chowdhury ATMM, Shahbaz M, Karim MR, Islam J, Guo D, He S. A randomized trial of ivermectin-doxycycline and hydroxychloroquine-azithromycin therapy on COVID19 patients. *Research Square*. 2020;Preprint. Available at: https://assets.researchsquare.com/files/rs-38896/v1/3ee350c3-9d3f-4253-85f9-1f17f3af9551.pdf.
24. Soto-Becerra P, Culquichicón C, Hurtado-Roca Y, Araujo-Castillo RV. Real-world effectiveness of hydroxychloroquine, azithromycin, and ivermectin among hospitalized COVID-19 patients: results of a target trial emulation using observational data from a nationwide healthcare system in Peru. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.06.20208066v3.
25. Hashim HA, Maulood MF, Rasheed AW, Fatak DF, Kabah KK, Abdulamir AS. Controlled randomized clinical trial on using ivermectin with doxycycline for treating COVID-19 patients in Baghdad, Iraq. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.26.20219345v1/.
26. Niaee MS, Gheibi N, Namdar P, et al. Ivermectin as an adjunct treatment for hospitalized adult COVID-19 patients: a randomized multi-center clinical trial. *Research Square*. 2020;Preprint. Available at: https://www.researchsquare.com/article/rs-109670/v1.
27. Khan MSI, Khan MSI, Debnath CR, et al. Ivermectin treatment may improve the prognosis of patients with COVID-19. *Arch Bronconeumol*. 2020;56(12):828-830. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33293006.
28. Chandler RE. Serious neurological adverse events after ivermectin—do they occur beyond the indication of

onchocerciasis? *Am J Trop Med Hyg*. 2018;98(2):382-388. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29210346.

29. Ivermectin [package insert]. *DailyMed*. 2017. Available at: https://dailymed.nlm.nih.gov/dailymed/fda/fdaDrugXsl.cfm?setid=847a1dd7-d65b-4a0e-a67d-d90392059dac&type=display.
30. Pacque M, Munoz B, Poetschke G, Foose J, Greene BM, Taylor HR. Pregnancy outcome after inadvertent ivermectin treatment during community-based distribution. *Lancet*. 1990;336(8729):1486-1489. Available at: https://www.ncbi.nlm.nih.gov/pubmed/1979100.
31. Chippaux JP, Gardon-Wendel N, Gardon J, Ernould JC. Absence of any adverse effect of inadvertent ivermectin treatment during pregnancy. *Trans R Soc Trop Med Hyg*. 1993;87(3):318. Available at: https://www.ncbi.nlm.nih.gov/pubmed/8236406.
32. Gyapong JO, Chinbuah MA, Gyapong M. Inadvertent exposure of pregnant women to ivermectin and albendazole during mass drug administration for lymphatic filariasis. *Trop Med Int Health*. 2003;8(12):1093-1101. Available at: https://www.ncbi.nlm.nih.gov/pubmed/14641844.

# Table 2c. Ivermectin: Selected Clinical Data

*Last Updated: July 19, 2021*

The Panel has reviewed other clinical studies of IVM for the treatment of COVID-19.[1-16] However, those studies have limitations that make them less definitive and informative than the studies discussed here. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin Versus Placebo for Treatment of Mild COVID-19[17]** | | | |
| Randomized, double-blind, placebo-controlled trial in Cali, Colombia (n = 476) | **Key Inclusion Criteria:**<br>• Positive SARS-CoV-2 PCR result or positive antigen test result<br>• Symptoms began ≤7 days prior to randomization<br>• Mild disease (defined as receiving outpatient or inpatient care, but not receiving HFNC oxygen or mechanical ventilation)<br>**Key Exclusion Criteria:**<br>• Asymptomatic disease<br>• Severe pneumonia<br>• Receipt of IVM within previous 5 days<br>• Hepatic dysfunction/abnormal liver function tests<br>**Interventions:**<br>• Oral IVM 300 µg/kg per day in solution for 5 days, taken primarily on an empty stomach<br>• Placebo<br>**Primary Endpoints:**<br>• Time from randomization to resolution of symptoms within | **Number of Participants:**<br>• IVM (n = 200) and placebo (n = 198) in primary analysis<br>**Participant Characteristics:**<br>• Median age was 37 years; 4% of patients in IVM arm and 8% in placebo arm were aged ≥65 years.<br>• 39% of patients in IVM arm and 45% in placebo arm were male.<br>• 79% of patients had no known comorbidities; median BMI in both arms was 26.<br>• Median time from symptom onset to randomization was 5 days (IQR 4–6 days).<br>• 62% of patients in IVM arm and 55% in placebo arm were not hospitalized and had no limitations of activities at baseline (ordinal scale 1); 38% and 44% were not hospitalized but had some limitations on activities, or they were receiving oxygen at home, or both (ordinal scale 2).<br>• 1% of patients in both arms were hospitalized at baseline.<br>**Primary Outcomes:**<br>• No difference in time to resolution of symptoms (median 10 days in IVM arm vs. 12 days in placebo arm; HR 1.07; 95% CI, 0.87–1.32; $P = 0.53$)<br>• Symptoms resolved in 82% of patients in IVM arm and 79% in placebo arm by Day 21.<br>**Other Outcomes:**<br>• No significant difference between arms in proportion of patients who showed clinical deterioration of ≥2 points on the ordinal scale (3.5% in IVM arm vs. 2.0% in placebo arm; absolute difference -1.5%; 95% CI, -4.8% to 1.7%) | **Key Limitations:**<br>• Relatively small sample size<br>• Primary endpoint was modified during the trial due to lower than expected event rates.<br>• The first 65 patients received a placebo that smelled and tasted different from IVM.<br>• The study enrolled a younger, healthier demographic than those who typically experience more serious cases of COVID-19.<br>• Study included 4 hospitalized patients (out of 398).<br>• The IVM dose used in this study was higher than the dose that is usually administered (IVM 200 µg/kg per day).<br>**Interpretation:**<br>• A 5-day course of IVM did not improve time to resolution of symptoms in patients with mild COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin Versus Placebo for Treatment of Mild COVID-19[17]**, continued | | | |
| | the 21-day follow-up period. Resolution of symptoms was defined as the first day a patient reported a score of 0 (no clinical evidence of infection) on an 8-point ordinal scale. | • No significant difference between arms in the odds of improvement in ordinal scale score and the proportion of patients who sought medical care or required escalation in care.<br>• 8% of patients in IVM arm and 3% in placebo arm discontinued treatment due to an AE. None of the reported SAEs were considered to be related to study interventions. | |
| **Ivermectin Versus Ivermectin Plus Doxycycline Versus Placebo for Treatment of COVID-19[18]** | | | |
| Randomized, double-blind, placebo-controlled trial of hospitalized adults in Dhaka, Bangladesh (n = 72) | **Key Inclusion Criteria:**<br>• Aged 18–65 years<br>• Laboratory-confirmed SARS-CoV-2 infection with fever, cough, or sore throat<br>• Admitted to hospital within previous 7 days<br>**Key Exclusion Criteria:**<br>• Chronic cardiac, renal, or liver disease<br>**Interventions:**<br>• IVM 12 mg PO once daily for 5 days<br>• Single dose of IVM 12 mg PO plus DOX 200 mg PO on Day 1, then DOX 100 mg every 12 hours for 4 days<br>• Placebo<br>**Primary Endpoints:**<br>• Time to virologic clearance, measured by obtaining an NP swab for SARS-CoV-2 PCR on Days 3, 7, and 14, then weekly until PCR result was negative<br>• Resolution of fever and cough within 7 days | **Number of Participants:**<br>• IVM (n = 24; 2 withdrew), IVM plus DOX (n = 24; 1 withdrew), and placebo (n = 24; 1 withdrew)<br>**Participant Characteristics:**<br>• Mean age was 42 years.<br>• 54% of patients were female.<br>• Mean time from symptom onset to assessment was 3.83 days.<br>• No patients required supplemental oxygen.<br>**Primary Outcomes:**<br>• Shorter mean time to virologic clearance with IVM than placebo (9.7 days vs. 12.7 days; $P = 0.02$), but not with IVM plus DOX (11.5 days; $P = 0.27$).<br>• Rates of virologic clearance were greater in IVM arm at Day 7 (HR 4.1; 95% CI, 1.1–14.7; $P = 0.03$) and at Day 14 (HR 2.7; 95% CI, 1.2–6.0; $P = 0.02$) compared to placebo, but not in the IVM plus DOX arm (HR 2.3; 95% CI, 0.6–9.0; $P = 0.22$ and HR 1.7; 95% CI, 0.8–4.0; $P = 0.19$).<br>• No statistically significant difference in time to resolution of fever, cough, or sore throat between IVM and placebo arms ($P = 0.35$, $P = 0.18$, and $P = 0.35$, respectively) or IVM plus DOX and placebo arms ($P = 0.09$, $P = 0.23$, and $P = 0.09$, respectively). | **Key Limitations:**<br>• Small sample size<br>• Unclear whether both IVM and DOX placebos were used.<br>• Excluded patients with chronic diseases.<br>• Disease appears to have been mild in all patients; thus, the reason for hospitalization is unclear.<br>• Absolute changes in inflammatory markers were not presented, but were reportedly significant.<br>• PCR results are not a validated surrogate marker for clinical efficacy.<br>**Interpretation:**<br>• A 5-day course of IVM resulted in faster virologic clearance than placebo, but not a faster time to resolution of symptoms (fever, cough, and sore throat). |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin Versus Ivermectin Plus Doxycycline Versus Placebo for Treatment of COVID-19[18]**, continued | | | |
| | | **Other Outcomes:**<br>• Mean values of CRP, LDH, procalcitonin, and ferritin declined in all arms from baseline to Day 7, but there were no between-arm comparisons of the changes.<br>• No between-arm differences in duration of hospitalization ($P$ = 0.93).<br>• No SAEs recorded. | Because time to virologic clearance is not a validated surrogate marker for clinical efficacy, the clinical efficacy of IVM is unknown. |
| **Effectiveness and Safety of Adding Ivermectin to Treatment in Patients With Severe COVID-19[19]** | | | |
| Randomized, single-blind trial of hospitalized adults in Turkey (n = 66) | **Key Inclusion Criteria:**<br>• Hospitalized with PCR-confirmed SARS-CoV-2 infection<br>• ≥1 of the following severity criteria:<br>  • Tachypnea (≥30 breaths/min), $SpO_2$ <90% on RA, or $PaO_2/FiO_2$ <300 mm Hg in patients who were receiving oxygen<br>  • Presence of "specific" radiologic findings<br>  • Mechanical ventilation<br>  • Acute organ dysfunction<br>**Key Exclusion Criteria:**<br>• Aged <18 years<br>• Pregnant or breast feeding<br>• Autoimmune disease<br>• Chronic liver or kidney disease<br>• Immunosuppression<br>• SNP mutation in MDR1/ABCB1 gene and/or haplotypes and mutations of the CYP3A4 gene (affects IVM metabolism and toxicity) | **Number of Participants:**<br>• IVM (n = 36) and SOC (n = 30)<br>• 6 participants in IVM arm were excluded after genotyping.<br>**Participant Characteristics:**<br>• Mean age was 58 years in IVM arm and 66 years in SOC arm.<br>• 70% of patients were male in IVM arm and 63% were male in SOC arm.<br>• Comorbidities (IVM vs. SOC): DM (30% vs. 33%), HTN (50% vs. 40%), CAD (17% vs. 27%)<br>**Primary Outcome:**<br>• Clinical improvement at Day 5: 14 of 30 patients (46.7%) in IVM arm, 11 of 30 (36.7%) in SOC arm ($P$ = 0.43)<br>**Secondary Outcomes**<br>*Between-Arm Comparisons at Day 10:*<br>• Clinical improvement: 73.3% in IVM arm, 53.3% in SOC arm ($P$ = 0.10)<br>• IVM vs. SOC arm SOFA score at Day 10: $P$ = 0.50<br>• Mean $SpO_2$: 95.4% in IVM arm, 93.0% in SOC arm ($P$ = 0.032)<br>• Mean $PaO_2/FiO_2$: 236.3 mm Hg in IVM arm, 220.8 mm Hg in SOC arm ($P$ = 0.39)<br>• Serum CRP, ferritin, and D-dimer levels were lower in IVM arm than in SOC arm ($P$ = 0.02, $P$ = 0.005, and $P$ = 0.03, respectively). | **Key Limitations:**<br>• Small sample size<br>• Time from symptom onset to intervention was not reported.<br>• Study used nonstandard severity classification for COVID-19.<br>• Primary endpoint was difficult to characterize; it was presented in the Methods section as a composite endpoint, but each component was analyzed separately.<br>• Power analysis performed for virologic endpoint, not primary endpoint.<br>• Only 57% of patients in IVM arm and 27% in SOC arm were evaluated for VL changes.<br>**Interpretation:**<br>• A 5-day course of IVM in hospitalized patients with severe COVID-19 did not result in clinical improvement at the end of treatment, and no reduction in mortality was observed. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effectiveness and Safety of Adding Ivermectin to Treatment in Patients With Severe COVID-19[19]**, continued | | | |
| | **Interventions:**<br>• IVM 200 µg/kg per day for 5 days plus SOC (HCQ plus favipiravir plus AZM)<br>• SOC alone<br>**Primary Endpoint:**<br>• "Clinical response" at Day 5: extubation (in mechanically ventilated patients), respiratory rate <26 breaths/min, $SpO_2$ >90% on RA, $PaO_2/FiO_2$ >300 mm Hg (if patient was receiving oxygen), presence of ≥2 of the 2-point reduction criteria in SOFA<br>**Key Secondary Endpoints:**<br>• Clinical response at Day 10: respiratory rate 22 to 24 breaths/min, $SpO_2$ >95% on RA, absence of oxygen requirement, and no need for intensive care<br>• Changes in $SpO_2$, $PaO_2/FiO_2$, and levels of CRP, ferritin, and D-dimer<br>• Mortality | *Within-Group Changes from Baseline:*<br>• Change in SOFA score to Day 10: $P = 0.009$ in IVM arm, $P = 0.88$ in SOC arm<br>• Mean changes in $SpO_2$ to Day 5: 89.9% to 93.5% ($P = 0.005$) in IVM arm, 89.7% to 93.0% ($P = 0.003$) in SOC arm<br>*Mortality During Follow-Up Period:*<br>• 6 patients (20%) in IVM arm and 9 (30%) in SOC arm ($P = 0.37$).<br>• Average length of follow-up was 3 months. | • Faster improvement of oxygenation and more pronounced reduction in inflammatory markers were observed in IVM arm. |
| **Chloroquine, Hydroxychloroquine, or Ivermectin in Patients With Severe COVID-19[20]** | | | |
| Randomized, double-blind, Phase 2 trial of hospitalized adults in Brazil (n = 168) | **Key Inclusion Criteria:**<br>• Hospitalized with laboratory-confirmed SARS-CoV-2 infection (PCR or IgM positive)<br>• ≥1 of the following severity criteria:<br>  • Dyspnea<br>  • Tachypnea (>30 breaths/min)<br>  • $SpO_2$ <93%<br>  • $PaO_2/FiO_2$ <300 mm Hg | **Number of Participants:**<br>• CQ (n = 61), HCQ (n = 54), and IVM (n = 53)<br>**Participant Characteristics:**<br>• Mean age was 53.4±15.6 years.<br>• 58.2% of patients were male.<br>• 78.9% of patients were Hispanic.<br>• 37.5% of patients had a BMI >30.<br>• Most common comorbidities were HTN (43.4% of patients) and DM (28.1%). | **Key Limitations:**<br>• Small sample size<br>• No placebo control<br>• No clear primary endpoint<br>**Interpretation:**<br>• Use of IVM did not reduce risk of oxygen requirement, ICU admission, invasive mechanical ventilation, or death in |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Chloroquine, Hydroxychloroquine, or Ivermectin in Patients With Severe COVID-19[20]**, continued | | | |
| | • Involvement of >50% of lungs on CXR or CT<br>**Key Exclusion Criteria:**<br>• Aged <18 years old<br>• Cardiac arrhythmia, including prolonged QT interval<br>• Previous use of CQ, HCQ, or IVM for >24 hours<br>**Interventions:**<br>• CQ 450 mg twice daily on Day 0, then CQ 450 mg once daily for 4 days<br>• HCQ 400 mg twice daily on Day 0, then HCQ 400 mg once daily for 4 days<br>• IVM 14 mg once daily for 3 days followed by placebo for 2 days<br>**Endpoints:**<br>• Need for supplemental oxygen, invasive mechanical ventilation, or ICU admission<br>• Mortality | • On admission, 76.5% of patients had respiratory failure, and 42.5% had "pneumonic syndrome."<br>**Outcomes:**<br>• No differences between arms in proportion of patients who required supplemental oxygen (88.5% in CQ arm, 90.2% in HCQ arm, and 88.4% in IVM arm) or mean number of days of supplemental oxygenation (7.9 vs. 7.8 vs. 8.1 days)<br>• No differences between arms in proportion of patients admitted to the ICU (22.4% in CQ arm, 21.1% in HCQ arm, and 28.0% in IVM arm) or proportion of patients who received invasive mechanical ventilation (20.6% vs. 21.1% vs. 23.5%)<br>• No differences between arms in proportion of patients who were receiving concomitant medications, including steroids and anticoagulants<br>• No differences between arms in death due to COVID-19 complications (21.3% in CQ arm, 22.2% in HCQ arm, and 23.0% in IVM arm)<br>• Baseline characteristics that were associated with mortality included age >60 years (HR 2.44; 95% CI, 1.40–4.30), DM (HR 1.87; 95% CI, 1.02–2.59), BMI >33 (HR 1.95; 95% CI, 1.07–3.09), and $SpO_2$ <90% (HR 5.79; 95% CI, 2.63–12.7).<br>• No difference in rates of AEs between arms | hospitalized patients with severe COVID-19. |
| **Ivermectin Versus Placebo for Outpatients With Mild COVID-19[21]** | | | |
| Open-label RCT of adult outpatients in Lahore, Pakistan (n = 50) | **Key Inclusion Criteria:**<br>• SARS-CoV-2 PCR positive<br>• Mild disease<br>**Key Exclusion Criteria:**<br>• Severe symptoms likely related to cytokine storm<br>• Malignancy, chronic kidney disease, or cirrhosis<br>• Pregnancy | **Number of Participants:**<br>• IVM (n = 25) and control (n = 25)<br>**Participant Characteristics:**<br>• Mean age was 40.6 years.<br>• 62% of patients were male.<br>• 40% of patients had diabetes, 30% were smokers, 26% had hypertension, 8% had cardiovascular disease, and 12% had obesity. | **Key Limitations:**<br>• Small sample size<br>• Open-label study<br>• Authors reported the proportions of patients with certain symptoms and comorbidities but did not provide objective assessment of disease severity. This precludes the ability to compare outcomes between arms. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin Versus Placebo for Outpatients With Mild COVID-19[21]**, continued | | | |
| | **Interventions:**<br>• IVM 12 mg PO immediately, followed by 12 mg doses at 12 and 24 hours, plus symptomatic treatment<br>• Symptomatic treatment<br>**Primary Endpoint:**<br>• Symptoms reported on Day 7. Patients were stratified as asymptomatic or symptomatic. | **Outcomes:**<br>• Proportion of asymptomatic patients at Day 7 was similar in IVM and control arms (64% vs. 60%; $P = 0.500$).<br>• AEs were attributed to IVM in 8 patients (32%). | • Study classified outcomes at Day 7 as "symptomatic" and "asymptomatic," but did not account for symptom worsening or improvement.<br>**Interpretation:**<br>• IVM showed no effect on symptom resolution in patients with mild COVID-19. |
| **Ivermectin in Patients With Mild to Moderate COVID-19[22]** | | | |
| Open-label, single-center, RCT of outpatients with laboratory-confirmed SARS-CoV-2 infection in Bangladesh (n = 62) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• ≤7 days of symptoms<br>• Mild or moderate disease<br>**Key Exclusion Criteria:**<br>• Hypersensitivity to IVM<br>• Pregnancy or breastfeeding<br>• Use of HCQ or "other antimicrobials"<br>**Interventions:**<br>• Single dose of IVM 200 µg/kg<br>• SOC<br>**Primary Endpoint:**<br>• Full recovery from all symptoms<br>**Secondary Endpoint:**<br>• Conversion to negative RT-PCR at Day 10 | **Number of Participants:**<br>• IVM (n = 32) and SOC (n = 30)<br>**Participant Characteristics:**<br>• 71% of patients were male.<br>• Mean age was 39.2 years (SD 12.1 years).<br>• 81% of patients had mild disease and 19% had moderate disease.<br>• Study provided no information on comorbidities.<br>**Outcomes:**<br>• Mean overall recovery time was 5.3 days (SD 2.5 days) in IVM arm and 6.3 days (SD 4.2 days) in SOC arm. The difference was not statistically significant. Time to resolution of fever, shortness of breath, and fatigue were no shorter in IVM arm.<br>• Negative SARS-CoV-2 PCR result at Day 10: 18 of 20 patients (90%) in IVM arm, 19 of 20 (95%) in SOC arm. | **Key Limitations:**<br>• Open-label study<br>• Small study<br>• Study enrolled young patients with mild disease who were unlikely to progress to severe COVID-19.<br>**Interpretation:**<br>• Compared to SOC, use of IVM did not lead to faster recovery from mild to moderate COVID-19.<br>• The small sample size and large number of comparisons make it difficult to assess the clinical efficacy of IVM in this population. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin Plus Doxycycline Versus Hydroxychloroquine Plus Azithromycin for Asymptomatic Patients and Patients With Mild to Moderate COVID-19[23]** | | | |
| RCT of outpatients with SARS-CoV-2 infection with or without symptoms in Bangladesh (n = 116) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection by RT-PCR<br>• $SpO_2$ ≥95%<br>• Normal or near-normal CXR<br>• No unstable comorbidities<br>**Interventions**<br>*Group A:*<br>• A single dose of IVM 200 µg/kg plus DOX 100 mg twice daily for 10 days<br>*Group B:*<br>• HCQ 400 mg on Day 1, then HCQ 200 mg twice daily for 9 days plus AZM 500 mg once daily for 5 days<br>**Primary Endpoints:**<br>• Time to negative PCR result. Asymptomatic patients were tested starting on Day 5, then every other day until a negative result occurred. Symptomatic patients were tested on their second symptom-free day, then every other day until a negative result occurred.<br>• Time to resolution of symptoms | **Number of Participants:**<br>• Group A (n = 60) and Group B (n = 56)<br>**Participant Characteristics:**<br>• Mean age was 33.9 years.<br>• 78% of patients were male.<br>• 91 of 116 patients (78.5%) were symptomatic.<br>**Outcomes:**<br>• PCR became negative in 60 of 60 patients (100%) in Group A and in 54 of 56 patients (96.4%) in Group B.<br>• Mean time to negative PCR result: 8.93 days (range 8–13 days) in Group A, 9.33 days (range 5–15 days) in Group B ($P$ = 0.2314).<br>• Mean time to symptom recovery: 5.93 days (range 5–10 days) in Group A, 6.99 days (range 4–12 days) in Group B ($P$ = 0.071).<br>• In a subgroup analysis of patients who were symptomatic at baseline, the mean time to negative PCR result for Groups A and B were 9.06 days and 9.74 days, respectively ($P$ = 0.0714).<br>• Patients who received IVM plus DOX had fewer AEs than those who received HCQ plus AZM (31.7% vs. 46.4%) in the subgroup analysis. | **Key Limitations:**<br>• Small sample size<br>• Open-label study<br>• No SOC alone group<br>• Study enrolled young patients without major risk factors for disease progression.<br>• None of the comparative outcome measures were statistically significant.<br>**Interpretation:**<br>• In this small study with a young population, the authors suggested that IVM plus DOX was superior to HCQ plus AZM despite no statistically significant difference in time from recovery to negative PCR result and symptom recovery between patients who received IVM plus DOX and those who received HCQ plus AZM. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Antiviral Effect of High-Dose Ivermectin in Adults with COVID-19[24]** | | | |
| Multicenter, randomized, open-label, blinded trial of hospitalized adults with mild to moderate COVID-19 in Argentina (n = 45) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• Hospitalized<br>• ≤5 days of symptoms<br>**Key Exclusion Criteria:**<br>• Use of immunomodulators or any agent with potential anti-SARS-CoV-2 activity prior to enrollment<br>• Poorly controlled comorbidities<br>**Interventions:**<br>• IVM 600 µg/kg once daily plus SOC for 5 days<br>• SOC<br>**Primary Endpoint:**<br>• VL reduction at Day 5. VL was quantified by NP swab at baseline, then at 24, 48, and 72 hours and Day 5.<br>**PK Sampling:**<br>• Performed 4 hours after dose on Days 1, 2, 3, 5, and 7 to assess elimination | **Number of Participants:**<br>• IVM (n = 30) and SOC (n = 15)<br>• After excluding patients with poor sample quality, those without a detectable VL at baseline, and those who withdrew, 32 patients (20 IVM, 12 SOC) were included in the viral efficacy analysis population.<br>**Participant Characteristics:**<br>• Mean age was 42.3±12.8 years in IVM arm and 38.1±11.7 years in SOC arm.<br>• 50% of patients were male in IVM arm and 67% were male in SOC arm.<br>**Primary Outcomes:**<br>• By Day 5, a similar magnitude of VL reduction was seen in both arms.<br>**Other Outcomes:**<br>• Patients with higher IVM concentrations had greater reductions in VL (r 0.44; $P < 0.04$).<br>• Treated patients were divided into 2 groups based on IVM $C_{max}$: IVM >160 ng/mL (median of 202 ng/mL) and <160 ng/mL (median of 109 ng/mL).<br>  • Median percentage of VL reduction by $C_{max}$ concentration vs. control ($P = 0.0096$) was 72% (IQR 59% to 77%) in >160 ng/mL group (n = 9), 40% (IQR 21% to 46%) in <160 ng/mL group (n = 11), and 42% (IQR 31% to 73%) in SOC arm.<br>  • Median viral decay rate ($P = 0.04$) was 0.64 $day^{-1}$ in >160 ng/mL group, 0.14 $day^{-1}$ in <160 ng/mL group, and 0.13 $day^{-1}$ in SOC arm.<br>• Percentages of AEs were similar between the arms (43% in IVM arm, 33% in SOC arm), and AEs were mostly mild. | **Key Limitations:**<br>• Small sample size<br>• No clinical response data reported.<br>• The $C_{max}$ level of 160 ng/mL used in the analysis appears to be arbitrary.<br>**Interpretation:**<br>• Concentration-dependent virologic response was seen when using a higher-than-usual dose of IVM (600 µg/kg vs. 200 or 400 µg/kg once daily), with minimal associated toxicities.<br>• The study results showed large interpatient variation of IVM $C_{max}$. Larger sample sizes are needed to further assess the safety and efficacy of using higher doses of IVM to treat COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Early Treatment With Ivermectin Versus Placebo on Viral Load, Symptoms, and Humoral Response in Patients With Mild COVID-19[25]** | | | |
| A single-center, randomized, double-blind, placebo-controlled pilot trial in Spain (n = 24) | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• ≤72 hours of symptoms<br>• No risk factors for severe disease or COVID-19 pneumonia<br>**Interventions:**<br>• Single dose of IVM 400 µg/kg<br>• Nonmatching placebo tablet administered by a nurse who did not participate in the patient's care<br>**Primary Endpoint:**<br>• Positive SARS-CoV-2 PCR result from an NP swab at Day 7 post-treatment | **Number of Participants:**<br>• IVM (n = 12) and placebo (n = 12)<br>**Participant Characteristics:**<br>• Mean age was 26 years (range 18–54 years).<br>• 50% of patients were male.<br>• All patients had symptoms at baseline; 70% had headache, 66% had fever, 58% had malaise, and 25% had cough.<br>• Median onset of symptoms was 24 hours in IVM arm and 48 hours in placebo arm.<br>**Outcomes:**<br>• At Day 7, 12 patients (100%) in both groups had a positive PCR (for gene N), and 11 of 12 who received IVM (92%) and 12 of 12 who received placebo (100%) had a positive PCR (for gene E); $P = 1.0$ for both comparisons.<br>• In a post hoc analysis, the authors reported fewer patient-days of cough and anosmia in the IVM-treated patients, but no differences in the patient-days for fever, general malaise, headache, and nasal congestion. | **Key Limitations:**<br>• Small sample size<br>• PCR is not a validated surrogate marker for clinical efficacy.<br>• PCR cycle threshold values were higher for patients who received IVM than those who received placebo at some time points, but these comparisons are not statistically significant.<br>• Symptom results were not a prespecified outcome and are of unclear statistical and clinical significance.<br>**Interpretation:**<br>• Patients who received IVM showed no difference in viral clearance compared to those who received placebo.<br>• The small sample size and large number of comparisons make it difficult to assess the clinical efficacy of IVM in this population. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin Plus Doxycycline Plus Standard Therapy Versus Standard Therapy Alone in Patients With Mild to Moderate COVID-19[26]** | | | |
| Randomized, unblinded, single-center study of patients with laboratory-confirmed SARS-CoV-2 infection in Baghdad, Iran (n = 140)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Diagnosis by clinical, radiological, and PCR testing<br>• Outpatients had mild or moderate COVID-19, while inpatients had severe and critical COVID-19.<br>**Interventions:**<br>• IVM 200 µg/kg PO daily for 2 days. If patient required more time to recover, a third dose was given 7 days after the first dose, plus DOX 100 mg twice daily for 5–10 days plus standard therapy (based on clinical condition).<br>• Standard therapy was based on clinical condition and included AZM, acetaminophen, vitamin C, zinc, vitamin D3, dexamethasone 6 mg daily or methylprednisolone 40 mg twice daily if needed, and oxygen or mechanical ventilation if needed.<br>• All critically ill patients were assigned to receive IVM plus DOX. | **Number of Participants:**<br>• IVM plus DOX plus standard therapy (n = 70) and standard therapy alone (n = 70)<br>**Participant Characteristics:**<br>• Median age was 50 years in IVM arm and 47 years in standard therapy arm.<br>• 50% of patients were male in IVM arm and 53% were male in standard therapy arm.<br>• In IVM arm, 48 patients had mild or moderate COVID-19, 11 had severe COVID-19, and 11 had critical COVID-19.<br>• In standard therapy arm, 48 patients had mild or moderate COVID-19, 22 had severe COVID-19, and no patients had critical COVID-19.<br>**Outcomes:**<br>• Mean recovery time in IVM arm was 10.1 days (SD 5.3 days) vs. 17.9 days (SD 6.8 days) for standard therapy arm ($P < 0.0001$). This result was only significant for those with mild to moderate disease.<br>• Disease progression occurred in 3 of 70 patients (4.3%) in IVM arm and 7 of 70 (10.0%) in standard therapy arm ($P = 0.19$)<br>• 2 of 70 patients (2.85%) in IVM arm and 6 of 70 (8.57%) in standard therapy arm died ($P = 0.14$) | **Key Limitations:**<br>• Not blinded<br>• Patient deaths prevent an accurate comparison of mean recovery time between arms in this study, and the authors did not account for competing mortality risks.<br>• Relies heavily on post hoc subgroup comparisons.<br>• Substantial imbalance in disease severity at baseline<br>• Authors noted that critical patients were not assigned to standard therapy arm; thus, the arms were not truly randomized.<br>• Unclear how many patients required corticosteroids.<br>**Interpretation:**<br>• IVM may shorten the time to recovery for patients with mild or moderate disease, but the lack of control for competing mortality causes in the study limits the ability to interpret the results. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin in Patients With Mild to Moderate COVID-19[27]** | | | |
| Double-blind RCT in patients with mild to moderate COVID-19 in India (n = 157) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Positive SARS-CoV-2 RT-PCR or antigen test<br>• Nonsevere COVID-19 (defined as $SpO_2$ >90% on RA and no hypotension or need for mechanical ventilation)<br>**Key Exclusion Criteria:**<br>• CrCl <30 mL/min<br>• Transaminases >5 times ULN<br>• MI or heart failure in previous 90 days<br>• QTc interval >450 ms<br>• Severe comorbidity<br>**Interventions:**<br>• Single dose of IVM 24 mg in alcohol-based elixir prepared by pharmacy<br>• Single dose of same elixir with IVM 12 mg<br>• Single dose of same elixir without IVM (placebo)<br>**Primary Endpoint:**<br>• Reduction of SARS-CoV-2 VL as measured by NP and OP swab at Day 5<br>• Conversion to negative RT-PCR at Day 5<br>**Key Secondary Endpoints:**<br>• Qualitative and quantitative RT-PCR on Days 3 and 7<br>• Time to clinical resolution | **Number of Participants:**<br>• ITT analysis (safety): IVM 24 mg (n = 51), IVM 12 mg (n = 49), and placebo (n = 52)<br>• mITT analysis (included only those with positive NP/OP RT-PCR result): IVM 24 mg (n = 40), IVM 12 mg (n = 40), and placebo (n = 45)<br>• 64% of patients had mild disease (including asymptomatic disease) and 36% had moderate disease<br>**Participant Characteristics:**<br>• Mean age was 35.5 years (SD 10.4 years).<br>• 88.8% of patients were male.<br>• Mean BMI was 25.<br>• Median duration of symptoms was similar between the arms (5 days; IQR 3–7 days).<br>• 10% of patients received concurrent antivirals (RDV, favipiravir, or HCQ). No difference in use of antivirals between arms.<br>**Primary Outcomes:**<br>• Proportion of patients with negative RT-PCR result on Day 5: 47.5% in IVM 24 mg arm, 35.0% in IVM 12 mg arm, and 31.1% in placebo arm ($P = 0.30$)<br>• VL at enrollment did not impact conversion to negative RT-PCR on Day 5.<br>• No significant difference in VL decline by Day 5 between the arms<br>• No difference in VL decline in the mild or moderate disease strata at Day 5<br>**Secondary Outcomes:**<br>• No difference between arms in mean time to symptom resolution or number of hospital-free days at Day 28<br>• Proportions of patients with clinical worsening were similar across the arms: 7.5% in IVM 24 mg arm, 5.0% in IVM 12 mg arm, and 11.1% in placebo arm ($P = 0.65$) | **Key Limitations:**<br>• Small sample size<br>**Interpretation:**<br>• Though the rate of negative RT-PCR results was numerically higher in the IVM arms than in the placebo arm on Day 5, the result was not statistically significant.<br>• No difference in clinical outcomes or frequency of AEs. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin in Patients With Mild to Moderate COVID-19[27]**, continued | | | |
| | • Frequency of clinical worsening<br>• Clinical status at Day 14<br>• Number of hospital-free days at Day 28 | • No difference between arms in frequency of AEs or SAEs | |
| **Efficacy and Safety of Ivermectin and Hydroxychloroquine in Patients With Severe COVID-19[28]** | | | |
| Randomized, double-blind trial of hospitalized adults with COVID-19 pneumonia in Mexico (n = 106)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• Pneumonia, diagnosed by CXR or high-resolution chest CT scan<br>• Recently established hypoxemic respiratory failure or deterioration of pre-existing lung or heart disease<br>**Key Exclusion Criteria:**<br>• Receipt of HFNC oxygen or invasive mechanical ventilation<br>• Patients with QT intervals ≥500 ms were not eligible for HCQ but were eligible for IVM.<br>**Interventions:**<br>• HCQ 400 mg twice daily on Day 1, then HCQ 200 mg/kg twice daily for 4 days<br>• Single dose of IVM 12 mg (in patients weighing ≤80 kg) or 18 mg (in those weighing >80 kg) plus calcium citrate for subsequent doses<br>• Calcium citrate placebo<br>**Primary Endpoint:**<br>• Time to discharge due to recovery | **Number of Participants:**<br>• HCQ (n = 33), IVM (n = 36), and placebo (n = 37)<br>**Participant Characteristics:**<br>• Mean age was 53 years (SD 16.9 years).<br>• 62% of patients were male.<br>• 34% of patients had diabetes, 32% had hypertension, and 72% had any comorbidity.<br>• Mean BMI was 29.6 (SD 6.6).<br>**Outcomes:**<br>• Median time to discharge due to recovery was 7 days (IQR 3–9 days) in HCQ arm, 6 days (IQR 4–11 days) in IVM arm, and 5 days (IQR 4–7 days) in placebo arm. The differences between arms were not statistically significant.<br>• Proportion of patients discharged alive: 79% in HCQ arm, 75% in IVM arm, and 73% in placebo arm<br>• Mortality: 6% of patients in HCQ arm, 14% in IVM arm, and 16% in placebo arm | **Key Limitations:**<br>• Small study<br>• Length of follow-up period is unclear.<br>• The study was stopped prior to achieving its target sample size.<br>**Interpretation:**<br>• In hospitalized patients with COVID-19 pneumonia who were not critically ill, neither IVM nor HCQ decreased the number of in-hospital days, rate of respiratory deterioration, or mortality.<br>• The small sample size and large number of comparisons make it difficult to assess the clinical efficacy of IVM in this population. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Ivermectin as Adjunctive Therapy to Hospitalized Patients With COVID-19[29]** | | | |
| Randomized, double-blind, placebo-controlled, multicenter, Phase 2 clinical trial of hospitalized adults with mild to severe SARS-CoV-2 infection in 5 facilities in Iran (n = 180)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Symptoms suggestive of COVID-19 pneumonia, with chest CT compatible with mild to severe COVID-19 or positive RT-PCR result for SARS-CoV-2<br>**Key Exclusion Criteria:**<br>• Severe immunosuppression, malignancy, or chronic kidney disease<br>• Pregnancy<br>**Interventions:**<br>• HCQ 200 mg/kg twice daily alone as SOC (standard arm)<br>• SOC plus 1 of the following:<br>  • Placebo<br>  • Single dose of IVM 200 µg/kg<br>  • IVM 200 µg/kg on Days 1, 3, and 5<br>  • Single dose of IVM 400 µg/kg<br>  • IVM 400 µg/kg on Day 1, then IVM 200 µg/kg on Days 3 and 5<br>**Primary Endpoint:**<br>• Clinical recovery within 45 days of enrollment (defined as normal temperature, respiratory rate, and $SpO_2$ >94% for 24 hours) | **Number of Participants:**<br>• All 6 arms (n = 30 in each arm)<br>**Participant Characteristics:**<br>• Average age was 56 years (range 45–67 years).<br>• 50% of patients were male.<br>• Disease stratification (based on CT findings): negative (1%), mild (14%), moderate (73%), and severe (12%)<br>• Mean $SpO_2$ at baseline was 89%.<br>**Primary Outcomes:**<br>• Durations of hypoxemia and hospitalization were shorter in IVM arms than placebo arm ($P = 0.025$ and $P = 0.006$, respectively), and mortality was lower in the IVM arms ($P = 0.001$).<br>• There was no difference in number of days of tachypnea ($P = 0.584$) or return to normal temperature ($P = 0.102$).<br>• Significant differences in change from baseline to Day 5 in absolute lymphocyte count, platelet count, erythrocyte sedimentation rate, and CRP.<br>• Higher mortality was reported in standard and placebo arms than IVM arms. | **Key Limitations:**<br>• Small study<br>• Power estimation is confusing.<br>• Mortality was not listed as the primary or secondary outcome.<br>• It is unclear whether IVM patients also received HCQ.<br>• It is unclear whether the between-group comparisons are between combined IVM groups and placebo plus SOC.<br>• Patients were stratified by disease severity based on CT findings. These categorizations are unclear and were not taken into account in outcome comparisons.<br>• The post hoc grouping of randomized arms raises risk of false positive findings.<br>**Interpretation:**<br>• IVM appeared to improve laboratory outcomes and some clinical outcomes (shorter duration of hypoxemia and hospitalization) and lowered mortality.<br>• The small size of the study, the unclear treatment arm assignments, and the lack of accounting for disease severity at baseline make it difficult to draw conclusions about the efficacy of using IVM to treat patients with mild COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Retrospective Analysis of Ivermectin in Hospitalized Patients With COVID-19[30]** | | | |
| Retrospective analysis of consecutive patients with laboratory-confirmed SARS-CoV-2 infection who were admitted to 4 Florida hospitals (n = 276) | **Key Inclusion Criteria:**<br>• Positive NP swab with SARS-CoV-2 RNA<br>**Interventions:**<br>• Single dose of IVM 200 µg/kg, repeated on Day 7 at the doctors' discretion; 90% of patients also received HCQ.<br>• Usual care: 97% of patients received HCQ and most also received AZM.<br>**Primary Endpoint:**<br>• All-cause, in-hospital mortality | **Number of Participants:**<br>• IVM (n = 173; 160 patients received a single dose, 13 patients received a second dose) and usual care (n = 103)<br>**Participant Characteristics:**<br>• Mean age was 60.2 years in IVM arm and 58.6 years in usual care arm.<br>• 51.4% of patients were male in IVM arm and 58.8% were male in usual care arm.<br>• 56.6% of patients were Black in IVM arm and 51.4% were Black in usual care arm.<br>**Outcomes:**<br>• All-cause mortality was lower in IVM arm than in usual care arm (OR 0.27; 95% CI, 0.09–0.80; $P = 0.03$); the benefit appeared to be limited to the subgroup of patients with severe disease.<br>• No difference in median length of hospital stay between arms (7 days for both) or proportion of mechanically ventilated patients who were successfully extubated (36% in IVM arm vs. 15% in usual care arm; $P = 0.07$). | **Key Limitations:**<br>• Not randomized<br>• Little to no information on $SpO_2$ or radiographic findings<br>• Timing of therapeutic interventions was not standardized.<br>• Ventilation and hospitalization duration analyses do not appear to account for death as a competing risk.<br>• No virologic assessments were performed.<br>**Interpretation:**<br>• IVM use was associated with lower mortality than usual care. However, the limitations of this retrospective analysis make it difficult to draw conclusions about the efficacy of using IVM to treat patients with COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Observational Study on the Effectiveness of Hydroxychloroquine, Azithromycin, and Ivermectin Among Hospitalized Patients With COVID-19[31]** | | | |
| Retrospective cohort study of hospitalized adults with COVID-19 in Peru (n = 5,683)<br>*This is a preliminary report that has not yet been peer-reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Symptomatic<br>• Laboratory-confirmed SARS-CoV-2 infection<br>• No life-threatening illness at admission<br>**Key Exclusion Criteria:**<br>• Required oxygen at admission<br>• Use of tocilizumab, LPV/RTV, or RDV<br>**Interventions:**<br>• One of the following interventions administered within 48 hours of admission:<br>  • HCQ or CQ alone<br>  • IVM alone<br>  • AZM alone<br>  • HCQ or CQ plus AZM<br>  • IVM plus AZM<br>  • SOC (e.g., supportive care, antipyretics, hydration)<br>**Primary Endpoint:**<br>• All-cause mortality<br>**Secondary Endpoint:**<br>• All-cause mortality and/or transfer to ICU | **Number of Participants:**<br>• HCQ or CQ alone (n = 200), IVM alone (n = 203), AZM alone (n = 1,600), HCQ or CQ plus AZM (n = 692), IVM plus AZM (n = 358), and SOC (n = 2,630)<br>**Participant Characteristics:**<br>• 63% of patients were male.<br>• Mean age was 59.4 years (range 18–104 years).<br>• All patients had mild or moderate disease.<br>**Outcomes:**<br>• Median follow-up time was 7 days. Mortality rate was 18.9% at the end of follow-up.<br>• IVM alone was associated with increased risk of death and/or ICU transfer compared to SOC (wHR 1.58; 95% CI, 1.11–2.25).<br>• IVM plus AZM did not have an effect on deaths or any secondary outcomes (all-cause death and/or ICU transfer, all-cause death and/or oxygen prescription) compared to SOC.<br>• HCQ or CQ plus AZM was associated with a higher risk of death (wHR 1.84; 95% CI, 1.12–3.02), death and/or ICU transfer (wHR 1.49; 95% CI, 1.01–2.19), and death and/or oxygen prescription (wHR 1.70; 95% CI, 1.07–2.69) compared to SOC. | **Key Limitations:**<br>• Not randomized<br>• Unclear whether all patients received IVM or other medications according to Peruvian guidelines referred to in the manuscript.<br>• Dosing and timing of administration are unclear.<br>**Interpretation:**<br>• Compared to SOC, IVM alone was associated with increased risk of death and/or ICU admission. Using IVM in combination with AZM was not associated with effects on mortality, ICU transfer, or oxygen prescription compared to SOC. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Retrospective Study of Ivermectin Versus Standard of Care in Patients With COVID-19[32]** | | | |
| Retrospective study of consecutive adult patients hospitalized in Bangladesh with laboratory-confirmed SARS-CoV-2 infection (n = 248) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Positive NP swab with SARS-CoV-2 RNA<br>• "Free from any other serious pathological conditions"<br>**Interventions:**<br>• Single dose of IVM 12 mg within 24 hours of hospital admission<br>• SOC<br>**Primary Outcome:**<br>• Not specified | **Number of Participants:**<br>• IVM (n = 115) and SOC (n = 133)<br>**Participant Characteristics:**<br>• Median age in IVM arm was 34 years; 70% of patients were male.<br>• Median age in SOC arm was 35 years; 52% of patients were male.<br>• All patients had mild or moderate disease.<br>• 12% of patients had hypertension in both arms.<br>• 17% of patients in IVM arm and 12% in SOC arm had DM.<br>**Outcomes:**<br>• Fewer patients in IVM arm had evidence of disease progression compared to SOC arm ($P < 0.001$): moderate respiratory distress (2.6% vs. 15.8%), pneumonia (0% vs. 9.8%), ischemic stroke (0% vs. 1.5%).<br>• Fewer patients in IVM arm required intensive care management compared to SOC arm (0.9% vs. 8.8%; $P < 0.001$).<br>• Fewer patients in IVM arm required antibiotic therapy (15.7% vs. 60.2%; $P < 0.001$) or supplemental oxygen (9.6% vs. 45.9%; $P < 0.001$) compared to SOC arm.<br>• Shorter median duration of viral clearance in IVM arm compared to SOC arm (4 vs. 15 days; $P < 0.001$).<br>• Shorter median duration of hospital stay in IVM arm compared to SOC arm (9 vs. 15 days; $P < 0.001$)<br>• Lower mortality in IVM arm compared to SOC arm (0.9% vs. 6.8%; $P < 0.05$) | **Key Limitations:**<br>• Not randomized<br>• Disease severity at admission was reported as mild or moderate, but 12% of patients in IVM arm and 9% in SOC arm had $SpO_2$ <94%<br>• Even though only 10% of patients developed pneumonia, 60% received antibiotics.<br>• Possibility of harm from concomitant medications<br>**Interpretation:**<br>• Compared to SOC, IVM use was associated with faster rates of viral clearance and better clinical outcomes, including shorter hospital stay and lower mortality. |

**Key:** AE = adverse event; AZM = azithromycin; BMI = body mass index; CAD = coronary artery disease; $C_{max}$ = maximum concentration; CQ = chloroquine; CrCl = creatinine clearance; CRP = C-reactive protein; CT = computed tomography; CXR = chest X-ray; CYP = cytochrome P450; DM = diabetes mellitus; DOX = doxycycline; HCQ = hydroxychloroquine; HFNC = high-flow nasal cannula; HTN = hypertension; ICU = intensive care unit; Ig = immunoglobulin; ITT = intention-to-treat; IVM = ivermectin; LDH = lactose dehydrogenase; LPV/RTV = lopinavir/ritonavir; MDR1 = multidrug resistance mutation 1; MI = myocardial infarction; mITT = modified intention-to-treat; NP = nasopharyngeal; OP = oropharyngeal; the Panel = the COVID-19 Treatment Guidelines Panel; $PaO_2/FiO_2$ = ratio of arterial partial pressure of oxygen to fraction of inspired oxygen; PCR = polymerase chain reaction; PK = pharmacokinetic; PO = orally; r = correlation coefficient; RA = room air; RCT = randomized controlled trial; RDV = remdesivir; RT-PCR = reverse transcriptase polymerase chain reaction; SAE = severe adverse event; SNP = single-nucleotide polymorphism; SOC = standard of care; SOFA = sequential organ failure assessment; $SpO_2$ = oxygen saturation; ULN = upper limit of normal; VL = viral load

## References


1. Spoorthi V, Sasank S. Utility of ivermectin and doxycycline combination for the treatment of SARS-CoV-2. *Int Arch Integr Med*. 2020;7(10):117-182. Available at: https://iaimjournal.com/wp-content/uploads/2020/10/iaim_2020_0710_23.pdf.
2. Camprubi D, Almuedo-Riera A, Marti-Soler H, et al. Lack of efficacy of standard doses of ivermectin in severe COVID-19 patients. *PLoS One*. 2020;15(11):e0242184. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33175880.
3. Bhattacharya R, Ray I, Mukherjee R, Chowdhury S, Kulasreshtha MK, Ghosh R. Observational study on clinical features, treatment and outcome of COVID-19 in a tertiary care centre in India - a retrospective case series. *Int J Sci Res*. 2020;9(10). Available at: https://www.worldwidejournals.com/international-journal-of-scientific-research-(IJSR)/article/observational-study-on-clinical-features-treatment-and-outcome-of-covid-19-in-a-tertiary-care-centre-in-india-andndash-a-retrospective-case-series/MzI0NTg=/?is=1&b1=141&k=36.
4. Morgenstern J, Redondo JN, León A, et al. The use of compassionate ivermectin in the management of symptomatic outpatients and hospitalized patients with clinical diagnosis of COVID-19 at the Medical Center Bournigal and the Medical Center Punta Cana, Rescue Group, Dominican Republic, from May 1 to August 10, 2020. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.29.20222505v1.
5. Cadegiani FA, Goren A, Wambier CG, McCoy J. Early COVID-19 therapy with azithromycin plus nitazoxanide, ivermectin or hydroxychloroquine in outpatient settings significantly reduced symptoms compared to known outcomes in untreated patients. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.31.20223883v1.
6. Carvallo H, Roberto H, Eugenia FM. Safety and efficacy of the combined use of ivermectin, dexamethasone, enoxaparin and aspirin against COVID 19. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.09.10.20191619v1.
7. Bukhari KHS, Asghar A, Perveen N, et al. Efficacy of ivermectin in COVID-19 patients with mild to moderate disease. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.02.02.21250840v1.
8. Elalfy H, Besheer T, El-Mesery A, et al. Effect of a combination of nitazoxanide, ribavirin, and ivermectin plus zinc supplement (MANS.NRIZ study) on the clearance of mild COVID-19. *J Med Virol*. 2021;93(5):3176-3183. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33590901.
9. Chahla RE, Ruiz LM, Mena T, et al. Cluster randomised trials—ivermectin repurposing for COVID-19 treatment of outpatients with mild disease in primary health care centers. *Research Square*. 2021;Preprint. Available at: https://www.researchsquare.com/article/rs-495945/v1.
10. Tanioka H, Tanioka S, Kaga K. Why COVID-19 is not so spread in Africa: how does ivermectin affect it? *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.26.21254377v1.
11. Roy S, Samajdar SS, Tripathi SK, Mukherjee S, Bhattacharjee K. Outcome of different therapeutic interventions in mild COVID-19 patients in a single OPD clinic of West Bengal: a retrospective study. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.08.21252883v2.
12. Pott-Junior H, Bastos Paoliello MM, Miguel AQC, et al. Use of ivermectin in the treatment of COVID-19: a pilot trial. *Toxicol Rep*. 2021;8:505-510. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33723507.
13. Merino J, Borja VH, Lopez O, et al. Ivermectin and the odds of hospitalization due to COVID-19: evidence from a quasi-experimental analysis based on a public intervention in Mexico City. *SocArXiv Papers*. 2021;Preprint. Available at: https://osf.io/preprints/socarxiv/r93g4/.
14. Shahbaznejad L, Davoudi A, Eslami G, et al. Effects of ivermectin in patients with COVID-19: a multicenter, double-blind, randomized, controlled

clinical yrial. *Clin Ther*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34052007.

15. Samaha AA, Mouawia H, Fawaz M, et al. Effects of a single dose of ivermectin on viral and clinical outcomes in asymptomatic SARS-CoV-2 infected subjects: a pilot clinical trial in Lebanon. *Viruses*. 2021;13(6). Available at: https://www.ncbi.nlm.nih.gov/pubmed/34073401.
16. Roman YM, Burela PA, Pasupuleti V, Piscoya A, Vidal JE, Hernandez AV. Ivermectin for the treatment of COVID-19: a systematic review and meta-analysis of randomized controlled trials. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.05.21.21257595v2.full.
17. Lopez-Medina E, Lopez P, Hurtado IC, et al. Effect of ivermectin on time to resolution of symptoms among adults with mild COVID-19: a randomized clinical trial. *JAMA*. 2021;325(14):1426-1435. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33662102.
18. Ahmed S, Karim MM, Ross AG, et al. A five-day course of ivermectin for the treatment of COVID-19 may reduce the duration of illness. *Int J Infect Dis*. 2020;103:214-216. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33278625.
19. Okumus N, Demirturk N, Cetinkaya RA, et al. Evaluation of the effectiveness and safety of adding ivermectin to treatment in severe COVID-19 patients. *BMC Infect Dis*. 2021;21(1):411. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33947344.
20. Galan LEB, Santos NMD, Asato MS, et al. Phase 2 randomized study on chloroquine, hydroxychloroquine or ivermectin in hospitalized patients with severe manifestations of SARS-CoV-2 infection. *Pathog Glob Health*. 2021;115(4):235-242. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33682640.
21. Chachar AZK, Khan KA, Asif M, Tanveer K, Khaqan A, Basri R. Effectiveness of ivermectin in SARS-COV-2/COVID-19 Patients. *Int J of Sci*. 2020;9:31-35. Available at: https://www.ijsciences.com/pub/article/2378.
22. Podder CS, Chowdhury N, Sina MI, Haque W. Outcome of ivermectin treated mild to moderate COVID-19 cases: a single-centre, open-label, randomised controlled study. *IMC J Med Sci*. 2020. Available at: https://doi.org/10.3329/imcjms.v14i2.52826.
23. Chowdhury ATMM, Shahbaz M, Karim MR, Islam J, Dan G, He S. A comparative study on ivermectin-doxycycline and hydroxychloroquine-azithromycin therapy on COVID-19 patients. *EJMO*. 2021;5(1):63-70. Available at: https://ejmo.org/pdf/A%20Comparative%20Study%20on%20IvermectinDoxycycline%20and%20HydroxychloroquineAzithromycin%20Therapy%20on%20COVID19%20Patients-16263.pdf.
24. Krolewiecki A, Lifschitz A, Moragas M, et al. Antiviral effect of high-dose ivermectin in adults with COVID-19: a proof-of-concept randomized trial. *Lancet*. 2021. Available at: https://www.sciencedirect.com/science/article/pii/S258953702100239X?via%3Dihub.
25. Chaccour C, Casellas A, Blanco-Di Matteo A, et al. The effect of early treatment with ivermectin on viral load, symptoms and humoral response in patients with non-severe COVID-19: A pilot, double-blind, placebo-controlled, randomized clinical trial. *Lancet*. 2021. Available at: https://www.thelancet.com/action/showPdf?pii=S2589-5370%2820%2930464-8.
26. Hashim HA, Maulood MF, Rasheed AW, Fatak DF, Kabah KK, Abdulamir AS. Controlled randomized clinical trial on using ivermectin with doxycycline for treating COVID-19 patients in Baghdad, Iraq. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.26.20219345v1/.
27. Mohan A, Tiwari P, Suri T, et al. Ivermectin in mild and moderate COVID-19 (RIVET-COV): a randomized, placebo-controlled trial. *Research Square*. 2021;Preprint. Available at: https://www.researchsquare.com/article/rs-191648/v1.
28. Gonzalez JLB, Gámez MG, Enciso EAM, et al. Efficacy and safety of ivermectin and hydroxychloroquine in patients with severe COVID-19. A randomized controlled trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.02.18.21252037v1.

29. Niaee MS, Gheibi N, Namdar P, et al. Ivermectin as an adjunct treatment for hospitalized adult COVID-19 patients: a randomized multi-center clinical trial. *Research Square*. 2020;Preprint. Available at: https://www.researchsquare.com/article/rs-109670/v1.

30. Rajter JC, Sherman MS, Fatteh N, Vogel F, Sacks J, Rajter JJ. Use of ivermectin is associated with lower mortality in hospitalized patients with coronavirus disease 2019: the ICON study. *Chest*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33065103.

31. Soto-Becerra P, Culquichicón C, Hurtado-Roca Y, Araujo-Castillo RV. Real-world effectiveness of hydroxychloroquine, azithromycin, and ivermectin among hospitalized COVID-19 patients: results of a target trial emulation using observational data from a nationwide healthcare system in Peru. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.10.06.20208066v3.

32. Khan MSI, Khan MSI, Debnath CR, et al. Ivermectin treatment may improve the prognosis of patients with COVID-19. *Arch Bronconeumol*. 2020;56(12):828-830. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33293006.

# Lopinavir/Ritonavir and Other HIV Protease Inhibitors

*Last Updated: February 11, 2021*

The replication of SARS-CoV-2 depends on the cleavage of polyproteins into an RNA-dependent RNA polymerase and a helicase.[1] Two proteases are responsible for this cleavage: 3-chymotrypsin-like protease (3CLpro) and papain-like protease (PLpro).

Lopinavir/ritonavir and darunavir/cobicistat have been studied in patients with COVID-19. The clinical trials discussed below have not demonstrated a clinical benefit for protease inhibitors in patients with COVID-19.

## Recommendations

- The COVID-19 Treatment Guidelines Panel (the Panel) **recommends against** the use of **lopinavir/ritonavir** and **other HIV protease inhibitors** for the treatment of COVID-19 in hospitalized patients **(AI)**.
- The Panel **recommends against** the use of **lopinavir/ritonavir** and **other HIV protease inhibitors** for the treatment of COVID-19 in nonhospitalized patients **(AIII)**.

## Rationale

The pharmacodynamics of lopinavir/ritonavir raise concerns about whether it is possible to achieve drug concentrations that can inhibit the SARS-CoV-2 proteases.[2,3] In addition, lopinavir/ritonavir did not show efficacy in two large randomized controlled trials in hospitalized patients with COVID-19.[4,5]

There is currently a lack of data on the use of lopinavir/ritonavir in nonhospitalized patients with COVID-19. However, the pharmacodynamic concerns and the lack of evidence for a clinical benefit among hospitalized patients with COVID-19 undermine confidence that lopinavir/ritonavir has a clinical benefit at any stage of SARS-CoV-2 infection.

## Adverse Events

The adverse events for lopinavir/ritonavir include:

- Nausea, vomiting, diarrhea (common)
- QTc prolongation
- Hepatotoxicity

## Drug-Drug Interactions

Lopinavir/ritonavir is a potent inhibitor of cytochrome P450 3A. Coadministering lopinavir/ritonavir with medications that are metabolized by this enzyme may increase the concentrations of those medications, resulting in concentration-related toxicities. Please refer to the *Guidelines for the Use of Antiretroviral Agents in Adults and Adolescents with HIV* for a list of potential drug interactions.

## Summary of Clinical Data for COVID-19

- The plasma drug concentrations achieved using typical doses of lopinavir/ritonavir are far below the levels that may be needed to inhibit SARS-CoV-2 replication.[3]
- Lopinavir/ritonavir did not demonstrate a clinical benefit in hospitalized patients with COVID-19 during a large randomized trial in the United Kingdom.[4]

- In a large international randomized trial, lopinavir/ritonavir did not reduce the mortality rate among hospitalized patients with COVID-19.[5]
- A moderately sized randomized trial (n = 199) failed to find a virologic or clinical benefit of lopinavir/ritonavir over standard of care.[6]
- Results from a small randomized controlled trial showed that darunavir/cobicistat was not effective for the treatment of COVID-19.[7]
- There are no data from clinical trials that support using other HIV protease inhibitors to treat COVID-19.
- Please see Clinical Data for COVID-19 below for more information.

## Clinical Data for COVID-19

The information presented in this section may include data from preprints or articles that have not been peer reviewed. This section will be updated as new information becomes available. Please see *ClinicalTrials.gov* for more information on clinical trials that are evaluating lopinavir/ritonavir.

### *Lopinavir/Ritonavir in Hospitalized Patients With COVID-19: The RECOVERY Trial*

The Randomised Evaluation of COVID-19 Therapy (RECOVERY) trial is an ongoing, open-label, randomized controlled trial with multiple arms, including a control arm; in one arm, participants received lopinavir/ritonavir. The trial was conducted across 176 hospitals in the United Kingdom and enrolled hospitalized patients with clinically suspected or laboratory-confirmed SARS-CoV-2 infection.[4]

Patients were randomized into several parallel treatment arms; this included randomization in a 2:1 ratio to receive either the usual standard of care only or the usual standard of care plus lopinavir 400 mg/ritonavir 100 mg orally every 12 hours for 10 days or until hospital discharge. Patients who had severe hepatic insufficiency or who were receiving medications that had potentially serious or life-threatening interactions with lopinavir/ritonavir were excluded from randomization into either of these arms. Mechanically ventilated patients were also underrepresented in this study because it was difficult to administer the oral tablet formulation of lopinavir/ritonavir to patients who were on mechanical ventilation. The primary outcome was all-cause mortality at Day 28 after randomization.

The lopinavir/ritonavir arm was discontinued on June 29, 2020, after the independent data monitoring committee concluded that the data showed no clinical benefit for lopinavir/ritonavir.

#### Patient Characteristics

- Of the 7,825 participants who were eligible to receive lopinavir/ritonavir, 1,616 were randomized to receive lopinavir/ritonavir and 3,424 were randomized to receive standard of care only. The remaining participants were randomized to other treatment arms in the study.
- In both the lopinavir/ritonavir arm and the standard of care arm, the mean age was 66 years; 44% of patients were aged ≥70 years.
- Test results for SARS-CoV-2 infection were positive for 88% of patients. The remaining 12% had a negative test result.
- Comorbidities were common; 57% of patients had at least one major comorbidity. Of those patients, 28% had diabetes mellitus, 26% had heart disease, and 24% had chronic lung disease.
- At randomization, 4% of patients were receiving invasive mechanical ventilation, 70% were receiving oxygen only (with or without noninvasive ventilation), and 26% were receiving neither.
- The percentages of patients who received azithromycin or another macrolide during the follow-up

period were similar in both arms (23% in the lopinavir/ritonavir arm vs. 25% in the standard of care arm). In addition, 10% of patients in both arms received dexamethasone.

#### Results

- There was no significant difference in the primary outcome of 28-day mortality between the two arms; 374 patients (23%) in the lopinavir/ritonavir arm and 767 patients (22%) in the standard of care arm had died by Day 28 (rate ratio 1.03; 95% CI, 0.91–1.17; $P = 0.60$).
- A similar 28-day mortality was reported for patients who received lopinavir/ritonavir in an analysis that was restricted to the 4,423 participants who had positive SARS-CoV-2 test results (rate ratio 1.05; 95% CI, 0.92–1.19; $P = 0.49$).
- Patients in the lopinavir/ritonavir arm and patients in the standard of care arm had similar median times to discharge (11 days in both arms) and similar probabilities of being discharged alive within 28 days (69% vs. 70%).
- Among participants who were not on invasive mechanical ventilation at baseline, patients who received lopinavir/ritonavir and those who received standard of care only had similar risks of progression to intubation or death.
- Results were consistent across subgroups defined by age, sex, ethnicity, or respiratory support at baseline.

#### Limitations

- The study was not blinded.
- No laboratory or virologic data were collected.

#### Interpretation

Lopinavir/ritonavir did not decrease 28-day all-cause mortality when compared to the usual standard of care in hospitalized persons with clinically suspected or laboratory-confirmed SARS-CoV-2 infection. Participants who received lopinavir/ritonavir and those who received standard of care only had similar median lengths of hospital stay. Among the patients who were not on invasive mechanical ventilation at the time of randomization, those who received lopinavir/ritonavir were as likely to require intubation or die during hospitalization as those who received standard of care.

### *Lopinavir/Ritonavir in Hospitalized Patients with COVID-19: The Solidarity Trial*

The Solidarity trial was an open-label, randomized controlled trial that enrolled hospitalized patients with COVID-19 in 405 hospitals across 30 countries. The study included multiple arms; in one arm, participants received lopinavir/ritonavir. The control group for this arm included people who were randomized at the same site and time who could have received lopinavir/ritonavir but received standard of care instead. Lopinavir 400 mg/ritonavir 100 mg was administered orally twice daily for 14 days or until hospital discharge. Only the oral tablet formulation of lopinavir/ritonavir was available, which precluded administration to those on mechanical ventilation. The primary outcome was in-hospital mortality.[5]

After the results of the RECOVERY trial prompted a review of the Solidarity data, the lopinavir/ritonavir arm ended enrollment on July 4, 2020. At that time, 1,411 patients had been randomized to receive lopinavir/ritonavir, and 1,380 patients received standard of care.

#### Patient Characteristics

- In both the lopinavir/ritonavir arm and the standard of care arm, 20% of the participants were aged ≥70 years and 37% were aged <50 years.
- Comorbidities were common. Diabetes mellitus was present in 24% of patients, heart disease in 21%, and chronic lung disease in 7%.

- At randomization, 8% of patients were receiving invasive mechanical ventilation or extracorporeal membrane oxygenation, 53% were receiving oxygen only (with or without noninvasive ventilation), and 39% were receiving neither.
- Similar percentages of patients received corticosteroids in the lopinavir/ritonavir arm and the standard of care arm (23% vs. 24%). Other nonstudy treatments were administered less often, and the use of these treatments was balanced between arms.

#### Results

- There was no significant difference in in-hospital mortality between the two arms; 148 patients (9.7%) in the lopinavir/ritonavir arm and 146 patients (10.3%) in the standard of care arm had died by Day 28 (rate ratio 1.00; 95% CI, 0.79–1.25; $P = 0.97$).
- Progression to mechanical ventilation among those who were not ventilated at randomization occurred in 126 patients in the lopinavir/ritonavir arm and 121 patients in the standard of care arm.
- In-hospital mortality results appeared to be consistent across subgroups.

#### Limitations

- The study was not blinded.
- Those who were on mechanical ventilation were unable to receive lopinavir/ritonavir.
- The study includes no data on time to recovery.

#### Interpretation

Among hospitalized patients, lopinavir/ritonavir did not decrease in-hospital mortality or the number of patients who progressed to mechanical ventilation compared to standard of care.

### *Lopinavir/Ritonavir Pharmacokinetics in Patients With COVID-19*

In a case series, eight patients with COVID-19 were treated with lopinavir 400 mg/ritonavir 100 mg orally twice daily and had plasma trough levels of lopinavir drawn and assayed by liquid chromatography-tandem mass spectrometry.[3]

#### Results

- The median plasma lopinavir concentration was 13.6 µg/mL.
- After correcting for protein binding, trough levels would need to be approximately 60-fold to 120-fold higher to achieve the in vitro half-maximal effective concentration ($EC_{50}$) for SARS-CoV-2.

#### Limitations

- Only the trough levels of lopinavir were quantified.
- The concentration of lopinavir required to effectively inhibit SARS-CoV-2 replication in vivo is currently unknown.

#### Interpretation

The plasma drug concentrations that were achieved using typical doses of lopinavir/ritonavir are far below the levels that may be needed to inhibit SARS-CoV-2 replication.

### *Other Reviewed Studies*

The Panel has reviewed other clinical studies that evaluated the use of protease inhibitors for the treatment of COVID-19.[6,8,9] These studies have limitations that make them less definitive and

informative than larger randomized clinical trials. The Panel's summaries and interpretations of some of these studies are available in the archived versions of the Guidelines.

## References


1. Zumla A, Chan JF, Azhar EI, Hui DS, Yuen KY. Coronaviruses - drug discovery and therapeutic options. *Nat Rev Drug Discov*. 2016;15(5):327-347. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26868298.
2. Marzolini C, Stader F, Stoeckle M, et al. Effect of systemic inflammatory response to SARS-CoV-2 on lopinavir and hydroxychloroquine plasma concentrations. *Antimicrob Agents Chemother*. 2020;64(9). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32641296.
3. Schoergenhofer C, Jilma B, Stimpfl T, Karolyi M, Zoufaly A. Pharmacokinetics of lopinavir and ritonavir in patients hospitalized with coronavirus disease 2019 (COVID-19). *Ann Intern Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32422065.
4. Group RC. Lopinavir-ritonavir in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *Lancet*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33031764.
5. WHO Solidarity Trial Consortium, Pan H, Peto R, et al. Repurposed antiviral drugs for COVID-19—interim WHO Solidarity Trial results. *N Engl J Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33264556.
6. Cao B, Wang Y, Wen D, et al. A trial of lopinavir-ritonavir in adults hospitalized with severe COVID-19. *N Engl J Med.* 2020;382(19):1787-1799. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32187464.
7. Chen J, Xia L, Liu L, et al. Antiviral activity and safety of darunavir/cobicistat for the treatment of COVID-19. *Open Forum Infect Dis*. 2020;7(7):ofaa241. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32671131.
8. Hung IF, Lung KC, Tso EY, et al. Triple combination of interferon beta-1b, lopinavir-ritonavir, and ribavirin in the treatment of patients admitted to hospital with COVID-19: an open-label, randomised, Phase 2 trial. *Lancet*. 2020;395(10238):1695-1704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32401715.
9. Li Y, Xie Z, Lin W, et al. Efficacy and safety of lopinavir/ritonavir or arbidol in adult patients with mild/moderate COVID-19: an exploratory randomized controlled trial. *Med*. 2020:[In Press]. Available at: https://www.sciencedirect.com/science/article/pii/S2666634020300015.

# Nitazoxanide

*Last Updated: July 8, 2021*

Nitazoxanide is a broad-spectrum thiazolide antiparasitic agent that is approved by the Food and Drug Administration (FDA) for the treatment of *Cryptosporidium parvum* and *Giardia duodenalis* infections in children aged ≥1 year and adults. Nitazoxanide is rapidly metabolized to its active metabolite, tizoxanide, and has in vitro antiviral activity against a range of viruses, including influenza viruses, hepatitis B and C viruses, norovirus, rotavirus, Ebola virus, Middle East respiratory syndrome coronavirus (MERS-CoV), and SARS-CoV-2.[1-3] The mechanism of antiviral activity is not fully characterized. Nitazoxanide inhibits host enzymes, which impairs the posttranslational processing of viral proteins. It also has inhibitory effects on proinflammatory cytokines. With the exception of a Phase 2b/3 trial for uncomplicated influenza, the evidence for clinical activity of nitazoxanide against other viruses is limited or of low quality.[4]

## Recommendation

- The COVID-19 Treatment Guidelines Panel (the Panel) **recommends against** the use of **nitazoxanide** for the treatment of COVID-19, except in a clinical trial **(BIIa)**.

## Rationale

Two randomized controlled trials that were conducted in Brazil and the United States did not find a significant clinical benefit for nitazoxanide treatment in nonhospitalized adults with COVID-19 when treatment was initiated within 2 to 5 days after illness onset.[5,6] One of these trials, which has not yet been published, reported that fewer patients in the nitazoxanide arm progressed to severe COVID-19 than in the placebo arm. However, the study was underpowered to detect a difference, and this finding was not statistically significant.[6] Additional small, unpublished studies were reviewed; however, due to their limitations, they did not provide support for the use of nitazoxanide.[7,8] Nitazoxanide was well tolerated in these trials. The Panel concluded that results from adequately powered, well-designed, and well-conducted clinical trials are needed to provide more specific, evidence-based guidance on the role of nitazoxanide in the treatment of COVID-19.

Please see Table 2d for more information.

## Monitoring, Adverse Effects, and Drug-Drug Interactions

- Nitazoxanide is generally well tolerated. The most commonly reported side effects include abdominal pain, diarrhea, headache, nausea, vomiting, urine discoloration, and, rarely, ocular discoloration.
- Nitazoxanide is a highly plasma protein-bound drug (>99.9%). Drug-drug interactions may occur when nitazoxanide is administered concurrently with other highly plasma protein-bound drugs due to competition for binding sites. If nitazoxanide is coadministered with other highly protein-bound drugs with narrow therapeutic indices, monitor the patient for adverse drug reactions.
- Please see Table 2e for more information.

## Considerations in Pregnancy

According to the animal study data included in the product label, nitazoxanide does not appear to affect fertility, nor does it cause fetal toxicity.[9] There are no data on using nitazoxanide to treat COVID-19 in pregnant women.

## Considerations in Children

Nitazoxanide is approved by the FDA for use in children aged ≥1 year old to treat *Cryptosporidium parvum* and *Giardia duodenalis* infections. Dosing for the nitazoxanide suspension or tablets is available for children that provides exposure that is similar to the approved adult dose of oral nitazoxanide 500 mg twice daily. There are no data on using nitazoxanide to treat COVID-19 in children.

## Clinical Trials

Several clinical trials that are evaluating the use of nitazoxanide for the treatment of COVID-19 are currently underway or in development. Please see *ClinicalTrials.gov* for the latest information.

## References


1. Jasenosky LD, Cadena C, Mire CE, et al. The FDA-approved oral drug nitazoxanide amplifies host antiviral responses and inhibits ebola virus. *iScience*. 2019;19:1279-1290. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31402258.
2. Rossignol JF. Nitazoxanide: a first-in-class broad-spectrum antiviral agent. *Antiviral Res*. 2014;110:94-103. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25108173.
3. Cao J, Forrest JC,Zhang X. A screen of the NIH Clinical Collection small molecule library identifies potential anti-coronavirus drugs. *Antiviral Res*. 2015;114:1-10. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25451075.
4. Haffizulla J, Hartman A, Hoppers M, et al. Effect of nitazoxanide in adults and adolescents with acute uncomplicated influenza: a double-blind, randomised, placebo-controlled, phase 2b/3 trial. *Lancet Infect Dis*. 2014;14(7):609-618. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24852376.
5. Rocco PRM, Silvia PL, Cruz FF, et al. Early use of nitazoxanide in mild COVID-19 disease: randomised, placebo-controlled trial. *Eur Respir J*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33361100.
6. Rossignol J, Bardin MC, Oaks JB,et al. Early treatment with nitazoxanide prevents worsening of mild and moderate COVID-19 and subsequent hospitalization. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.19.21255441v1.
7. Blum VF, Cimerman S, Hunter JR,et al. Nitazoxanide in vitro efficacy against SARS CoV-2 and in vivo superiority to placebo to treat moderate COVID-19—a Phase 2 randomized double-blind clinical trial. *Preprints with the Lancet*. 2021. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3763773.
8. Silva M, Espejo A, Pereyra ML, et al. Efficacy of nitazoxanide in reducing the viral load in COVID-19 patients: randomized, placebo-controlled, single-blinded, parallel-group, pilot study. *MedRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.03.21252509v1.full.pdf.
9. Nitazoxanide (Alinia) [package insert]. Lupin Pharma. 2021. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2016/021497s001,021498s004lbl.pdf.

# Table 2d. Nitazoxanide: Selected Clinical Data

*Last Updated: July 8, 2021*

The information in this table may include data from preprints or articles that have not been peer reviewed. This section will be updated as new information becomes available. Please see *ClinicalTrials.gov* for more information on clinical trials that are evaluating NTZ for the treatment of COVID-19. The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing recommendations for NTZ.[1,2]

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Early Treatment of Mild COVID-19 with Nitazoxanide[3]** | | | |
| Randomized, double-blind, placebo-controlled trial in nonhospitalized adults with mild COVID-19 in Brazil (n = 475) | **Key Inclusion Criteria:**<br>• Clinical signs and symptoms of COVID-19 for ≤3 days (fever, dry cough, and/or fatigue)<br>**Key Exclusion Criteria:**<br>• Negative SARS-CoV-2 RT-PCR result from an NP swab<br>• Renal, heart, respiratory, liver, or autoimmune diseases<br>• Participant had a history of cancer in the past 5 years<br>**Interventions:**<br>• NTZ 500 mg 3 times daily for 5 days using the oral liquid formulation<br>• Color-matched placebo 3 times daily for 5 days<br>**Primary Endpoint:**<br>• Complete resolution of dry cough, fever, and/or fatigue after receiving treatment for 5 days<br>**Key Secondary Endpoints:**<br>• Reduction in SARS-CoV-2 VL<br>• Incidence of hospital admission after completing therapy | **Number of Participants:**<br>• NTZ (n = 194) and placebo (n = 198)<br>**Participant Characteristics:**<br>• Median age of patients was 37 years.<br>  • Percentage of patients aged 18–39 years: 58%<br>  • Percentage of patients aged 40–59 years: 36%<br>  • Percentage of patients aged 60–77 years: 6%<br>• 53% of patients were women.<br>• 69% of patients were White.<br>• 31% of patients had a BMI ≥30.<br>• 85% of patients had no reported comorbidities.<br>• Median time from symptom onset to first dose of study drug was 5 days (IQR 4–5 days).<br>• Baseline median SARS-CoV-2 VL was 7.06 $\log_{10}$ c/mL (IQR 5.77–8.13) in NTZ arm and 7.49 $\log_{10}$ c/mL (IQR 6.15–8.32) in placebo arm ($P = 0.065$).<br>**Primary Outcome:**<br>• There was no difference in time to complete resolution of symptoms between NTZ and placebo arms ($P = 0.277$)<br>**Secondary Outcomes:**<br>• After 5 days, median SARS-CoV-2 VL was lower in NTZ arm (3.63 $\log_{10}$ c/mL [IQR 0–5.03]) than in placebo arm (4.13 $\log_{10}$ c/mL [IQR 2.88–5.31]; $P = 0.006$). | **Key Limitations:**<br>• In general, the patients in this study were young and relatively healthy.<br>• At baseline, the median VL was 0.43 $\log_{10}$ c/mL lower in the NTZ arm than in the placebo arm; however, this difference was not statistically significant (trend toward a significant difference; $P = 0.065$). Although the difference in absolute VLs between the arms at Day 5 was reported as statistically significant, without the information on the change in VL in each arm, it is difficult to interpret the significance of the findings.<br>• Some participants who received the study drug were excluded from the analysis population due to discontinued intervention (21 in NTZ arm vs. 18 in placebo arm); AEs (6 in NTZ arm vs. 1 in placebo arm); hospitalization (5 in NTZ arm vs. 5 in placebo arm); and protocol deviations (7 in NTZ arm vs. 7 in placebo arm). This complicates the interpretation of the study results, because an ITT analysis was not included. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Early Treatment of Mild COVID-19 with Nitazoxanide[3]**, continued | | | |
| | | • 29.9% of patients in NTZ arm and 18.2% of patients in placebo arm had a negative SARS-CoV-2 RT-PCR result at the fifth treatment visit ($P = 0.009$).<br>• In the ITT study population, 5 patients on NTZ and 5 on placebo were hospitalized due to clinical deterioration; 2 who received NTZ required ICU admission vs. 0 who received placebo. These individuals were excluded from the analysis population because they did not complete the 5-day treatment course before clinical progression occurred.<br>**Other Outcomes:**<br>• Mild to moderate AEs occurred in about 30% of participants in each arm who completed 5 days of therapy. | **Interpretation:**<br>• NTZ did not improve time to resolution of symptoms compared to placebo.<br>• Median VL was lower at Day 5 in the NTZ arm than in the placebo arm, but this may reflect differences in baseline VLs.<br>• NTZ was well tolerated. |
| **Early Treatment of Mild to Moderate COVID-19 with an Investigational Formulation of Nitazoxanide[4]** | | | |
| Randomized, double-blind, placebo-controlled trial in nonhospitalized patients with COVID-19 in the United States and Puerto Rico (n = 1,092)<br>*This is a preliminary, unpublished report that has not been peer reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥12 years<br>• Enrollment ≤72 hours of symptom onset<br>• Mild to moderate COVID-19<br>• ≥2 respiratory symptom domains with a score ≥2 on FLU-PRO questionnaire at screening, and no improvement in overall symptom severity compared to previous day<br>**Key Exclusion Criteria:**<br>• Signs or symptoms of severe COVID-19<br>• Previous COVID-19 or any symptom suggestive of COVID-19<br>• Recent acute upper respiratory tract infection<br>• Severe immunodeficiency<br>• Severe heart, lung, neurological, or other systemic diseases | **Number of Participants:**<br>• mITT analysis: NTZ (n = 184) and placebo (n = 195)<br>**Participant Characteristics:**<br>• Median age of patients was 40 years.<br>• 43.5% of patients were men.<br>• 87.6% of patients were White.<br>• Median BMI was 28.9.<br>• Median time from symptom onset to randomization was 45.9 hours.<br>• 64.8% of patients had mild disease.<br>• 35.2% of patients had moderate disease.<br>• 62.8% of patients were at risk for severe illness.<br>**Primary Outcome:**<br>• NTZ was not associated with a reduction in median time to sustained response compared to placebo (13.3 days in NTZ arm vs. 12.4 days in placebo arm; $P = 0.88$)<br>**Secondary Outcomes:**<br>• Progression to severe disease occurred in 1 of 184 patients (0.5%) in NTZ arm and 7 of 195 patients (3.6%) in placebo arm ($P = 0.07$). | **Key Limitations:**<br>• Information is limited in this preliminary report.<br>• Because the number of high-risk participants who progressed to severe COVID-19 in this study was small, the results for this subgroup are fragile. Larger studies are needed.<br>**Interpretation:**<br>• NTZ did not demonstrate significant clinical or virologic benefits when compared to placebo.<br>• NTZ was well tolerated. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Early Treatment of Mild to Moderate COVID-19 with an Investigational Formulation of Nitazoxanide[4]**, continued | | | |
| | **Interventions:**<br>• 2 investigational NTZ 300 mg extended-release tablets (for a total dose of 600 mg) PO with food twice daily for 5 days<br>• Matching placebo for 5 days<br>• All subjects received a vitamin B complex supplement twice daily to mask potential NTZ-associated chromaturia.<br>**Primary Endpoint:**<br>• Time from first dose to sustained response<br>**Secondary Endpoint:**<br>• Rate of progression to severe COVID-19 | • Among a subgroup of patients who had a high risk for severe illness according to CDC criteria, 1 of 112 patients (0.9%) in NTZ arm and 7 of 126 patients (5.6%) in placebo arm progressed to severe disease ($P = 0.07$).<br>• 1 of 184 patients (0.5%) in NTZ arm and 5 of 195 (2.6%) in placebo arm were hospitalized ($P = 0.18$).<br>• There was no significant difference in viral endpoints between arms at Days 4 and 10.<br>**Other Outcomes:**<br>• The safety analysis included 935 participants (472 in NTZ arm and 463 in placebo arm).<br>• 2 patients in NTZ arm and 3 patients in placebo arm stopped the study drug due to AEs. | |

**Key:** AE = adverse event; BMI = body mass index; CDC = Centers for Disease Control and Prevention; FLU-PRO = Influenza Patient Reported Outcomes; ICU = intensive care unit; ITT = intention-to-treat; mITT = modified intention-to-treat; NP = nasopharyngeal; NTZ = nitazoxanide; the Panel = the COVID-19 Treatment Guidelines Panel; PO = orally; RT-PCR = reverse transcription polymerase chain reaction; VL = viral load

## References


1. Blum VF, Cimerman S, Hunter JR, et al. Nitazoxanide in vitro efficacy against SARS CoV-2 and in vivo superiority to placebo to treat moderate COVID-19–a Phase 2 randomized double-blind clinical trial. *Preprints with the Lancet*. 2021. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3763773.
2. Silva M, Espejo A, Pereyra ML, et al. Efficacy of nitazoxanide in reducing the viral load in COVID-19 patients. Randomized, placebo-controlled, single-blinded, parallel group, pilot study. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.03.21252509v1.
3. Rocco PRM, Silva PL, Cruz FF, et al. Early use of nitazoxanide in mild COVID-19 disease: randomised, placebo-controlled trial. *Eur Respir J*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33361100.
4. Rossignol J, Bardin MC, Oaks JB, et al. Early treatment with nitazoxanide prevents worsening of mild and moderate COVID-19 and subsequent hospitalization. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.19.21255441v1.

# Table 2e. Characteristics of Antiviral Agents That Are Approved or Under Evaluation for the Treatment of COVID-19

*Last Updated: July 8, 2021*

- The information in this table is derived from data on the use of these drugs for FDA-approved indications or in investigational trials, and it is supplemented with data on their use in patients with COVID-19, when available.
- Information on CQ, HCQ, and LPV/RTV are available in the archived versions of the Guidelines. However, the Panel **recommends against** using these agents to treat COVID-19.
- There are limited or no data on dose modifications for patients with organ failure or those who require extracorporeal devices. Please refer to product labels, when available.
- There are currently not enough data to determine whether certain medications can be safely coadministered with therapies for the treatment of COVID-19. When using concomitant medications with similar toxicity profiles, consider performing additional safety monitoring.
- The potential additive, antagonistic, or synergistic effects and the safety of using combination therapies for the treatment of COVID-19 are unknown. Clinicians are encouraged to report AEs to the FDA *MedWatch* program.
- For drug interaction information, please refer to product labels and visit the Liverpool COVID-19 Drug Interactions website.
- For the Panel's recommendations on using the drugs listed in this table, please refer to the individual drug sections or Therapeutic Management of Hospitalized Adults With COVID-19.

| **Dosing Regimens**<br>*The doses listed here are for approved indications or from reported experiences or clinical trials.* | **Adverse Events** | **Monitoring Parameters** | **Drug-Drug Interaction Potential** | **Comments and Links to Clinical Trials** |
|---|---|---|---|---|
| **Remdesivir** | | | | |
| The doses and indications listed below come from the FDA product information. Please see Therapeutic Management of Hospitalized Adults With COVID-19 for the Panel's recommendations on when to use RDV.<br>**For Hospitalized Adults and Children (Aged ≥12 Years and Weighing ≥40 kg)** | • Nausea<br>• ALT and AST elevations<br>• Hypersensitivity<br>• Increases in prothrombin time<br>• Drug vehicle is SBECD, which has been associated with renal and liver toxicity. SBECD accumulation may occur in patients with moderate or severe renal impairment. | • Infusion reactions<br>• Renal function and hepatic function should be monitored before and during treatment as clinically indicated.<br>• In the FDA product information, RDV **is not recommended** when eGFR is <30 mL/min. See the Remdesivir section for a discussion on using RDV in people with renal insufficiency. | • Clinical drug-drug interaction studies of RDV have not been conducted.<br>• In vitro, RDV is a substrate of CYP3A4, OATP1B1, and P-gp and an inhibitor of CYP3A4, OATP1B1, OATP1B3, and MATE1.[1] | • RDV should be administered in a hospital or a health care setting that can provide a similar level of care to an inpatient hospital.<br>• RDV is approved by the FDA for the treatment of COVID-19 in hospitalized adult and pediatric patients (aged ≥12 years and weighing ≥40 kg). |

| **Dosing Regimens**<br>*The doses listed here are for approved indications or from reported experiences or clinical trials.* | **Adverse Events** | **Monitoring Parameters** | **Drug-Drug Interaction Potential** | **Comments and Links to Clinical Trials** |
|---|---|---|---|---|
| **Remdesivir**, continued | | | | |
| *For Patients Who Are Not Mechanically Ventilated and/or on ECMO:*<br>• RDV 200 mg IV[a] on Day 1, then RDV 100 mg IV on Days 2–5<br>• For patients who do not show clinical improvement after 5 days of therapy, treatment may be extended to up to 10 days.<br>*For Mechanically Ventilated Patients and/or Patients on ECMO:*<br>• RDV 200 mg IV[a] on Day 1, then RDV 100 mg IV on Days 2–10<br>**Suggested Dose in EUA[b] for Hospitalized Children**<br>*For Patients Weighing 3.5 kg to <40 kg:*<br>• RDV 5 mg/kg IV[a] on Day 1, then RDV 2.5 mg/kg IV once daily starting on Day 2<br>• For patients who are not mechanically ventilated and/or on ECMO, the duration is 5 days. If patients have not shown clinical improvement after 5 days, treatment may be extended to up to 10 days.<br>• For mechanically ventilated patients and/or patients on ECMO, the recommended treatment duration is 10 days.<br>*For Patients Aged <12 Years and Weighing ≥40 kg:*<br>• Same dose as for adults | • Each 100 mg vial of RDV lyophilized powder contains 3 g of SBECD, and each 100 mg/20 mL vial of RDV solution contains 6 g of SBECD.<br>• Clinicians may consider preferentially using the lyophilized powder formulation (which contains less SBECD) in patients with renal impairment. | • RDV may need to be discontinued if ALT level increases to >10 times ULN and should be discontinued if there is an increase in ALT level and signs or symptoms of liver inflammation are observed.[1] | • Minimal to no reduction in RDV exposure is expected when RDV is coadministered with dexamethasone (Gilead Sciences, written communication, July 2020).<br>• CQ or HCQ may decrease the antiviral activity of RDV; coadministration of these drugs **is not recommended**.[1]<br>• No significant interaction is expected between RDV and oseltamivir or baloxavir (Gilead Sciences, personal and written communications, August and September 2020). | • An EUA[b] is available for hospitalized pediatric patients weighing 3.5 kg to <40 kg or aged <12 years and weighing ≥3.5 kg.<br>• A list of clinical trials is available here: Remdesivir |

| **Dosing Regimens**<br>*The doses listed here are for approved indications or from reported experiences or clinical trials.* | **Adverse Events** | **Monitoring Parameters** | **Drug-Drug Interaction Potential** | **Comments and Links to Clinical Trials** |
|---|---|---|---|---|
| **Ivermectin** | | | | |
| **Adults:**<br>• The dose most commonly used in clinical trials is IVM 0.2–0.6 mg/kg PO given as a single dose or as a once-daily dose for up to 5 days. | • Generally well tolerated<br>• Dizziness<br>• Pruritis<br>• GI effects (e.g., nausea, diarrhea)<br>• Neurological AEs have been reported when IVM has been used to treat parasitic diseases, but it is not clear whether these AEs were caused by IVM or the underlying conditions. | • Monitor for potential AEs. | • Minor CYP3A4 substrate<br>• P-gp substrate | • Generally given on an empty stomach with water; however, administering IVM with food increases its bioavailability.[2]<br>• A list of clinical trials is available here: Ivermectin |
| **Nitazoxanide** | | | | |
| **Adults:**<br>• Doses reported in COVID-19 studies range from NTZ 500 mg PO 3 times daily to 4 times daily.[3,4] Higher doses are being studied (*ClinicalTrials.gov* Identifier NCT04746183).<br>• Doses used for antiprotozoal indications range from NTZ 500 mg to 1 g PO twice daily. | • Generally well tolerated<br>• Abdominal pain<br>• Diarrhea<br>• Headache<br>• Nausea<br>• Vomiting<br>• Urine discoloration<br>• Ocular discoloration (rare) | • Monitor for potential AEs. | • Drug-drug interactions may occur if NTZ is administered concurrently with other highly plasma protein-bound drugs due to competition for binding sites.[5]<br>• If NTZ is coadministered with other highly protein-bound drugs with narrow therapeutic indices, monitor the patient for AEs. | • NTZ should be taken with food.<br>• The oral suspension is not bioequivalent to the tablet formulation.<br>• A list of clinical trials is available here: Nitazoxanide |

[a] Infuse over 30–120 minutes.

[b] The FDA EUA permits the emergency use of RDV for the treatment of suspected COVID-19 or laboratory-confirmed SARS-CoV-2 infection in hospitalized pediatric patients weighing 3.5 kg to <40 kg or aged <12 years and weighing ≥3.5 kg.[6]

**Key:** AE = adverse event; ALT = alanine transaminase; AST = aspartate aminotransferase; CQ = chloroquine; CYP = cytochrome P450; ECMO = extracorporeal membrane oxygenation; eGFR = estimated glomerular filtration rate; EUA = Emergency Use Authorization; FDA = Food and Drug Administration; GI = gastrointestinal; HCQ = hydroxychloroquine; IV = intravenous; IVM = ivermectin; LPV/RTV = lopinavir/ritonavir; MATE = multidrug and toxin extrusion protein; NTZ = nitazoxanide; OATP = organic anion transporter polypeptide; the Panel = the COVID-19 Treatment Guidelines Panel; P-gp = P-glycoprotein; PO = orally; RDV = remdesivir; SBECD = sulfobutylether-beta-cyclodextrin; ULN = upper limit of normal

## References


1. Remdesivir (Veklury) [package insert]. Food and Drug Administration. 2020. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2020/214787Orig1s000lbl.pdf.
2. Ivermectin (Stromectol) [package insert]. Food and Drug Administration. 2009. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2009/050742s024s025lbl.pdf.
3. Rocco PRM, Silvia PL, Cruz FF, et al. Early use of nitazoxanide in mild COVID-19 disease: randomised, placebo-controlled trial. *Eur Respir J*. 2021;Published online ahead of print. Available at: https://pubmed.ncbi.nlm.nih.gov/33361100/.
4. Silva M, Espejo A, Pereyra ML, et al. Efficacy of Nitazoxanide in reducing the viral load in COVID-19 patients: randomized, placebo-controlled, single-blinded, parallel-group, pilot study. *MedRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.03.21252509v1.full.pdf.
5. Nitazoxanide (Alinia) [package insert]. Food and Drug Administration. 2017. Available at: https://www.alinia.com/wp-content/uploads/2017/08/prescribing-information.pdf.
6. Food and Drug Administration. Fact sheet for health care providers emergency use authorization (EUA) of remdesivir (GS-5734™). 2020. Available at: https://www.fda.gov/media/137566/download.

# Anti-SARS-CoV-2 Antibody Products

*Last Updated: August 4, 2021*

**Summary Recommendations**

**Anti-SARS-CoV-2 Monoclonal Antibodies for the Treatment of COVID-19**

- The COVID-19 Treatment Guidelines Panel (the Panel) recommends using one of the following anti-SARS-CoV-2 monoclonal antibodies, listed in alphabetical order, to treat nonhospitalized patients with mild to moderate COVID-19 who are at high risk of clinical progression, as defined by the Emergency Use Authorization (EUA) criteria:
  - **Casirivimab plus imdevimab**; *or*
  - **Sotrovimab**
- When using casirivimab plus imdevimab, the Panel recommends:
  - **Casirivimab 600 mg plus imdevimab 600 mg IV infusion (AIIa)**
  - If IV infusions are not feasible or would cause a delay in treatment, **casirivimab 600 mg plus imdevimab 600 mg** administered by four subcutaneous injections (2.5 mL per injection) can be used as an alternative **(BIII)**.
- At this time, the Panel **recommends against** the use of **bamlanivimab plus etesevimab** for the treatment of COVID-19 **(AIII)** because the Gamma (P.1) and Beta (B.1.351) variants of concern, which have reduced susceptibility to both agents, are circulating in the United States. See the Centers for Disease Control and Prevention COVID Data Tracker for the latest information on variant proportions by region in the United States.
- The strength of the evidence for using anti-SARS-CoV-2 monoclonal antibodies for the treatment of COVID-19 varies depending on the factors that place patients at risk for progression to severe COVID-19 and/or hospitalization (see Anti-SARS-CoV-2 Monoclonal Antibodies for details). The recommendations are based on the following criteria from the Food and Drug Administration EUAs:
  - Patients with high-risk conditions that were represented in clinical trials **(AIIa)**, *and*
  - Patients with other medical conditions and factors that had limited representation in clinical trials **(BIII)**; however, for patients who have an immunocompromising condition or who are receiving immunosuppressive therapy, the rating is **AIII**.
- Treatment with anti-SARS-CoV-2 monoclonal antibodies should be started as soon as possible after the patient receives a positive result on a SARS-CoV-2 antigen or nucleic acid amplification test (NAAT) and within 10 days of symptom onset.
- The use of anti-SARS-CoV-2 monoclonal antibodies should be considered for patients with mild to moderate COVID-19 who are hospitalized for a reason other than COVID-19 if they otherwise meet EUA criteria for outpatient treatment.
- Anti-SARS-CoV-2 monoclonal antibodies are not currently authorized for use in patients who are hospitalized with severe COVID-19; however, they may be available through expanded access programs for patients who have not developed an antibody response or who are not expected to mount an effective immune response to SARS-CoV-2 infection.

**COVID-19 Convalescent Plasma**

- The Panel **recommends against** the use of **low-titer COVID-19 convalescent plasma** for the treatment of COVID-19 **(AIIb)**. Low-titer COVID-19 convalescent plasma is no longer authorized through the convalescent plasma EUA.
- For hospitalized patients with COVID-19 who do not have impaired immunity:
  - The Panel **recommends against** the use of **COVID-19 convalescent plasma** for the treatment of COVID-19 in mechanically ventilated patients **(AI)**.
  - The Panel **recommends against** the use of **high-titer COVID-19 convalescent plasma** for the treatment of COVID-19 in hospitalized patients who do not require mechanical ventilation, except in a clinical trial **(AI)**.
- For hospitalized patients with COVID-19 who have impaired immunity:
  - There is insufficient evidence for the Panel to recommend either for or against the use of high-titer COVID-19 convalescent plasma for the treatment of COVID-19.

| **Summary Recommendations**, continued |
| --- |
| • For nonhospitalized patients with COVID-19:<br>  • There is insufficient evidence for the Panel to recommend either for or against the use of high-titer COVID-19 convalescent plasma for the treatment of COVID-19.<br>**Anti-SARS-CoV-2 Specific Immunoglobulin**<br>• There is insufficient evidence for the Panel to recommend either for or against the use of anti-SARS-CoV-2 specific immunoglobulins for the treatment of COVID-19. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

# Anti-SARS-CoV-2 Monoclonal Antibodies

*Last Updated: August 4, 2021*

The SARS-CoV-2 genome encodes four major structural proteins: spike (S), envelope (E), membrane (M), and nucleocapsid (N), as well as nonstructural and accessory proteins. The spike protein is further divided into two subunits, S1 and S2, that mediate host cell attachment and invasion. Through its receptor-binding domain (RBD), S1 attaches to angiotensin-converting enzyme 2 (ACE2) on the host cell; this initiates a conformational change in S2 that results in virus-host cell membrane fusion and viral entry.[1] Monoclonal antibodies that target the spike protein have been shown to have a clinical benefit in treating SARS-CoV-2 infection (as discussed below). Preliminary data suggest that monoclonal antibodies may play a role in preventing SARS-CoV-2 infection in household contacts of infected patients[2] and during skilled nursing and assisted living facility outbreaks.[3]

## Anti-SARS-CoV-2 Monoclonal Antibodies That Received Emergency Use Authorizations From the Food and Drug Administration

Three anti-SARS-CoV-2 monoclonal antibody products currently have Emergency Use Authorizations (EUAs) from the Food and Drug Administration (FDA) for the treatment of mild to moderate COVID-19 in nonhospitalized patients with laboratory-confirmed SARS-CoV-2 infection who are at high risk for progressing to severe disease and/or hospitalization. The issuance of an EUA does not constitute FDA approval. These products are:

- *Bamlanivimab plus etesevimab:* These are neutralizing monoclonal antibodies that bind to different but overlapping epitopes in the spike protein RBD of SARS-CoV-2.
  - The distribution of bamlanivimab plus etesevimab was paused on June 25, 2021, because both the Gamma (P.1) and Beta (B.1.351) variants of concern (VoC) that are currently circulating in the United States have reduced susceptibility to bamlanivimab and etesevimab.[4]
- *Casirivimab plus imdevimab:* These are recombinant human monoclonal antibodies that bind to nonoverlapping epitopes of the spike protein RBD of SARS-CoV-2.
- *Sotrovimab:* This monoclonal antibody was originally identified in 2003 from a SARS-CoV survivor. It targets an epitope in the RBD of the spike protein that is conserved between SARS-CoV and SARS-CoV-2.

The FDA also updated the EUA for casirivimab plus imdevimab as post-exposure prophylaxis for certain individuals who are at high risk of acquiring SARS-CoV-2 infection and, if infected, are at high risk of progressing to serious illness. See the FDA EUA Fact Sheet for details.

## Recommendations

- The COVID-19 Treatment Guidelines Panel (the Panel) recommends using one of the following anti-SARS-CoV-2 monoclonal antibodies, listed in alphabetical order, to treat nonhospitalized patients with mild to moderate COVID-19 who are at high risk of clinical progression (see below for criteria and discussion):
  - **Casirivimab plus imdevimab**; *or*
  - **Sotrovimab 500 mg intravenous (IV) infusion**
- When using casirivimab plus imdevimab, the Panel recommends:
  - **Casirivimab 600 mg plus imdevimab 600 mg IV infusion (AIIa)**
  - If IV infusions are not feasible or would cause a delay in treatment, **casirivimab 600 mg plus**

**imdevimab 600 mg** administered by four subcutaneous (SQ) injections (2.5 mL per injection) can be used as an alternative **(BIII)**.

- When using monoclonal antibodies, treatment should be started as soon as possible after the patient receives a positive result on a SARS-CoV-2 antigen or nucleic acid amplification test (NAAT) and within 10 days of symptom onset.
- At this time, the Panel **recommends against** the use of **bamlanivimab** plus **etesevimab (AIII)** because the Gamma (P.1) and Beta (B.1.351) VoC, which have reduced susceptibility to both agents, are circulating in the United States.
- The use of anti-SARS-CoV-2 monoclonal antibodies should be considered for patients with mild to moderate COVID-19 who are hospitalized for a reason other than COVID-19 if they otherwise meet the EUA criteria for outpatient treatment.
- Anti-SARS-CoV-2 monoclonal antibodies are not currently authorized for use in patients who are hospitalized with severe COVID-19; however, they may be available through expanded access programs for patients who have not developed an antibody response or who are not expected to mount an effective immune response to SARS-CoV-2 infection.

## Rationale for the Use of Anti-SARS-CoV-2 Monoclonal Antibodies

In randomized, placebo-controlled trials of nonhospitalized patients who had mild to moderate COVID-19 symptoms and certain risk factors for disease progression, the use of anti-SARS-CoV-2 monoclonal antibody products reduced the risk of hospitalization and death (see Table 3a).[5-7] It is worth noting that these studies were conducted before the widespread circulation of VoC. The potential impact of these variants on susceptibility to different anti-SARS-CoV-2 monoclonal antibodies is discussed below.

### *Casirivimab Plus Imdevimab*

On June 3, 2021, the FDA updated the EUA for casirivimab plus imdevimab.[6] The authorized dosages were reduced from a single IV infusion of casirivimab 1,200 mg plus imdevimab 1,200 mg to casirivimab 600 mg plus imdevimab 600 mg. In addition, these lower doses of casirivimab and imdevimab may now be administered by SQ injection if IV infusions are not feasible or may delay treatment. It should be noted that SQ administration requires four injections (2.5 mL per injection) at four different sites (see the FDA EUA for details).

The recommendation for using the lower dose of casirivimab 600 mg plus imdevimab 600 mg IV is based on the Phase 3 results from the R10933-10987-COV-2067 study (*ClinicalTrials.gov* Identifier NCT04425629). This study is a double-blind, placebo-controlled randomized trial in outpatients with mild to moderate COVID-19. The modified full analysis set included participants aged ≥18 years who had a positive SARS-CoV-2 polymerase chain reaction result at randomization and who had one or more risk factors for progression to severe COVID-19. The primary outcome of COVID-19-related hospitalization or death from any cause was reported in 7 of 736 participants (1.0%) in the casirivimab 600 mg plus imdevimab 600 mg IV arm and in 24 of 748 participants (3.2%) in the placebo arm ($P = 0.0024$), demonstrating a 2.2% absolute reduction and a 70% relative reduction in hospitalization or death among the casirivimab plus imdevimab recipients compared to the placebo recipients. These results are comparable to the results observed for IV infusions of casirivimab 1,200 mg plus imdevimab 1,200 mg. The primary outcome of COVID-19-related hospitalization or death from any cause was reported in 18 of 1,355 patients (1.3%) who received casirivimab 1,200 mg plus imdevimab 1,200 mg IV, compared with 62 of 1,341 patients (4.6%) who received placebo ($P < 0.0001$). These findings represent a 3.3% absolute reduction and a 71% relative reduction in hospitalization or death among patients who received this dose of casirivimab plus imdevimab.

The recommendation for using SQ injections is based on safety data from the Phase 1 R10933-10987-HV-2093 study (*ClinicalTrials.gov* Identifier NCT04519437), a double-blind, placebo-controlled randomized trial that compared casirivimab plus imdevimab administered by SQ injection to placebo in healthy volunteers who did not have SARS-CoV-2 infection. Injection site reactions were observed in 12% of the 729 casirivimab plus imdevimab participants and in 4% of the 240 placebo participants. According to the FDA EUA, in a separate trial among symptomatic participants, there were similar reductions in viral load between the IV and SQ arms.[6] Because the safety and efficacy data for casirivimab plus imdevimab administered by SQ injection are limited, this route of administration should only be used when IV infusions are not feasible or would lead to a delay in treatment **(BIII)**.

### *Sotrovimab*

The data that support the EUA for sotrovimab come from the Phase 3 COMET-ICE trial (*ClinicalTrials.gov* Identifier NCT04545060). The COMET-ICE trial included outpatients with mild to moderate COVID-19 who were at high risk for progression to severe disease and/or hospitalization. A total of 583 participants were randomized to receive sotrovimab 500 mg IV (n = 291) or placebo (n = 292). The primary endpoint was the proportion of participants who were hospitalized (for ≥24 hours) or who died from any cause by Day 29. Endpoint events occurred in 3 of 291 participants (1%) in the sotrovimab arm and 21 of 292 participants (7%) in the placebo arm ($P = 0.002$), resulting in a 6% absolute reduction and an 85% relative reduction in hospitalizations or death among the sotrovimab recipients compared to the placebo recipients.[7]

### *Bamlanivimab Plus Etesevimab*

This antibody combination has been shown to have a clinical benefit in people with mild to moderate COVID-19 who are at high risk for progression to severe disease and/or hospitalization (see Table 3a). At this time, however, the Panel **recommends against** the use of **bamlanivimab plus etesevimab** for the treatment of COVID-19 **(AIII)** because the Gamma (P.1) and Beta (B.1.351) VoC, which have reduced susceptibility to both bamlanivimab and etesevimab, are circulating in the United States; distribution of this agent has consequently been paused.[8] See the Centers for Disease Control and Prevention (CDC) COVID-19 Data Tracker website for the latest information on variant proportions by region in the United States. Casirivimab plus imdevimab and sotrovimab are expected to remain active against these variants.

## Criteria for Using Anti-SARS-CoV-2 Monoclonal Antibodies Under the Emergency Use Authorizations

The FDA EUAs for the anti-SARS-CoV-2 monoclonal antibodies originally included a list of specific conditions that placed patients at high risk for clinical progression. On May 14, 2021, the FDA broadened these criteria.[5,6] Notable changes included lowering the body mass index (BMI) cutoff from ≥35 to >25 and adding other conditions and factors (e.g., pregnancy, race or ethnicity). There are no longer any age criteria (other than being aged ≥12 years) for using these agents in patients with the following conditions: sickle cell disease, neurodevelopmental disorders, medical-related technological dependence, asthma, cardiovascular disease, hypertension, and chronic lung disease.

## Recommendations

The strength of the evidence for using anti-SARS-CoV-2 monoclonal antibodies varies depending on the factors that place patients at high risk for progression to severe COVID-19 and/or hospitalization. The recommendations for treatment are based on the following criteria from the FDA EUAs.

### *Medical Conditions or Other Factors That Were Represented in Clinical Trials That Evaluated Anti-SARS-CoV-2 Monoclonal Antibodies*

- Aged ≥65 years **(AIIa)**
- Obesity (BMI >30) **(AIIa)**
- Diabetes **(AIIa)**
- Cardiovascular disease (including congenital heart disease) or hypertension **(AIIa)**
- Chronic lung diseases (e.g., chronic obstructive pulmonary disease, moderate-to-severe asthma, interstitial lung disease, cystic fibrosis, pulmonary hypertension) **(AIIa)**

### *Other Conditions or Factors That Had Limited Representation in Clinical Trials but Are Considered Risk Factors for Progression to Severe COVID-19 by the Centers for Disease Control and Prevention*

- An immunocompromising condition or immunosuppressive treatment **(AIII)**. Many experts strongly recommend therapy for patients with these conditions, despite their limited representation in clinical trials.
- Being overweight (BMI 25–30) as the sole risk factor **(BIII)**
- Chronic kidney disease **(BIII)**
- Pregnancy **(BIII)**
- Sickle cell disease **(BIII)**
- Neurodevelopmental disorders (e.g., cerebral palsy) or other conditions that confer medical complexity (e.g., genetic or metabolic syndromes and severe congenital anomalies) **(BIII)**
- Medical-related technological dependence (e.g., tracheostomy, gastrostomy, or positive pressure ventilation that is not related to COVID-19) **(BIII)**

It is important to note that the likelihood of developing severe COVID-19 increases when a person has multiple high-risk conditions or comorbidities.[9-11] Other factors (e.g., race or ethnicity) or medical conditions may also place individual patients at high risk for progression to severe COVID-19. The current EUAs state that the use of anti-SARS-CoV-2 monoclonal antibodies may be considered for many of these other patients. For additional information on medical conditions and factors that are associated with increased risks for progression to severe COVID-19, see the CDC webpage Extra Precautions: People With Certain Medical Conditions. Health care providers should consider the benefits and risks of using anti-SARS-CoV-2 monoclonal antibodies for each individual patient.[7]

The Panel's recommendations for using anti-SARS-CoV-2 monoclonal antibodies according to the updated EUA criteria are based on preliminary results from the clinical trials that evaluated these products. The details on the study designs, methods, and follow-up periods for these trials are currently limited. When peer-reviewed data from the Phase 3 trials become publicly available, the Panel will review the results and update the recommendations if necessary.

See the Considerations in Children section below for additional information on using these products in nonhospitalized children with COVID-19.

## Using Anti-SARS-CoV-2 Monoclonal Antibodies in Patients Hospitalized for COVID-19

The FDA EUAs do not authorize the use of anti-SARS-CoV-2 monoclonal antibodies for the following patients:

- Those hospitalized for COVID-19,

- Those who require oxygen therapy due to COVID-19, *or*
- Those who are on chronic oxygen therapy due to an underlying non-COVID-19-related comorbidity and who require an increase in oxygen flow rate from baseline because of COVID-19.

The FDA EUAs do permit the use of these agents in patients who are hospitalized for a diagnosis other than COVID-19, provided they have mild to moderate COVID-19 and are at high risk for progressing to severe disease.[12-14]

Anti-SARS-CoV-2 monoclonal antibodies have been evaluated in hospitalized patients with severe COVID-19. A substudy of the ACTIV-3 trial randomized patients who were hospitalized for COVID-19 to receive bamlanivimab 7,000 mg or placebo, each in addition to remdesivir. On October 26, 2020, following a prespecified interim futility analysis, enrollment into this study was stopped due to the lack of a clinical benefit.[15,16]

There are now data that support the use of casirivimab 4,000 mg plus imdevimab 4,000 mg in hospitalized patients with COVID-19 who are seronegative for the anti-spike protein antibody. In the RECOVERY study, hospitalized patients with COVID-19 were randomized to receive standard of care with casirivimab 4,000 mg plus imdevimab 4,000 mg IV or standard of care alone. There was no difference in 28-day all-cause mortality between the casirivimab plus imdevimab arm and the standard of care arm; 944 of 4,839 patients (20%) in the casirivimab plus imdevimab arm died versus 1,026 of 4,946 patients (21%) in the standard of care arm (rate ratio 0.94; 95% CI, 0.86–1.03; $P = 0.17$). However, in the subgroup of patients who were seronegative for the anti-spike protein antibody, there was a significant reduction in 28-day all-cause mortality in the casirivimab plus imdevimab arm: 396 of 1,633 patients (24%) died in the casirivimab plus imdevimab arm compared to 451 of 1,520 patients (30%) in the standard of care arm (rate ratio 0.80; 95% CI, 0.70–0.91; $P = 0.001$).[17] It should be noted that this higher dose of casirivimab plus imdevimab is not available through the current EUA, and at this time, casirivimab plus imdevimab is only authorized for use in nonhospitalized patients with COVID-19. In addition, rapid serology testing that can identify seronegative individuals is currently not widely available.

Anti-SARS-CoV-2 monoclonal antibodies may be available through expanded access programs for the treatment of immunocompromised patients who are hospitalized because of COVID-19. It is not yet known whether these antibodies provide clinical benefits in people with B-cell immunodeficiency or other immunodeficiencies.

## SARS-CoV-2 Variants of Concern or Interest and Their Susceptibility to Anti-SARS-CoV-2 Monoclonal Antibodies

In laboratory studies, some CDC SARS-CoV-2 VoC or variants of interest (VoI) that harbor certain mutations have markedly reduced susceptibility to a number of the FDA EUA monoclonal antibody therapies.[18] However, the impact of these mutations on the patient's clinical response to anti-SARS-CoV-2 monoclonal antibody combinations varies, as do the proportions of these variants in different geographic regions.

Some of the key variants that have been identified are:

- *Alpha (B.1.1.7) variant:* This VoC retains in vitro susceptibility to all the anti-SARS-CoV-2 monoclonal antibodies that are currently available through EUAs.[5,6]
- *Beta (B.1.351) variant:* This VoC includes the E484K and K417N mutations, which results in a marked reduction in in vitro susceptibility to bamlanivimab and etesevimab.[5] In vitro studies also suggest that this variant has markedly reduced susceptibility to casirivimab, although the combination of casirivimab and imdevimab appears to retain activity; sotrovimab appears to retain activity as well.[6,7]

- *Gamma (P.1) variant:* This VoC includes the E484K and K417T mutations, which results in a marked reduction in in vitro susceptibility to bamlanivimab and etesevimab.[5,19,20] This variant also has reduced susceptibility to casirivimab, although the combination of casirivimab and imdevimab appears to retain activity; sotrovimab appears to retain activity as well.[6,7]
- *Delta (B.1.617.2) variant:* This is the predominant VoC in the United States. The Delta variant contains the L452R mutation, which results in a modest decrease in in vitro susceptibility to the combination of bamlanivimab and etesevimab, although the clinical implications of this finding are not fully known. Sotrovimab and casirivimab plus imdevimab appear to retain activity.[6,7,21]
- *Epsilon (B.1.429/B.1.427) variant:* This VoI (also called 20C/CAL.20C) includes the L452R mutation. There appears to be a modest decrease in in vitro susceptibility to the combination of bamlanivimab and etesevimab, although the clinical implications of this finding are not fully known.[5] Sotrovimab and casirivimab plus imdevimab appear to retain activity.[6,7,21]
- *Iota (B.1.526) variant:* This VoI includes the E484K mutation and is associated with a reduced in vitro susceptibility to the combination of bamlanivimab and etesevimab, although the clinical implications of this finding are not fully known.[5] In vitro studies suggest that the E484K mutation may reduce susceptibility to casirivimab, although the combination of casirivimab and imdevimab appears to retain activity; sotrovimab appears to retain activity as well.[6,7,21]

**Table A. SARS-CoV-2 Variants of Concern and Interest and Susceptibility to Anti-SARS-CoV-2 Monoclonal Antibodies**

| WHO Label | Pango Lineage | CDC Variant Class | Notable Mutations | Bamlanivimab Plus Etesevimab | | Casirivimab Plus Imdevimab | | Sotrovimab | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | In Vitro Susceptibility[a] | Activity[b] | In Vitro Susceptibility[a] | Activity[b] | In Vitro Susceptibility[a] | Activity[b] |
| Alpha | B.1.1.7 | VoC | N501Y | No change | Active | No change | Active | No change | Active |
| Beta | B.1.351 | VoC | K417N, E484K, N501Y | Marked change | Unlikely to be active | No change[c] | Active | No change | Active |
| Gamma | P.1 | VoC | K417T, E484K, N501Y | Marked change | Unlikely to be active | No change[c] | Active | No change | Active |
| Delta | B.1.617.2 | VoC | L452R | Modest change[d] | Likely to be active | No change | Active | No change | Active |
| Epsilon | B.1.429 / B.1.427 | VoI | L452R | Modest change[d] | Likely to be active | No change | Active | No change | Active |
| Iota | B.1.526 | VoI | E484K | Modest change[d] | Likely to be active | No change[c] | Active | No change | Active |

[a] Based on the fold reduction in susceptibility reported in the FDA EUAs.[5-7]

[b] Anticipated clinical activity against the variant, based on in vitro studies.

[c] Marked change for casirivimab and no change for imdevimab. The combination of casirivimab plus imdevimab appears to retain activity.

[d] Modest change for the combination of bamlanivimab and etesevimab, although the clinical implications of this finding are not fully known.

**Key:** CDC = Centers for Disease Control and Prevention; VoC = variant of concern; VoI = variant of interest; WHO = World Health Organization

Ongoing population-based genomic surveillance of the types and proportions of circulating SARS-CoV-2 variants, as well as studies on the susceptibility of different variants to available anti-SARS-CoV-2 monoclonal antibodies, will be important in defining the utility of specific monoclonal antibodies in the future.

## Clinical Trials

See Table 3a for information on the clinical trials that are evaluating the safety and efficacy of anti-SARS-CoV-2 monoclonal antibodies in patients with COVID-19. Health care providers are encouraged to discuss participation in anti-SARS-CoV-2 monoclonal antibody clinical trials with patients who have mild to moderate COVID-19.

## SARS-CoV-2 Vaccination

SARS-CoV-2 vaccination should be deferred for ≥90 days in people who have received anti-SARS-CoV-2 monoclonal antibodies. This is a precautionary measure, as the antibody treatment may interfere with vaccine-induced immune responses.[22]

For people who develop COVID-19 after receiving SARS-CoV-2 vaccination, prior vaccination should not affect treatment decisions, including the use of and timing of treatment with monoclonal antibodies.[22]

## Monitoring

These anti-SARS-CoV-2 monoclonal antibodies should be given as either IV infusions or SQ injections and should only be administered in health care settings by qualified health care providers who have immediate access to emergency medical services and medications that treat severe infusion reactions.

Patients should be monitored during the IV infusion or SQ injections and for at least 1 hour after the infusion or injections are completed.

## Adverse Effects

Hypersensitivity, including anaphylaxis and infusion-related reactions, has been reported in patients who received anti-SARS-CoV-2 monoclonal antibodies. Rash, diarrhea, nausea, dizziness, and pruritis have also been reported.[6,7,13]

## Drug-Drug Interactions

Drug-drug interactions are unlikely between the authorized anti-SARS-CoV-2 monoclonal antibodies and medications that are renally excreted or that are cytochrome P450 substrates, inhibitors, or inducers (see Table 3c).

## Considerations in Pregnancy

The use of anti-SARS-CoV-2 monoclonal antibodies can be considered in pregnant people with COVID-19, especially those who have additional risk factors for severe disease (see the EUA criteria for the use of these products above).

As immunoglobulin (Ig) G monoclonal antibodies, the authorized anti-SARS-CoV-2 monoclonal antibodies would be expected to cross the placenta. There is no pregnancy-specific data on the use of these monoclonal antibodies; however, other IgG products have been safely used in pregnant people when their use is indicated. Therefore, these products should not be withheld in the setting of pregnancy. When possible, pregnant and lactating people should be included in clinical trials that are evaluating the

use of anti-SARS-CoV-2 monoclonal antibodies.

## Considerations in Children

Please see Special Considerations in Children for therapeutic recommendations for children.

## Drug Availability

Casirivimab plus imdevimab and sotrovimab are available through FDA EUAs. Currently, distribution of bamlanivimab plus etesevimab has been halted in the United States. Updates on the distribution of bamlanivimab plus etesevimab are available from the U.S. Department of Health and Human Services Bamlanivimab/Etesevimab website. Efforts should be made to ensure that the communities that are most affected by COVID-19 have equitable access to these monoclonal antibodies.

## References


1. Jiang S, Hillyer C, Du L. Neutralizing antibodies against SARS-CoV-2 and other human coronaviruses. *Trends Immunol*. 2020;41(5):355-359. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32249063.
2. O'Brien MP, Forleo-Neto E, Musser BJ, et al. Subcutaneous REGEN-COV antibody combination for COVID-19 Prevention. *medRxiv*. 2021;Preprint. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34159344.
3. Cohen MS, Nirula A, Mulligan MJ, et al. Effect of bamlanivimab vs placebo on incidence of COVID-19 among residents and staff of skilled nursing and assisted living facilities: a randomized clinical trial. *JAMA*. 2021;326(1):46-55. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34081073.
4. Public Health Emergency. Pause in the distribution of bamlanivimab/etesevimab. 2021. Available at: https://www.phe.gov/emergency/events/COVID19/investigation-MCM/Bamlanivimab-etesevimab/Pages/bamlanivimab-etesevimab-distribution-pause.aspx. Accessed July 29, 2021.
5. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of bamlanivimab and etesevimab. 2021. Available at: https://www.fda.gov/media/145802/download.
6. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of REGEN-COV (casirivimab and imdevimab). 2020. Available at: https://www.fda.gov/media/145611/download.
7. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of sotrovimab. 2021. Available at: https://www.fda.gov/media/149534/download.
8. Public Health Emergency. Bamlanivimab/etesevimab. 2021. Available at: https://www.phe.gov/emergency/events/COVID19/investigation-MCM/Bamlanivimab-etesevimab/Pages/default.aspx. Accessed July 22, 2021.
9. Kim L, Garg S, O'Halloran A, et al. Risk factors for intensive care unit admission and in-hospital mortality among hospitalized adults identified through the U.S. coronavirus disease 2019 (COVID-19)-associated hospitalization surveillance network (COVID-NET). *Clin Infect Dis*. 2021;72(9):e206-e214. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32674114.
10. Guan WJ, Liang WH, Zhao Y, et al. Comorbidity and its impact on 1590 patients with COVID-19 in China: A Nationwide Analysis. *Eur Respir J*. 2020;55(5):2000547. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32217650.
11. Zhang Y, Luo W, Li Q, et al. Risk factors for death among the first 80,543 COVID-19 cases in China: relationships between age, underlying disease, case severity, and region. *Clin Infect Dis*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34043784.
12. Food and Drug Administration. Frequently Asked Questions on the Emergency Use Authorization of REGEN-COV (Casirivimab and Imdevimab). 2021. Available at: https://www.fda.gov/media/143894/download.

13. Food and Drug Administration. Frequently asked questions on the emergency use authorization for bamlanivimab and etesevimab. 2021. Available at: https://www.fda.gov/media/145808/download.

14. Food and Drug Administration. Frequently asked questions on the emergency use authorization of sotrovimab. 2021. Available at: https://www.fda.gov/media/149535/download.

15. National Institute of Allergy and Infectious Diseases. Statement—NIH-sponsored ACTIV-3 trial closes LY-CoV555 sub-study. 2020. Available at: https://www.niaid.nih.gov/news-events/statement-nih-sponsored-activ-3-trial-closes-ly-cov555-sub-study. Accessed July 29, 2021.

16. ACTIV-3/TICO LY-CoV555 Study Group, Lundgren JD, Grund B, et al. A neutralizing monoclonal antibody for hospitalized patients with COVID-19. *N Engl J Med*. 2021;384(10):905-914. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33356051.

17. RECOVERY Collaborative Group, Horby PW, Mafham M, et al. Casirivimab and imdevimab in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.06.15.21258542v1.full.

18. Centers for Disease Control and Prevention. SARS-CoV-2 variant classifications and definitions. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/variant-surveillance/variant-info.html. Accessed April 5, 2021.

19. Wang P, Liu L, Iketani S, et al. Increased resistance of SARS-CoV-2 variants B.I.315 and B.I.I.7 to antibody neutralization. *bioRxiv*. 2021;Preprint. Available at: https://www.biorxiv.org/content/10.1101/2021.01.25.428137v2.

20. Wang P, Wang M, Yu J, et al. Increased resistance of SARS-CoV-2 variant P.1 to antibody neutralization. *bioRxiv*. 2021;Preprint. Available at: https://www.biorxiv.org/content/10.1101/2021.03.01.433466v1.

21. Liu C, Ginn HM, Dejnirattisai W, et al. Reduced neutralization of SARS-CoV-2 B.1.617 by vaccine and convalescent serum. *Cell*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34242578.

22. Centers for Disease Control and Prevention. Interim clinical considerations for use of COVID-19 vaccines currently authorized in the United States. 2021. Available at: https://www.cdc.gov/vaccines/covid-19/info-by-product/clinical-considerations.html. Accessed July 29, 2021.

# Table 3a. Anti-SARS-CoV-2 Monoclonal Antibodies: Selected Clinical Data

*Last Updated: August 4, 2021*

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Casirivimab Plus Imdevimab Versus Placebo in Outpatients With COVID-19[1]** | | | |
| Double-blind, Phase 3 RCT in outpatients with mild to moderate COVID-19 (modified full analysis subset of the Phase 3 trial)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Onset of COVID-19 symptoms ≤7 days before randomization<br>• SARS-CoV-2 PCR positive at baseline<br>• Criteria for the modified full analysis:<br>  • Aged ≥18 years<br>  • ≥1 risk factor for severe COVID-19<br>**Interventions:**<br>• Single IV infusion of:<br>  • CAS 600 mg plus IMD 600 mg<br>  • CAS 1,200 mg plus IMD 1,200 mg<br>  • Placebo<br>**Endpoint:**<br>• Proportion of patients with COVID-19-related hospitalization or all-cause death through Day 29 | **Number of Participants:**<br>• CAS 600 mg plus IMD 600 mg (n = 736) vs. placebo (n = 748)<br>• CAS 1,200 mg plus IMD 1,200 mg (n = 1,355) vs. placebo (n = 1,341)<br>**Participant Characteristics:**<br>• Median age was 50 years.<br>• 35% were Hispanic/Latinx and 5% were Black or African American.<br>• Median duration of symptoms prior to enrollment was 3 days (IQR 2–5 days).[2]<br>**Outcomes:**<br>• COVID-19-related hospitalization or all-cause death through Day 29:<br>  • 7 of 736 (1.0%) in CAS 600 mg plus IMD 600 mg arm vs. 24 of 748 (3.2%) in placebo arm ($P$ = 0.0024)<br>  • 18 of 1,355 (1.3%) in CAS 1,200 mg plus IMD 1,200 mg arm vs. 62 of 1,341 (4.6%) in placebo arm ($P$ < 0.0001)<br>• All-cause deaths:<br>  • 1 of 736 (0.1%) in CAS 600 mg plus IMD 600 mg arm vs. 1 of 748 (0.1%) in placebo arm<br>  • 1 of 1,355 (0.07%) in CAS 1,200 mg plus IMD 1,200 mg arm vs. 3 of 1,341 (0.22%) in placebo arm | **Key Limitations:**<br>• The modified full analysis data is only available as a preprint.<br>**Interpretation:**<br>• There was a 2.2% absolute reduction and a 70% relative risk reduction in COVID-19-related hospitalizations or all-cause deaths in patients who received CAS 600 mg plus IMD 600 mg compared to those who received placebo.<br>• There was a 3.3% absolute reduction and a 71% relative risk reduction in COVID-19-related hospitalizations and all-cause deaths in patients who received CAS 1,200 mg plus IMD 1,200 mg compared to those who received placebo. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Sotrovimab Versus Placebo in Outpatients With COVID-19 (COMET-ICE Trial)[3]** | | | |
| Double-blind, Phase 1/2/3 RCT in outpatients with mild to moderate COVID-19<br><br>*These data are from the FDA EUA for SOT.* | **Key Inclusion Criteria:**<br>• Aged ≥18 years with ≥1 comorbidity, or aged ≥55 years regardless of comorbidities<br>• Onset of COVID-19 symptoms ≤5 days before enrollment<br>• Laboratory-confirmed SARS-CoV-2 infection<br><br>**Key Exclusion Criteria:**<br>• Severe COVID-19 that required supplemental oxygen or hospitalization<br>• Severely immunocompromised<br><br>**Interventions:**<br>• SOT 500 mg IV<br>• Placebo<br><br>**Primary Endpoint:**<br>• Proportion of patients with hospitalization (i.e., ≥24 hours of acute care) or death from any cause by Day 29 | **Number of Participants:**<br>• SOT (n = 291) and placebo (n = 292)<br><br>**Participant Characteristics:**<br>• Median age was 53 years; 22% were aged ≥65 years.<br>• 63% were Hispanic/Latinx and 7% were Black or African American<br><br>**Primary Outcome:**<br>• All-cause hospitalization or death by Day 29: 3 of 291 (1%) in SOT arm vs. 21 of 292 (7%) in placebo arm ($P = 0.002$)<br><br>**Other Outcomes:**<br>• 1% of patients in both arms experienced infusion-related reactions | **Key Limitations:**<br>• Details on the study design, follow-up, and methods are limited.<br><br>**Interpretation:**<br>• There was a 6% absolute reduction and an 85% relative risk reduction in all-cause hospitalizations or deaths in patients who received SOT compared to those who received placebo. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Bamlanivimab Plus Etesevimab Versus Placebo in Outpatients With COVID-19 (BLAZE-1)[4-6]** | | | |
| Double-blind, Phase 3 RCT in outpatients with mild to moderate COVID-19 who were at high risk for progressing to severe COVID-19 | **Key Inclusion Criteria:**<br>• Aged ≥12 years<br>• Not currently hospitalized<br>• ≥1 mild or moderate COVID-19 symptom<br>• ≥1 risk factor for severe COVID-19<br>**Key Exclusion Criteria:**<br>• $SpO_2$ ≤93% on room air, *or*<br>• Respiratory rate ≥30 breaths/min, *or*<br>• Heart rate ≥125 bpm<br>**Interventions:**<br>• Single IV infusion of:<br>  • BAM 2,800 mg plus ETE 2,800 mg<br>  • Placebo<br>• Administered within 3 days of a positive SARS-CoV-2 virologic test<br>**Primary Endpoint:**<br>• Proportion of patients with COVID-19-related hospitalization (i.e., ≥24 hours of acute care) or death by any cause by Day 29<br>**Secondary Endpoint:**<br>• Proportion of patients with persistently high VL (SARS-CoV-2 level >5.27 $log_{10}$ copies/mL) at Day 7 | **Number of Participants:**<br>• BAM plus ETE (n = 518) and placebo (n = 517)<br>**Participant Characteristics:**<br>• Mean age was 53.8 years; 31% were aged ≥65 years.<br>• 48% were men.<br>• 87% were White; 8% were Black or African American; and 29% were Hispanic/Latinx.<br>• Median days from symptom onset to infusion was 4 days.<br>• 77% had mild COVID-19.<br>**Primary Outcomes:**<br>• COVID-19-related hospitalization or death by any cause by Day 29: 11 of 518 (2.1%) in BAM plus ETE arm vs. 36 of 517 (7.0%) in placebo arm; relative risk difference: 70%; $P < 0.001$<br>• Death from any cause by Day 29: 0 of 518 (0%) in BAM plus ETE arm vs. 10 of 517 (1.9%) in placebo arm<br>**Secondary Outcome:**<br>• Proportion of patients with persistently high VLs at Day 7: 9.8% in BAM plus ETE arm vs. 29.5% in placebo arm ($P < 0.001$). | **Key Limitations:**<br>• Data are for BAM plus ETE doses that are not currently authorized in the EUA.<br>**Interpretation:**<br>• There was a 4.8% absolute reduction and a 70% relative reduction in COVID-19-related hospitalizations or deaths from any cause among the participants who received BAM plus ETE compared to those who received placebo. |

**Key:** BAM = bamlanivimab; CAS = casirivimab; ETE = etesevimab; EUA = Emergency Use Authorization; FDA = Food and Drug Administration; IMD = imdevimab; IV = intravenous; PCR = polymerase chain reaction; RCT = randomized controlled trial; SOT = sotrovimab; $SpO_2$ = oxygen saturation; VL = viral load

## References


1. Weinreich DM, Sivapalasingam S, Norton T, et al. REGEN-COV antibody cocktail clinical outcomes study in COVID-19 outpatients. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.05.19.21257469v2.
2. Regeneron. Phase 3 trial shows REGEN-COV (casirivimab with imdevimab) antibody cocktail reduced hospitalization or death by 70% in non-hospitalized COVID-19 patients. 2021. Available at: https://investor.regeneron.com/news-releases/news-release-details/phase-3-trial-shows-regen-covtm-casirivimab-imdevimab-antibody. Accessed April 5, 2021.
3. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of sotrovimab. 2021. Available at: https://www.fda.gov/media/149534/download.
4. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of bamlanivimab and etesevimab. 2021. Available at: https://www.fda.gov/media/145802/download. Accessed February 17, 2021.
5. Dougan M, Nirula A, Gottlieb RL, et al. Bamlanivimab+etesevimab for treatment of COVID-19 in high-risk ambulatory patients. Conference on Retroviruses and Opportunistic Infections. 2021. Virtual. Available at: https://www.croiconference.org/wp-content/uploads/sites/2/resources/2021/vCROI-2021-Abstract-eBook.pdf.
6. Dougan M, Nirula A, Azizad M, et al. Bamlanivimab plus etesevimab in mild or moderate COVID-19. *N Engl J Med*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34260849.

# Convalescent Plasma

*Last Updated: April 21, 2021*

Plasma from donors who have recovered from COVID-19 may contain antibodies to SARS-CoV-2 that may help suppress the virus and modify the inflammatory response.[1] The Food and Drug Administration (FDA) issued an Emergency Use Authorization (EUA) for convalescent plasma for the treatment of certain hospitalized patients with COVID-19.

## Recommendation

- The COVID-19 Treatment Guidelines Panel (the Panel) **recommends against** the use of **low-titer COVID-19 convalescent plasma** for the treatment of COVID-19 **(AIIb)**.
  - Low-titer COVID-19 convalescent plasma is no longer authorized through the convalescent plasma EUA.

### *For Hospitalized Patients With COVID-19 Who Do Not Have Impaired Immunity*

- The Panel **recommends against** the use of COVID-19 **convalescent plasma** for the treatment of COVID-19 in mechanically ventilated patients **(AI)**.
- The Panel **recommends against** the use of **high-titer COVID-19 convalescent plasma** for the treatment of COVID-19 in hospitalized patients who do not require mechanical ventilation, except in a clinical trial **(AI)**.

### *For Hospitalized Patients With COVID-19 Who Have Impaired Immunity*

- There is insufficient evidence for the Panel to recommend either for or against the use of high-titer COVID-19 convalescent plasma for the treatment of COVID-19.
  - Observational data including data from case reports, case series, and a retrospective case control study suggest a benefit of COVID-19 convalescent plasma in patients with various primary and secondary humoral immunodeficiencies.[2-16]
  - Several case reports indicate that patients with impaired humoral immunity may experience persistent SARS-CoV-2 viral replication and therefore, may be at risk for developing viral resistance to SARS-CoV-2 antibodies after treatment with COVID-19 convalescent plasma.[17-19]
  - High-titer convalescent plasma is authorized under the EUA for the treatment of hospitalized patients with COVID-19 and impaired immunity.

### *For Nonhospitalized Patients With COVID-19*

- There is insufficient evidence for the Panel to recommend either for or against the use of high-titer COVID-19 convalescent plasma for the treatment of COVID-19 in patients who are not hospitalized, except in a clinical trial.
  - Convalescent plasma is not authorized for nonhospitalized patients with COVID-19 under the EUA.
  - Results from additional adequately powered, well-designed, and well-conducted randomized clinical trials are needed to provide more specific, evidence-based guidance on the role of COVID-19 convalescent plasma in the treatment of nonhospitalized patients with COVID-19.

## Rationale for Recommendation

On August 23, 2020, the FDA issued an EUA for convalescent plasma for the treatment of hospitalized patients with COVID-19 based on retrospective, indirect evaluations of efficacy generated from a large Expanded Access Program (EAP). The EAP allowed for the use of convalescent plasma regardless of titer. The Panel reviewed the EAP analyses and determined that the data were not sufficient to establish the efficacy or safety of COVID-19 convalescent plasma due to potential confounding, the lack of randomization, and the lack of an untreated control group.

On February 4, 2021, the FDA revised the convalescent plasma EUA to limit the authorization to high-titer COVID-19 convalescent plasma and only for the treatment of hospitalized patients with COVID-19 early in the disease course or hospitalized patients who have impaired humoral immunity.

## Use of Convalescent Plasma in Hospitalized Patients With COVID-19 and Without Impaired Humoral Immunity

An updated retrospective analysis of data collected through the EAP indicated that patients who received high-titer plasma had a lower relative risk of death within 30 days after transfusion than patients who received low-titer plasma (relative risk 0.82; 95% CI, 0.67–1.00).[20]

- Among the patients who were on mechanical ventilation before transfusion, no effect of high-titer plasma versus low-titer plasma was observed (relative risk 1.02; 95% CI, 0.78–1.32).
- Among the patients who were not on mechanical ventilation before transfusion, mortality was lower among patients who received high-titer plasma than among those who received low-titer plasma (relative risk 0.66; 95% CI, 0.48–0.91).[20]

The Randomised Evaluation of COVID-19 Therapy (RECOVERY) trial is an open-label, randomized controlled platform trial evaluating potential treatments for COVID-19. In the convalescent plasma portion of the trial, 11,558 patients were randomized to receive either convalescent plasma (n = 5,795) or usual care (n = 5,763) before enrollment was stopped due to futility.[21]

The trial results demonstrated no significant differences in the primary endpoint of 28-day mortality between the convalescent plasma arm (24%) and the usual care arm (24%; risk ratio 1.00; 95% CI, 0.93–1.07). Additionally, the trial did not meet its two secondary endpoints: time to hospital discharge and, for those not on mechanical ventilation at randomization, receipt of invasive mechanical ventilation or death. The proportion of patients discharged within 28 days was similar in the convalescent plasma arm and the usual care arm (66% vs. 67%; rate ratio 0.98; 95% CI, 0.94–1.03). Among those not requiring invasive mechanical ventilation at baseline, the proportion of those progressing to invasive mechanical ventilation or death was also similar in the convalescent plasma arm and the usual care arm (28% vs. 29%; risk ratio 0.99; 95% CI, 0.93–1.05). The 28-day mortality rate ratio was similar in all prespecified patient subgroups, including in those patients without detectable SARS-CoV-2 antibodies at randomization (32% in the convalescent plasma arm vs. 34% in the usual care arm; rate ratio 0.94; 95% CI, 0.84–1.06). Subgroup analyses suggested a slight trend towards benefit of convalescent plasma in certain subgroups (e.g., those with symptom onset ≤7 days, no requirement for supplemental oxygen at baseline, no concomitant use of corticosteroids). See Table 3b for additional details.

Data from several other randomized clinical trials, all of which were underpowered, have not demonstrated the efficacy of convalescent plasma for the treatment of hospitalized patients with COVID-19.[22-29] See Table 3b for details.

Additionally, two large, randomized trials evaluating convalescent plasma in hospitalized patients have been paused or have limited enrollment due to futility.

- The CONvalescent Plasma for Hospitalized Adults With COVID-19 Respiratory Illness (CONCOR-1) trial, which evaluated convalescent plasma versus usual care, was stopped after an interim analysis of 614 patients met the predefined threshold for futility.[30]
- The Randomised, Embedded, Multifactorial Adaptive Platform Trial for Community-Acquired Pneumonia (REMAP-CAP), which evaluated convalescent plasma in hospitalized patients, paused enrollment for patients in intensive care units after a preliminary analysis that included 912 participants indicated that convalescent plasma was unlikely to benefit this patient group.[31] REMAP-CAP continues to recruit hospitalized patients who do not require intensive care support into the trial's convalescent plasma evaluation domain.

Results from adequately powered, well-designed, and well-conducted randomized clinical trials are needed to provide more specific, evidence-based guidance on the role of convalescent plasma in the treatment of hospitalized patients with COVID-19 who do not have impaired humoral immunity.

## Use of Convalescent Plasma in Hospitalized Patients With COVID-19 and Impaired Humoral Immunity

Data from case reports, case series, and a retrospective case-control study suggest a benefit of convalescent plasma in patients with primary and secondary humoral immunodeficiencies, including patients with hematologic malignancy, common variable immune deficiency, and agammaglobulinemia, and those who have received a transplanted solid organ.[2-13,15,16] Several case reports indicate that patients with impaired humoral immunity may experience persistent SARS-CoV-2 viral replication and, therefore, may be at risk for developing viral resistance to SARS-CoV-2 antibodies after treatment with convalescent plasma.

Results from adequately powered, well-designed, and well-conducted randomized clinical trials are needed to provide more specific, evidence-based guidance on the role of convalescent plasma in the treatment of patients with COVID-19 who have impaired humoral immunity.[17-19]

## Use of Convalescent Plasma in Nonhospitalized Patients With COVID-19

Current data are insufficient to establish the safety or efficacy of convalescent plasma in outpatients with COVID-19.

- Data from a double-blind, placebo-controlled randomized trial of high-titer convalescent plasma in elderly outpatients with <72 hours of mild COVID-19 symptoms suggested a potential for benefit.[32] However, the trial included relatively few participants, and only a small number of clinical events related to COVID-19 occurred. See Table 3b for details.
- The Clinical Trial of COVID-19 Convalescent Plasma of Outpatients (C3PO) evaluated convalescent plasma for the treatment of nonhospitalized patients with ≤7 days of mild or moderate COVID-19 symptoms and at least one risk factor for severe COVID-19. The trial was halted after an interim analysis indicated no benefit of convalescent plasma for this group of patients. The trial enrolled 511 of the planned 900 participants before the study was halted.

Convalescent plasma is not authorized for nonhospitalized patients with COVID-19 under the EUA.

## Clinical Data to Date

Table 3b includes a summary of key studies of convalescent plasma for the treatment of COVID-19.

## Considerations in Pregnancy

The safety and efficacy of using COVID-19 convalescent plasma during pregnancy have not been evaluated. Pathogen-specific immunoglobulins are used clinically during pregnancy to prevent infection from varicella zoster virus and rabies virus and have been used in clinical trials of congenital cytomegalovirus infection.[33] Some ongoing clinical trials that are evaluating COVID-19 convalescent plasma include pregnant individuals.[34]

## Considerations in Children

The safety and efficacy of COVID-19 convalescent plasma have not been evaluated in pediatric patients outside of evaluations described in single-center reports. Clinical trials of COVID-19 convalescent plasma in children are ongoing. There is insufficient evidence for the Panel to recommend either for or against the use of convalescent plasma for the treatment of COVID-19 in hospitalized children who do not require mechanical ventilation. The Panel **recommends against** the use of **convalescent plasma** for the treatment of COVID-19 in mechanically ventilated pediatric patients **(AIII)**. In consultation with a pediatric infectious disease specialist, high-titer convalescent plasma may be considered on a case-by-case basis for children with COVID-19 who meet the EUA criteria.

## Adverse Effects

Available data suggest that serious adverse reactions following the administration of COVID-19 convalescent plasma are infrequent and consistent with the risks associated with plasma infusions for other indications. These risks include transfusion-transmitted infections (e.g., HIV, hepatitis B, hepatitis C), allergic reactions, anaphylactic reactions, febrile nonhemolytic reactions, transfusion-related acute lung injury, transfusion-associated circulatory overload, and hemolytic reactions. Hypothermia, metabolic complications, and post-transfusion purpura have also been described.[21,35,36]

Additional risks of COVID-19 convalescent plasma transfusion include a theoretical risk of antibody-dependent enhancement of SARS-CoV-2 infection and a theoretical risk of long-term immunosuppression.

The Panel recommends consulting a transfusion medicine specialist when considering convalescent plasma for patients with a history of severe allergic or anaphylactic transfusion reactions.

## Product Availability

On February 4, 2021, the FDA revised the convalescent plasma EUA to limit the authorization to high-titer COVID-19 convalescent plasma.[37]

- The revised EUA Letter of Authorization provides an expanded list of anti-SARS-CoV-2 antibody tests and corresponding qualifying results that may be used to determine the suitability of donated convalescent plasma.
- Please refer to the FDA's Recommendations for Investigational COVID-19 Convalescent Plasma webpage for guidance on the transfusion of investigational convalescent plasma while blood establishments develop the necessary operating procedures to manufacture COVID-19 convalescent plasma in accordance with the Conditions of Authorization described in the EUA.[38]

## Clinical Trials

Randomized clinical trials that are evaluating convalescent plasma for the treatment of COVID-19 are underway. Please see *ClinicalTrials.gov* for the latest information.

## References


1. Wang X, Guo X, Xin Q, et al. Neutralizing antibodies responses to SARS-CoV-2 in COVID-19 inpatients and convalescent patients. *Clin Infect Dis*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32497196.
2. Ferrari S, Caprioli C, Weber A, Rambaldi A, Lussana F. Convalescent hyperimmune plasma for chemo-immunotherapy induced immunodeficiency in COVID-19 patients with hematological malignancies. *Leuk Lymphoma*. 2021:1-9. Available at: https://www.tandfonline.com/doi/full/10.1080/10428194.2021.1872070.
3. Hueso T, Pouderoux C, Pere H, et al. Convalescent plasma therapy for B-cell-depleted patients with protracted COVID-19. *Blood*. 2020;136(20):2290-2295. Available at: https://ashpublications.org/blood/article/136/20/2290/463806/Convalescent-plasma-therapy-for-B-cell-depleted.
4. Rahman F, Liu STH, Taimur S, et al. Treatment with convalescent plasma in solid organ transplant recipients with COVID-19: experience at large transplant center in New York City. *Clin Transplant*. 2020;34(12):e14089. Available at: https://onlinelibrary.wiley.com/doi/10.1111/ctr.14089.
5. Mira E, Yarce OA, Ortega C, et al. Rapid recovery of a SARS-CoV-2-infected X-linked agammaglobulinemia patient after infusion of COVID-19 convalescent plasma. *J Allergy Clin Immunol Pract*. 2020;8(8):2793-2795. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7345404/.
6. Fung M, Nambiar A, Pandey S, et al. Treatment of immunocompromised COVID-19 patients with convalescent plasma. *Transpl Infect Dis.* 2020; 2020/09/30:e13477. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7537112/pdf/TID-9999-na.pdf. Accessed March 23, 2021.
7. Quinti I, Lougaris V, Milito C, et al. A possible role for B cells in COVID-19? Lesson from patients with agammaglobulinemia. *J Allergy Clin Immunol*. 2020;146(1):211-213 e214. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0091674920305571?via%3Dihub.
8. Jin H, Reed JC, Liu STH, et al. Three patients with X-linked agammaglobulinemia hospitalized for COVID-19 improved with convalescent plasma. *J Allergy Clin Immunol Pract*. 2020;8(10):3594-3596 e3593. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7490621/.
9. Betrains A, Godinas L, Woei AJF, et al. Convalescent plasma treatment of persistent severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection in patients with lymphoma with impaired humoral immunity and lack of neutralising antibodies. 2020. Available at: https://onlinelibrary.wiley.com/doi/10.1111/bjh.17266.
10. Balashov D, Trakhtman P, Livshits A, et al. SARS-CoV-2 convalescent plasma therapy in pediatric patient after hematopoietic stem cell transplantation. *Transfus Apher Sci*. 2021;60(1):102983. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33153902.
11. Thompson MA, Henderson JP, Shah PK, et al. Convalescent plasma and improved survival in patients with hematologic malignancies and COVID-19. *MedRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.02.05.21250953v1.
12. Senefeld JW, Klassen SA, Ford SK, et al. Therapeutic use of convalescent plasma in COVID-19 patients with immunodeficiency. 2020. Available at: https://www.medrxiv.org/content/10.1101/2020.11.08.20224790v1.full.pdf. Accessed March 24, 2021.
13. Clark E, Guilpain P, Filip IL, et al. Convalescent plasma for persisting COVID-19 following therapeutic lymphocyte depletion: a report of rapid recovery. *Br J Haematol*. 2020;190(3):e154-e156. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32593180.
14. Iaboni A, Wong N, Betschel SD. A patient with X-linked agammaglobulinemia and COVID-19 infection treated with remdesivir and convalescent plasma. *J Clin Immunol*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33547548.
15. Van Damme KFA, Tavernier S, Roy NV, et al. Case report: convalescent plasma, a targeted therapy for patients with CVID and severe COVID-19. *Front Immunol*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7714937/.
16. Tremblay D, Seah C, Schneider T, et al. Convalescent plasma for the treatment of severe COVID-19 infection

in cancer patients. *Cancer Medicine*. 2020. Available at: https://onlinelibrary.wiley.com/doi/10.1002/cam4.3457.

17. Choi B, Choudhary MC, Regan J, et al. Persistence and Evolution of SARS-CoV-2 in an Immunocompromised Host. *N Engl J Med*. 2020;383(23):2291-2293. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33176080.
18. Kemp SA, Collier DA, Datir RP, et al. SARS-CoV-2 evolution during treatment of chronic infection. *Nature*. 2021. Available at: https://www.nature.com/articles/s41586-021-03291-y.
19. Tarhini H, Recoing A, Bridier-Nahmias A, et al. Long term SARS-CoV-2 infectiousness among three immunocompromised patients: from prolonged viral shedding to SARS-CoV-2 superinfection. *The Journal of Infectious Diseases*. 2021. Available at: https://academic.oup.com/jid/advance-article/doi/10.1093/infdis/jiab075/6131370.
20. Joyner MJ, Carter RE, Senefeld JW, et al. Convalescent plasma antibody levels and the risk of death from COVID-19. *N Engl J Med*. 2021. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa2031893.
21. The RECOVERY Collaborative Group, Horby PW, Estcourt L, et al. Convalescent plasma in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *MedRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.09.21252736v1.
22. Simonovich VA, Pratx LDB, Scibona P, et al. A randomized trial of convalescent plasma in Covid-19 severe pneumonia. *N Engl J Med*. 2021. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa2031304.
23. Agarwal A, Mukherjee A, Kumar G, et al. Convalescent plasma in the management of moderate covid-19 in adults in India: open label phase II multicentre randomised controlled trial (PLACID Trial). *BMJ*. 2020;371. Available at: https://www.bmj.com/content/bmj/371/bmj.m3939.full.pdf.
24. Li L, Zhang W, Hu Y, et al. Effect of convalescent plasma therapy on time to clinical improvement in patients with severe and life-threatening COVID-19: A randomized clinical trial. *JAMA*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32492084.
25. Gharbharan A, Jordans CCE, GeurtsvanKessel C, et al. Convalescent plasma for COVID-19: a randomized clinical trial. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.07.01.20139857v1.
26. Avendano-Sola C, Ramos-Martinez A, Muñez-Rubio E, et al. Convalescent plasma for COVID-19: a multicenter, randomized clinical trial. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.08.26.20182444v3.full.pdf. Accessed March 23, 2021.
27. AlQahtani M, Abdulkarim A, Almadani A, et al. Randomized controlled trial of convalescent plasma therapy against standard therapy in patients with severe COVID-19 disease. *MedRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.11.02.20224303v1.full.
28. Ray Y, Paul SR, Bandopadhyay P, et al. Clinical and immunological benefits of convalescent plasma therapy in severe COVID-19: insights from a single center open label randomised control trial. *MedRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.11.25.20237883v1.
29. O'Donnell MR, Grinsztejn B, Cummings MJ, et al. A randomized, double-blind, controlled trial of convalescent plasma in adults with severe COVID-19. *MedRxiv*. 2021. Available at: https://www.medrxiv.org/content/10.1101/2021.03.12.21253373v1?%25253fcollection=.
30. CONCOR-1. Welcome to CONCOR-1 clinical trial website. Available at: https://concor1.ca/. Accessed March 25, 2021.
31. REMAP-CAP PR. International Trial of SARS-CoV-2 Convalescent Plasma Pauses Enrollment of Critically Ill COVID-19 Patients. 2021. Available at: https://www.recover-europe.eu/press-release-international-trial-of-sars-cov-2-convalescent-plasma-pauses-enrollment-of-critically-ill-covid-19-patients/. Accessed March 25, 2021.
32. Libster R, Perez Marc G, Wappner D, et al. Early high-titer plasma therapy to prevent severe COVID-19 in older adults. *N Engl J Med*. 2021;384(7):610-618. Available at:

https://www.nejm.org/doi/full/10.1056/NEJMoa2033700.

33. Centers for Disease Control and Prevention. Updated recommendations for use of VariZIG—United States, 2013. *MMWR Morb Mortal Wkly Rep.* 2013;62(28):574-576. Available at: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6228a4.htm. Accessed March 26, 2021.
34. University of Pennsylvania. COVID-19 convalescent plasma for mechanically ventilated population. 2020. Available at: https://clinicaltrials.gov/ct2/show/NCT04388527. Accessed March 26, 2021.
35. Food and Drug Administration. EUA of COVID-19 convalescent plasma for the treatment of COVID-19 in hospitalized patients: fact sheet for health care providers. 2020. Available at: https://www.fda.gov/media/141478/download. Accessed September 22, 2020.
36. Nguyen FT, van den Akker T, Lally K, et al. Transfusion reactions associated with COVID-19 convalescent plasma therapy for SARS-CoV-2. *Transfusion*. 2021;61(1):78-93. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33125158.
37. Food and Drug Administration. Convalescent Plasma Letter of Authorization. 2020. Available at: https://www.fda.gov/media/141477/download. Accessed August 31, 2020.
38. Food and Drug Administration. Recommendations for investigational COVID-19 convalescent plasma. 2021. Available at: https://www.fda.gov/vaccines-blood-biologics/investigational-new-drug-ind-or-device-exemption-ide-process-cber/recommendations-investigational-covid-19-convalescent-plasma. Accessed March 26, 2021.

# Table 3b. COVID-19 Convalescent Plasma: Selected Clinical Data

*Last Updated: April 21, 2021*

The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing the recommendations for COVID-19 CP. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Convalescent Plasma in Hospitalized Patients With COVID-19 (RECOVERY Trial)[1]** | | | |
| Open-label, platform RCT evaluating potential treatments, including high-titer CP, in hospitalized patients with COVID-19 in the United Kingdom (n = 11,558)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Clinically suspected or laboratory-confirmed SARS-CoV-2 infection<br>• CP available at study site<br>**Key Exclusion Criteria:**<br>• CP contraindicated (e.g., known allergy to blood components)<br>**Interventions:**<br>• One 275 mL (+/- 75 mL) unit of CP immediately and another unit the next day (≥12 hours after the first unit)<br>• CP was selected by sample to cut-off IgG SARS-CoV-2 spike protein ratio ≥6.0.<br>• Usual care<br>**Primary Endpoint:**<br>• All-cause mortality at Day 28<br>**Secondary Endpoints:**<br>• Time to hospital discharge<br>• Among patients not receiving IMV at randomization, receipt of IMV or death by Day 28 | **Number of Participants:**<br>• ITT analysis: CP (n = 5,795) and usual care (n = 5,763)<br>**Participant Characteristics:**<br>• Mean age was 63.5 years.<br>• 63% of patients in the CP arm and 66% in the usual care arm were men.<br>• 5% of patients in each arm were on IMV.<br>• At baseline, 52% of the patients in the CP arm and 48% in the usual care arm were SARS-CoV-2 antibody seropositive.<br>• 93% of the patients in the CP arm and 92% in the usual care arm received corticosteroids.<br>**Outcomes:**<br>• No difference in 28-day mortality between the CP arm and the usual care arm (24% vs. 24%; rate ratio 1.00; 95% CI, 0.93–1.07).<br>• No difference in the proportion of patients discharged within 28 days (66% in CP arm vs. 67% in usual care arm; rate ratio 0.98; 95% CI, 0.94–1.03; $P = 0.50$).<br>• 28-day mortality rate ratio was consistent across prespecified patient subgroups, including subgroups by SARS-CoV-2 antibody presence at randomization. In particular, among patients without detectable SARS-CoV-2 antibodies, there was no evidence of a mortality difference between those who received CP and those who received usual care (32% vs. 34%; rate ratio 0.94; 95% CI, 0.84–1.06).<br>• Among those not receiving IMV at baseline, the percentage of patients who progressed to IMV or died was similar in the CP arm and the usual care arm (28% vs. 29%; rate ratio 0.99; 95% CI, 0.93–1.05; $P = 0.79$).<br>• Severe allergic reactions were rare (occurred in 16 patients in the CP arm and 2 in the usual care arm). | **Limitations:**<br>• The study was not blinded.<br>• >90% of participants received corticosteroids. There is uncertainty about the effect of CP in hospitalized patients who do not require supplemental oxygen and for whom corticosteroids are not recommended.<br>**Interpretation:**<br>• The trial did not demonstrate a benefit of CP in hospitalized patients with COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Convalescent Plasma in Hospitalized Adults With COVID-19 (PLACID Trial)[2]** | | | |
| Multicenter, open-label, Phase 2 RCT in hospitalized adults with severe COVID-19 in India (n = 464) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Positive SARS-CoV-2 RT-PCR<br>• $PaO_2/FiO_2$ = 200–300 mm Hg or respiratory rate >24 breaths/min with $SpO_2$ ≤93% on room air<br>**Key Exclusion Criteria:**<br>• Critical illness<br>**Interventions:**<br>• 2 doses of 200 mL CP, transfused 24 hours apart<br>• SOC<br>**Primary Endpoint:**<br>• Composite of progression to severe disease (defined as $PaO_2/FiO_2$ <100 mm Hg) any time within 28 days of enrollment or all-cause mortality at 28 days | **Number of Participants:**<br>• CP (n = 235) and SOC (n = 229)<br>**Participant Characteristics:**<br>• Median age was 52 years.<br>• 75% of participants in the CP arm and 77% in the SOC arm were men.<br>• Higher prevalence of diabetes in the CP arm (48%) than in SOC arm (38%).<br>**Outcomes:**<br>• No difference between the arms in the primary outcome of progression to severe disease or death (occurred in 18.7% of participants in CP arm and 17.9% in SOC arm).<br>• A post hoc analysis evaluating outcomes among patients without detectable SARS-CoV-2 neutralizing antibody titers at baseline also revealed no benefit of CP. | **Limitations:**<br>• The study was not blinded.<br>• SARS-CoV-2 antibody testing was not used to select donated CP units; therefore, many participants may have received CP units with low titers of SARS-CoV-2 neutralizing antibodies.<br>**Interpretation:**<br>• This trial did not demonstrate a benefit of CP in hospitalized patients with severe COVID-19. |
| **Convalescent Plasma in COVID-19 Severe Pneumonia (PlasmAr Study)[3]** | | | |
| Double-blind, placebo-controlled, multicenter RCT in hospitalized adults with severe COVID-19 in Argentina (n = 333) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Positive SARS-CoV-2 RT-PCR<br>• Severe COVID-19<br>**Key Exclusion Criteria:**<br>• Critical illness<br>**Interventions**<br>*2:1 Randomization:*<br>• Single dose (median volume | **Number of Participants:**<br>• CP (n = 228) and placebo (n = 105)<br>**Participant Characteristics:**<br>• Median age was 62 years.<br>• 67.6% of the participants were men.<br>• 64.9% of the participants had a coexisting condition at trial entry.<br>• Median time from symptom onset to enrollment was 8 days.<br>• Of 215 participants tested, 46% had no detectable SARS-CoV-2 antibodies at baseline. Median SARS-CoV-2 antibody titer in both the CP arm and placebo arm was 1:50. | **Limitations:**<br>• The majority of participants in both arms received concomitant glucocorticoid treatment, potentially masking subtle differences in clinical outcomes between the study arms. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Convalescent Plasma in COVID-19 Severe Pneumonia (PlasmAr Study)[3]**, continued | | | |
| | 500 mL) of CP pooled from 2–5 donors. Only plasma units with a SARS-CoV-2 viral spike-RBD IgG titer ≥1:800 were transfused.<br>• Placebo<br>**Primary Endpoint:**<br>• Change in clinical status 30 days after intervention measured using a 6-point ordinal scale | **Outcomes:**<br>• No significant differences between the arms in the distribution of outcomes according to the categories on the 6-point ordinal scale (OR 0.83; 95% CI, 0.52–1.35).<br>• 30-day mortality was similar in CP arm (11.0%) and placebo arm (11.4%).<br>• Infusion-related AEs were more frequent in the CP arm than in the placebo arm (occurred in 4.8% vs. 1.9% of participants). | **Interpretation:**<br>• This trial did not demonstrate a benefit of CP in hospitalized patients with severe COVID-19. |
| **Convalescent Plasma in Adults With Severe COVID-19[4]** | | | |
| Double-blind, Phase 2 RCT in hospitalized adults with severe COVID-19 (n = 223) in the United States (n = 73) and Brazil (n = 150)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• COVID-19 pneumonia<br>• $SpO_2$ ≤94% on room air or requirement for supplemental oxygen, IMV, or ECMO<br>**Key Exclusion Criteria:**<br>• >5 days on IMV or ECMO<br>• Severe multiorgan failure<br>**Interventions**<br>*2:1 Randomization:*<br>• Single dose of SARS-CoV-2 CP (approximately 250 mL). Only units with a SARS-CoV-2 viral spike-RBD IgG titer ≥1:400 were transfused.<br>• Non-SARS-CoV-2 plasma (normal control plasma) | **Number of Participants:**<br>• CP (n = 150) and normal control plasma (n = 73)<br>• Enrollment initiated in New York City in April 2020 and in Brazil in August 2020<br>**Participant Characteristics:**<br>• Median age was 61 years.<br>• 66% of the participants were men.<br>• Median duration of symptoms prior to randomization was 9 days.<br>• 57% of the participants required supplemental oxygen at baseline, 25% required high-flow oxygen or noninvasive ventilation, and 13% required IMV or ECMO.<br>• There were some imbalances between the study arms at baseline. The CP arm included more women; the participants were younger and had slightly longer symptom durations.<br>• 81% of the participants received corticosteroids.<br>**Outcomes:**<br>• No difference in clinical status on Day 28 was observed between the CP arm and the control arm (OR 1.5 for being in a better category with CP vs. control plasma; 95% CI, 0.83–2.68; $P = 0.18$). | **Limitations:**<br>• The intervention in the control group arm was blood plasma without SARS-CoV-2 antibodies. This ensured blinded administration; however, because the trial was not placebo controlled; it is not possible to identify potential harm due to plasma infusion.<br>• Low sample size and number of events<br>• There were imbalances in baseline characteristics between the study arms that may have impacted study outcomes. After adjustment for the imbalances, the |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Convalescent Plasma in Adults With Severe COVID-19**[4], continued | | | |
| | **Primary Endpoint:**<br>• Clinical status on Day 28, measured using an ordinal scale (initially with 7 categories, but modified to 6).<br>**Secondary Endpoints:**<br>• Time to clinical improvement<br>• In-hospital and 28-day mortality<br>• Time to discontinuation of supplemental oxygen<br>• Time to hospital discharge | • In-hospital mortality was lower in the CP arm (13%) than in the control arm (25%; HR 0.44; 95% CI, 0.22–0.91; $P = 0.034$). The treatment difference was not significant after adjustment for age, sex, and duration of symptoms at baseline.<br>• In both arms, mortality at 28 days was the same as in-hospital mortality.<br>• Time to oxygen discontinuation and time to hospital discharge were similar between the arms.<br>• 25.5% of patients in the CP arm vs. 36.1% in the control arm experienced SAEs. | difference in mortality between the arms was not significant.<br>• The treatment difference in the primary outcome (clinical status on Day 28) was not statistically significant; mortality was a secondary outcome.<br>• There were no subgroup analyses for mortality.<br>**Interpretation:**<br>• Although the difference between the CP arm and the non-SARS-CoV-2 antibody plasma arm for the primary outcome of clinical status on Day 28 was not statistically significant, the lower 28-day mortality in the CP arm suggests a potential benefit of CP in hospitalized patients with severe COVID-19. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Early High-Titer Plasma Therapy to Prevent Severe COVID-19 in Older Adults[5]** | | | |
| Double-blind, placebo-controlled RCT in outpatients with mild COVID-19 in Argentina (n = 160) | **Key Inclusion Criteria:**<br>• Aged >75 years or aged 65–74 years with ≥1 coexisting condition<br>• Outpatient with <72 hours of mild COVID-19 symptoms<br>**Key Exclusion Criteria:**<br>• Severe respiratory disease<br>**Interventions:**<br>• Single 250 mL dose of CP with an IgG titer against SARS-CoV-2 spike protein of >1:1000<br>• Placebo<br>**Primary Endpoint:**<br>• Severe respiratory disease defined as a respiratory rate ≥30 breaths/min and/or $SpO_2$ <93% on room air by Day 15 | **Number of Participants:**<br>• ITT analysis: CP (n = 80) and placebo (n = 80)<br>**Participant Characteristics:**<br>• Mean age was 77 years.<br>• Most of the patients had comorbidities.<br>**Outcomes:**<br>• 13 of 80 patients (16%) in the CP arm and 25 of 80 (31%) in the placebo arm experienced severe respiratory disease by Day 15 (relative risk 0.52; 95% CI, 0.29–0.94; *P* = 0.026).<br>• 2 participants in the CP arm and 5 in the placebo arm died.<br>• No solicited AEs were reported. | **Limitations:**<br>• The trial was terminated early because cases of COVID-19 at the study site decreased.<br>• The trial included relatively few participants.<br>**Interpretation:**<br>• This trial demonstrated a benefit of CP in elderly outpatients with <72 hours of mild COVID-19 symptoms. |
| **Effect of Convalescent Plasma Therapy on Time to Clinical Improvement in Patients With Severe and Life-Threatening COVID-19[6]** | | | |
| Multicenter, open-label, randomized trial in hospitalized adults with severe or life-threatening COVID-19 in China (n = 103) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Positive SARS-CoV-2 PCR within 72 hours of randomization<br>• Met study definition of severe or life-threatening COVID-19 | **Number of Participants:**<br>• CP (n = 52) and SOC (n = 51)<br>**Participant Characteristics:**<br>• Median age was 70 years.<br>• 58.3% of the participants were men.<br>**Outcomes:**<br>• No significant difference in time to clinical improvement between the CP arm and the control arm (HR 1.40; 95% CI, 0.79–2.49; *P* = 0.26).<br>• No significant difference in mortality between the CP arm (16%) and the control arm (24%; *P* = 0.30). | **Limitations:**<br>• The study was not blinded.<br>• The trial was stopped early because of decreasing numbers of cases of COVID-19 at the study site; therefore, the study lacked sufficient power to detect differences in clinical outcomes. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Convalescent Plasma Therapy on Time to Clinical Improvement in Patients With Severe and Life-Threatening COVID-19[6]**, continued | | | |
| | **Key Exclusion Criteria:**<br>• Baseline RBD-specific IgG antibody ≥1:64<br>• Certain sequalae of severe COVID-19 (e.g., severe septic shock, severe heart failure)<br>**Interventions:**<br>• Single 4–13 mL/kg dose of CP. Only CP units with a SARS-CoV-2 viral spike-RBD-specific IgG titer of ≥1:640 were transfused.<br>• SOC<br>**Primary Endpoint:**<br>• Time to clinical improvement (patient discharge or a reduction of 2 points on a 6-point disease severity scale; 6 points = death, 1 point = hospital discharge) within 28 days. | | • Only 103 of 200 planned participants were randomized to receive treatment.<br>• CP was administered late (approximately 1 month) into disease course.<br>**Interpretation:**<br>• This trial did not demonstrate a benefit of CP in hospitalized patients with severe or life-threatening COVID-19. |
| **Early Versus Deferred Anti-SARS-CoV-2 Convalescent Plasma in Hospitalized Patients With COVID-19[7]** | | | |
| Open-label, single-center, Phase 2 randomized trial in hospitalized adults with COVID-19 in Chile (n = 58) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• ≤7 days of COVID-19 symptoms<br>• High risk of progression to respiratory failure<br>**Key Exclusion Criteria:**<br>• $PaO_2/FiO_2$ <200 mm Hg<br>• Mechanical ventilation | **Number of Participants:**<br>• Immediate CP (n = 28) and deferred CP (n = 30)<br>**Participant Characteristics:**<br>• Median age was 66 years.<br>• 50% of the participants were men.<br>• Median interval between symptom onset and randomization was 6 days.<br>• 13 of 28 participants (43%) in the deferred CP arm received CP at a median of 3 days after enrollment. | **Limitations:**<br>• The study was not blinded.<br>• Small sample size.<br>**Interpretation:**<br>• This trial did not demonstrate a benefit of immediate vs. deferred administration of CP in hospitalized COVID-19 patients with ≤7 days of COVID-19 symptoms. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Early Versus Deferred Anti-SARS-CoV-2 Convalescent Plasma in Hospitalized Patients With COVID-19**[7], continued | | | |
| | **Interventions**<br>*Immediate CP:*<br>• Two 400 mL doses of CP with anti-SARS-CoV-2 neutralizing antibody titers ≥1:400, transfused 24 hours apart<br>*Deferred CP:*<br>• CP transfusion only if $PaO_2/FiO_2$ <200 mm Hg, or if participant still required hospitalization for COVID-19 symptoms 7 days after enrollment<br>**Primary Endpoint:**<br>• Composite of mechanical ventilation, hospitalization >14 days, or in-hospital death | **Outcomes:**<br>• There was no difference between the arms in the percentage of participants who met the primary composite endpoint of death, mechanical ventilation, or >14 days hospitalization (32% in immediate CP arm vs. 33% in deferred CP arm; OR 0.95; 95% CI, 0.32–2.84).<br>• 18% of participants in the immediate CP arm vs. 7% in the deferred CP arm died within 30 days (OR 3.0; 95% CI, 0.5–17.2; *P* = 0.25). | |
| **Convalescent Plasma for COVID-19 (ConCOVID trial)**[8] | | | |
| Multicenter, open-label, RCT in hospitalized adults with COVID-19 in the Netherlands (n = 86)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Clinical disease with positive SARS-CoV-2 RT-PCR within 96 hours of enrollment<br>**Key Exclusion Criteria:**<br>• Mechanical ventilation for >96 hours<br>**Interventions:**<br>• One to two 300 mL doses of CP with anti-SARS-CoV-2 neutralizing antibody titers ≥1:80<br>• SOC | **Number of Participants:**<br>• CP (n = 43) and SOC (n = 43)<br>**Participant Characteristics:**<br>• Median age was 63 years.<br>• Most of the participants were men.<br>**Outcomes:**<br>• No differences in mortality (*P* = 0.95), length of hospital stay (*P* = 0.68), or disease severity at Day 15 (*P* = 0.58) were observed between the study arms. | **Limitations:**<br>• The study was not blinded.<br>• Trial halted early by the investigators when the baseline SARS-CoV-2 neutralizing antibody titers of participant plasma and CP were found to be comparable, challenging the potential benefit of CP for the study population. Thus, the study lacked sufficient power to detect differences in clinical outcomes between the study arms. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Convalescent Plasma for COVID-19 (ConCOVID trial)[8]**, continued | | | |
| | **Primary Endpoint:**<br>• Day-60 mortality | | • Only 86 of 426 planned participants were randomized to receive CP or SOC.<br>**Interpretation:**<br>• This trial did not demonstrate a benefit of COVID-19 CP in hospitalized patients. |
| **Convalescent Plasma for COVID-19 (ConPlas-19 Study)[9]** | | | |
| Multicenter, open-label, RCT in hospitalized adults with COVID-19 in Spain (n = 81)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>**Key Exclusion Criteria:**<br>• Receiving IMV, noninvasive ventilation, or high-flow oxygen<br>**Interventions:**<br>• Single dose of 250–300 mL of CP plus SOC.<br>• All administered units had neutralizing antibodies (VMNT-ID50: all titers >1:80, median titer 1:292, IQR 238–451; pseudovirus neutralizing ID50 assay: median titer 1:327; IQR 168–882)<br>• SOC alone<br>**Primary Endpoint:**<br>• Proportion of patients in ordinal scale categories 5, 6, or 7 at Day 15. | **Number of Participants:**<br>• CP (n = 38) and SOC (n = 43)<br>**Participant Characteristics:**<br>• Mean age was 59 years.<br>• At baseline, 49% of the participants were SARS-CoV-2 antibody positive.<br>**Outcomes:**<br>• 0 of 38 participants (0%) in the CP arm progressed to ordinal scale categories 5–7 vs. 6 of 43 participants (14.0%) in the SOC arm ($P$ = 0.57, not statistically significant according to the planned analysis; but $P$ = 0.03 using Fisher test as a post hoc sensitivity analysis given small numbers and the by-center heterogenous distribution).<br>• 0 of 38 participants (0%) in the CP arm died vs. 4 of 43 (9.3%) in the SOC arm ($P$ = 0.06). | **Limitations:**<br>• The study was not blinded.<br>• The trial was stopped early because of decreasing numbers of COVID-19 cases at the study site and, thus, the study lacked sufficient power to detect differences in clinical outcomes.<br>• Only 81 of planned 278 participants were enrolled.<br>**Interpretation:**<br>• Although the results did not reach statistical significance and only a small number of clinical events related to COVID-19 occurred, these results suggest a potential benefit of CP in hospitalized patients who are not receiving high-flow oxygen, noninvasive ventilation, or invasive ventilation. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Clinical and Immunological Benefits of Convalescent Plasma Therapy in Severe COVID-19[10]** | | | |
| Single-center, open-label, RCT in hospitalized adults with COVID-19 and ARDS in India (n = 80)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Evidence of ARDS (defined as $PaO_2/FiO_2$ 100–300 mm Hg)<br>• Not on mechanical ventilation<br>**Key Exclusion Criteria:**<br>• Mechanical ventilation<br>**Intervention:**<br>• 2 consecutive doses of ABO-matched 200 mL CP, 1 day apart<br>• SOC alone<br>**Primary Endpoint:**<br>• All-cause mortality at Day 30 | **Number of Participants:**<br>• CP (n = 40) and SOC (n = 40)<br>**Participant Characteristics:**<br>• Mean age was 61 years.<br>• 71% of the participants were men.<br>• No difference in mean number of days of hospitalization at enrollment between the CP arm (4.2 days) and the SOC arm (3.9 days).<br>**Outcomes**:<br>• 10 of 40 participants (25%) in the CP arm had died by Day 30 vs. 14 of 40 (35%) in the SOC arm.<br>• Difference in survival between the arms was not statistically significant (HR 0.6731; 95% CI, 0.3010–1.505). | **Limitations**:<br>• The study was not blinded.<br>• The study lacked sufficient power to detect differences in clinical outcomes between the study arms.<br>**Interpretation**:<br>• This trial did not demonstrate a benefit of CP in hospitalized patients with mild to moderate ARDS who are not receiving mechanical ventilation. |
| **Convalescent Plasma Therapy Versus Standard Therapy in Patients With Severe COVID-19[11]** | | | |
| Open-label, RCT in hospitalized adults with COVID-19 in Bahrain (n = 40)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥21 years<br>• Radiologic evidence of pneumonia<br>• Requirement for oxygen therapy for COVID-19<br>**Key Exclusion Criteria:**<br>• Requirement for IMV, noninvasive ventilation, or high-flow oxygen<br>**Interventions:**<br>• Two 200 mL transfusions of CP over 24 hours<br>• SOC alone<br>**Primary Endpoints:**<br>• Requirement for IMV or noninvasive ventilation | **Number of Participants:**<br>• CP (n = 20) and SOC (n = 20)<br>**Participant Characteristics:**<br>• Mean age was 53 years in the CP arm and 51 years in the SOC arm.<br>• Most of the participants were men (75% in the CP arm and 85% in the SOC arm).<br>**Outcomes:**<br>• 6 patients in the SOC arm and 4 patients in the CP arm required mechanical ventilation (risk ratio 0.67; 95% CI, 0.22–2.0; $P$ = 0.72).<br>• 2 patients in the SOC arm died vs. 1 in the CP arm. | **Limitations:**<br>• The study was not blinded.<br>• The study lacked sufficient power to detect differences in clinical outcomes between the study arms.<br>**Interpretation:**<br>• This trial did not demonstrate a benefit of CP in hospitalized patients who are not receiving high-flow oxygen, noninvasive ventilation, or invasive ventilation. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Convalescent Plasma Therapy Versus Standard Therapy in Patients With Severe COVID-19[11]**, continued | | | |
| | • In patients who require ventilation, duration of ventilation | | |
| **Convalescent Plasma Antibody Levels and the Risk of Death from COVID-19[12]** | | | |
| Retrospective, indirect evaluation of a subset of patients from the Mayo Clinic COVID-19 CP EAP (n = 3,082). More than 100,000 patients hospitalized with COVID-19 in the United States received CP through the Mayo Clinic EAP. | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Severe or life-threatening (critical) COVID-19<br>• Analysis limited to patients for whom samples were available for retrospective analysis of CP titer.<br>**Intervention:**<br>• CP transfusion (no titer specified in real time; high, medium, and low titer CP determined retrospectively)<br>**Primary Endpoint:**<br>• Mortality 30 days after CP transfusion | **Number of Participants:**<br>• High-titer CP (n = 515), medium-titer CP (n = 2,006), and low-titer CP (n = 561)<br>**Participant Characteristics:**<br>• 61% of the participants were men.<br>• 48% of the participants were White and 37% were Hispanic/Latino.<br>• 61% of the participants required ICU-level care prior to infusion.<br>• 33% of the participants were on mechanical ventilation.<br>• 51% of the participants received corticosteroids; 31% received RDV.<br>**Outcomes:**<br>• The analysis included 3,082 participants who received a single unit of CP. The participants were among 35,322 participants who had received CP through the EAP by July 4, 2020.<br>• Death within 30 days occurred in 115 of 515 patients (22%) in the high-titer group, 549 of 2,006 patients (27%) in the medium-titer group, and 166 of 561 patients (30%) in the low-titer group.<br>• Using a relative-risk regression model that assumed all patients who were discharged were alive at Day 30, patients in the high-titer group had a lower relative risk of death within 30 days than patients in the low-titer group (relative risk 0.82; 95% CI, 0.67–1.00).<br>• Among patients who received mechanical ventilation before transfusion, there was no difference in the risk of death between those who received high-titer CP and those who received low-titer CP (relative risk 1.02; 95% CI, 0.78–1.32).<br>• Mortality was lower among patients who were not receiving mechanical ventilation before transfusion (relative risk 0.66; 95% CI, 0.48–0.91). | **Limitations:**<br>• Lack of untreated control arm limits interpretation of the safety and efficacy data; the possibility that differences in outcomes are attributable to harm from low-titer plasma rather than benefit from high-titer plasma cannot be excluded.<br>• Assays to determine the effective antibody titers remain limited, and the antibody titers of currently available CP from COVID-19 survivors are highly variable.<br>• Efficacy analysis relied on only a subset of EAP patients who represent a fraction of the patients who received CP through the EAP.<br>• Post hoc subgroups were selected by combining several subsetting rules that favored subgroups. This approach tends to overestimate the treatment effect.<br>**Interpretation:**<br>• Given the lack of an untreated control arm and the limitations listed above, this retrospective analysis is not sufficient to establish the efficacy or safety of CP. |

**Key:** AE = adverse event; ARDS = acute respiratory distress syndrome; ConCOVID Trial = Convalescent-plasma-for-COVID-9; ConPlas-19 Study = Convalescent Plasma for COVID-19; CP = convalescent plasma; EAP = Expanded Access Program; ECMO = extracorporeal membrane oxygenation; ICU = intensive care unit; ID50 = 50% inhibitory dose; IgG = immunoglobulin G; IMV = invasive mechanical ventilation; ITT = intention to treat; the Panel = the COVID-19 Treatment Guidelines Panel; $PaO_2/FiO_2$ = ratio of arterial partial pressure of oxygen to fraction of inspired oxygen; PCR = polymerase chain reaction; PLACID Trial = Convalescent plasma in the management of moderate covid-19 in adults in India: open label phase II multicentre randomized controlled trial; PlasmAr Study = A Randomized Trial of Convalescent Plasma in COVID-19 Severe Pneumonia; RBD = receptor binding domain; RCT = randomized controlled trial; RDV = remdesivir; RECOVERY = Randomised Evaluation of COVID-19 Therapy; RT-PCR = reverse transcriptase polymerase chain reaction; SAE = serious adverse event; SOC = standard of care; $SpO_2$ = saturation of oxygen; VMNT = virus microneutralization test

## References


1. The RECOVERY Collaborative Group, Horby PW, Estcourt L, et al. Convalescent plasma in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.09.21252736v1.
2. Agarwal A, Mukherjee A, Kumar G, et al. Convalescent plasma in the management of moderate COVID-19 in adults in India: open label Phase II multicentre randomised controlled trial (PLACID Trial). *BMJ*. 2020;371:m3939. Available at: https://pubmed.ncbi.nlm.nih.gov/33093056/.
3. Simonovich VA, Pratx LDB, Scibona P, et al. A randomized trial of convalescent plasma in COVID-19 severe pneumonia. *N Engl J Med*. 2021;384(7):619-629. Available at: https://pubmed.ncbi.nlm.nih.gov/33232588/.
4. O'Donnell MR, Grinsztejn B, Cummings MJ, et al. A randomized, double-blind, controlled trial of convalescent plasma in adults with severe COVID-19. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.03.12.21253373v1?%25253fcollection=.
5. Libster R, Perez Marc G, Wappner D, et al. Early high-titer plasma therapy to prevent severe COVID-19 in older adults. *N Engl J Med*. 2021;384(7):610-618. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa2033700.
6. Li L, Zhang W, Hu Y, et al. Effect of convalescent plasma therapy on time to clinical improvement in patients with severe and life-threatening COVID-19: A randomized clinical trial. *JAMA*. 2020;324(5):460-470. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32492084.
7. Balcells ME, Rojas L, Le Corre N, et al. Early versus deferred anti-SARS-CoV-2 convalescent plasma in patients admitted for COVID-19: a randomized Phase II clinical trial. *PLoS Med*. 2021;18(3):e1003415. Available at: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1003415.
8. Gharbharan A, Jordans CCE, Geurtsvankessel C, et al. Convalescent plasma for COVID-19: a randomized clinical trial. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.07.01.20139857v1.
9. Avendano-Sola C, Ramos-Martinez A, Muñez-Rubio E, et al. Convalescent plasma for COVID-19: a multicenter, randomized clinical trial. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.08.26.20182444v3.full.pdf.
10. Ray Y, Paul SR, Bandopadhyay P, et al. Clinical and immunological benefits of convalescent plasma therapy in severe COVID-19: insights from a single center open label randomised control trial. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.11.25.20237883v1.
11. AlQahtani M, Abdulkarim A, Almadani A, et al. Randomized controlled trial of convalescent plasma therapy against standard therapy in patients with severe COVID-19 disease. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.11.02.20224303v1.full.
12. Joyner MJ, Carter RE, Senefeld JW, et al. Convalescent plasma antibody levels and the risk of death from COVID-19. *N Engl J Med*. 2021;384(11):1015-1027. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa2031893.

# Immunoglobulins: SARS-CoV-2 Specific

*Last Updated: July 17, 2020*

## Recommendation

- There is insufficient evidence for the COVID-19 Treatment Guidelines Panel to recommend either for or against **severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) immunoglobulins** for the treatment of COVID-19.

## Rationale

Currently, there are no clinical data on the use of SARS-CoV-2 immunoglobulins. Trials evaluating SARS-CoV-2 immunoglobulins are in development but not yet active and enrolling participants.

## Proposed Mechanism of Action and Rationale for Use in Patients with COVID-19

Concentrated antibody preparations derived from pooled plasma collected from individuals who have recovered from COVID-19 can be manufactured as SARS-CoV-2 immunoglobulin, which could potentially suppress the virus and modify the inflammatory response. The use of virus-specific immunoglobulins for other viral infections (e.g., cytomegalovirus [CMV] immunoglobulin for the prevention of post-transplant CMV infection and varicella zoster immunoglobulin for postexposure prophylaxis of varicella in individuals at high-risk) has proven to be safe and effective; however, there are currently no clinical data on the use of such products for COVID-19. Potential risks may include transfusion reactions. Theoretical risks may include antibody-dependent enhancement of infection.

## Clinical Data

There are no clinical data on the use of SARS-CoV-2 immunoglobulins for the treatment of COVID-19. Similarly, there are no clinical data on use of specific immunoglobulin or hyperimmunoglobulin products in patients with severe acute respiratory syndrome (SARS) or Middle East respiratory syndrome (MERS).

## Considerations in Pregnancy

Pathogen-specific immunoglobulins are used clinically during pregnancy to prevent varicella zoster virus (VZV) and rabies and have also been used in clinical trials of therapies for congenital CMV infection.

## Considerations in Children

Hyperimmunoglobulin has been used to treat several viral infections in children, including VZV, respiratory syncytial virus, and CMV; efficacy data on their use for other respiratory viruses is limited.

# Table 3c. Characteristics of SARS-CoV-2 Antibody-Based Products Under Evaluation for the Treatment of COVID-19

*Last Updated: April 21, 2021*

- The information in this table is based on data from investigational trials that enrolled people with COVID-19. The table includes dose recommendations from the FDA EUAs for patients with COVID-19 who meet specified criteria.
- There are limited or no data on dose modifications for patients with organ failure or those who require extracorporeal devices. Please refer to product labels, when available.
- There are currently not enough data to determine whether certain medications can be safely coadministered with therapies for the treatment of COVID-19. When using concomitant medications with similar toxicity profiles, consider performing additional safety monitoring.
- The potential additive, antagonistic, or synergistic effects and the safety of using combination therapies for the treatment of COVID-19 are unknown. Clinicians are encouraged to report AEs to the FDA *Medwatch* program.
- For drug interaction information, please refer to product labels and visit the Liverpool COVID-19 Drug Interactions website.
- For the Panel's recommendations for the drugs listed in this table, please refer to the individual drug sections of the Guidelines and Therapeutic Management of Nonhospitalized Adults With COVID-19.

| Dosing Regimens | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|
| **Casirivimab Plus Imdevimab (Anti-SARS-CoV-2 Monoclonal Antibodies)** | | | | |
| **Dose Recommended in EUA for Treatment of COVID-19:**<br>• CAS 600 mg plus IMD 600 mg IV administered together as a single dose. This is the recommended route of administration.<br>• When IV infusion is not feasible or would delay treatment, CAS 600 mg plus IMD 600 mg can be administered as 4 SQ injections (2.5 mL per injection) at 4 different sites. See the FDA EUA for details. | • Hypersensitivity, including anaphylaxis and infusion-related reactions<br>• These AEs were observed over multiple trials where participants received CAS 600 mg plus IMD 600 mg or higher doses. | • Only for administration in health care settings by qualified health care providers who have immediate access to emergency medical services and medications that treat severe infusion reactions.<br>• Monitor patient during the IV infusion or SQ injections and for ≥1 hour after the infusion or injections are completed. | • Drug-drug interactions are unlikely between CAS plus IMD and medications that are renally excreted or that are CYP substrates, inhibitors, or inducers. | **Availability:**<br>• CAS plus IMD is available through the FDA EUA for high-risk outpatients with mild to moderate COVID-19.[1] See Anti-SARS-CoV-2 Monoclonal Antibodies for a list of high-risk conditions.<br>• A list of clinical trials is available: Casirivimab Plus Imdevimab<br>• For information regarding the use of CAS plus IMD for PEP, please refer to the revised FDA EUA. |

| Dosing Regimens | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|
| **Sotrovimab (Anti-SARS-CoV-2 Monoclonal Antibody)** | | | | |
| **Dose Recommended in EUA:**<br>• SOT 500 mg IV | • Rash<br>• Diarrhea<br>• Hypersensitivity, including anaphylaxis and infusion-related reactions | • Only for administration in health care settings by qualified health care providers who have immediate access to emergency medical services and medications that treat severe infusion reactions.<br>• Monitor patient during the IV infusion and for ≥1 hour after the infusion is completed. | • Drug-drug interactions are unlikely between SOT and medications that are renally excreted or that are CYP substrates, inhibitors, or inducers. | **Availability:**<br>• SOT is available through the FDA EUA for high-risk outpatients with mild to moderate COVID-19.[2] See Anti-SARS-CoV-2 Monoclonal Antibodies for a list of high-risk conditions.<br>• A list of clinical trials is available: Sotrovimab |
| **Bamlanivimab Plus Etesevimab (Anti-SARS-CoV-2 Monoclonal Antibodies)** | | | | |
| **Dose Recommended in EUA:**<br>• BAM 700 mg and ETE 1,400 mg IV administered together as a single dose | • Nausea<br>• Dizziness<br>• Pruritis<br>• Hypersensitivity, including anaphylaxis and infusion-related reactions<br>• These AEs were observed over multiple trials where participants received the authorized doses of BAM and ETE or higher doses. | • Only for administration in health care settings by qualified health care providers who have immediate access to emergency medical services and medications to treat severe infusion reactions.<br>• Monitor patient during the IV infusion and for ≥1 hour after the infusion is completed. | • Drug-drug interactions are unlikely between BAM plus ETE and medications that are renally excreted or that are CYP substrates, inhibitors, or inducers. | **Availability:**<br>• The distribution of BAM plus ETE has been paused because the Gamma (P.1) and Beta (B.1.351) VoC are circulating in the United States and both have reduced susceptibility to BAM and ETE.<br>• Updates on the distribution of BAM plus ETE are available from the U.S. Department of Health and Human Services Bamlanivimab/Etesevimab website.<br>• A list of clinical trials is available: Bamlanivimab Plus Etesevimab |

| Dosing Regimens | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|
| **COVID-19 Convalescent Plasma** | | | | |
| **Dose Recommended in EUA:**<br>• Per the EUA, consider starting clinical dosing with 1 high-titer COVID-19 CP unit (about 200 mL), with administration of additional CP units based on the prescribing provider's medical judgment and the patient's clinical response. | • TRALI<br>• TACO<br>• Allergic reactions<br>• Anaphylactic reactions<br>• Febrile nonhemolytic reactions<br>• Hemolytic reactions<br>• Hypothermia<br>• Metabolic complications<br>• Transfusion-transmitted infections[3]<br>• Thrombotic events<br>• Theoretical risk of antibody-mediated enhancement of infection and suppressed long-term immunity | • Before administering CP to patients with a history of severe allergic or anaphylactic transfusion reactions, the Panel recommends consulting a transfusion medicine specialist who is associated with the hospital blood bank.<br>• Monitor for transfusion-related reactions.<br>• Monitor patient's vital signs at baseline and during and after transfusion. | • Drug products **should not be added** to the IV infusion line for the blood product. | • The decision to treat patients aged <18 years with COVID-19 CP should be based on an individualized assessment of risk and benefit.[4]<br>• Patients with impaired cardiac function and heart failure may require a smaller volume of CP or a slower transfusion rate.<br>**Availability:**<br>• High-titer COVID-19 CP is available through the FDA EUA for hospitalized patients with COVID-19.[5] See Convalescent Plasma.<br>• A list of clinical trials is available: COVID-19 Convalescent Plasma |
| **SARS-CoV-2-Specific Immunoglobulin** | | | | |
| Dose varies by clinical trial | • TRALI<br>• TACO<br>• Allergic reactions<br>• Antibody-mediated enhancement of infection<br>• RBC alloimmunization<br>• Transfusion-transmitted infections[3] | • Monitor for transfusion-related reactions.<br>• Monitor patient's vital signs at baseline and during and after transfusion. | • Drug products **should not be added** to the IV infusion line for the blood product. | • A list of clinical trials is available: SARS-CoV-2 Immunoglobulin |

**Key:** AE = adverse event; BAM = bamlanivimab; CAS = casirivimab; CP = convalescent plasma; CYP = cytochrome P450; ETE = etesevimab; EUA = Emergency Use Authorization; FDA = Food and Drug Administration; IMD = imdevimab; IV = intravenous; the Panel = the COVID-19 Treatment Guidelines Panel; PEP = post-exposure prophylaxis; RBC = red blood cell; SOT = sotrovimab; SQ = subcutaneous; TACO = transfusion-associated circulatory overload; TRALI = transfusion-related acute lung injury; VoC = variants of concern

## References


1. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of REGEN-COV (casirivimab and imdevimab). 2021. Available at: https://www.fda.gov/media/145611/download.
2. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of sotrovimab. 2021. Available at: https://www.fda.gov/media/149534/download.
3. Marano G, Vaglio S, Pupella S, et al. Convalescent plasma: new evidence for an old therapeutic tool? *Blood Transfus*. 2016;14(2):152-157. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26674811.
4. Food and Drug Administration. EUA of COVID-19 convalescent plasma for the treatment of COVID-19 in hospitalized patients: fact sheet for health care providers. 2021. Available at: https://www.fda.gov/media/141478/download.
5. Food and Drug Administration. Convalescent Plasma Letter of Authorization. 2021. Available at: https://www.fda.gov/media/141477/download.

# Cell-Based Therapy Under Evaluation for the Treatment of COVID-19

*Last Updated: April 21, 2021*

## Mesenchymal Stem Cells

Mesenchymal stem cells are investigational products that have been studied extensively for broad clinical applications in regenerative medicine[1] and for their immunomodulatory properties.[2] It is hypothesized that mesenchymal stem cells could reduce the acute lung injury and inhibit the cell-mediated inflammatory response induced by SARS-CoV-2.

## Recommendation

- The COVID-19 Treatment Guidelines Panel **recommends against** the use of **mesenchymal stem cells** for the treatment of COVID-19, except in a clinical trial **(AIIb)**.

## Rationale for Recommendation

No mesenchymal stem cells products are approved by the Food and Drug Administration (FDA) for the treatment of COVID-19. There are limited data to date to assess the role of mesenchymal stem cells for the treatment of COVID-19.

The FDA has recently issued several warnings about patients being vulnerable to stem cell treatments that are illegal and potentially harmful.[3] Several umbilical cord blood-derived products are currently licensed by the FDA for indications such as the treatment of cancer (e.g., stem cell transplant) or rare genetic diseases, and as scaffolding for cartilage defects and wound beds. None of these products are approved for the treatment of COVID-19 or any other viral disease.[4] In the United States, mesenchymal stem cells **should not be used** for the treatment of COVID-19 outside of an FDA-approved clinical trial, expanded access program, or an Emergency Investigational New Drug application **(AII)**.

## Rationale for Use in COVID-19

Mesenchymal stem cells are multipotent adult stem cells that are present in most human tissues, including the umbilical cord. Mesenchymal stem cells can self-renew by dividing and can differentiate into multiple types of tissues (including osteoblasts, chondroblasts, adipocytes, hepatocytes, and others), which has led to a robust clinical research agenda in regenerative medicine. It is hypothesized that mesenchymal stem cells could reduce the acute lung injury and inhibit the cell-mediated inflammatory response induced by SARS-CoV-2. Furthermore, because they lack the angiotensin-converting enzyme 2 (ACE2) receptor that SARS-CoV-2 uses for viral entry into cells, mesenchymal stem cells are resistant to infection.[5,6]

## Clinical Data

Data supporting the use of mesenchymal stem cells in patients who have viral infections, including SARS-CoV-2 infection, are limited to case reports and small, open-label studies.

### *Clinical Data for COVID-19*

A pilot study of intravenous mesenchymal stem cell transplantation in China enrolled 10 patients with confirmed COVID-19 categorized according to the National Health Commission of China criteria as critical, severe, or common type. Seven patients (one with critical illness, four with severe illness, and two with common-type illness) received mesenchymal stem cells; three patients with severe illness

received placebo. All seven patients who received mesenchymal stem cells recovered. Among the three severely ill placebo-treated patients, one died, one developed acute respiratory distress syndrome (ARDS), and one remained stable with severe disease.[7]

A small clinical trial evaluated human umbilical cord mesenchymal stem cell (hUC-MSC) infusion in patients with severe COVID-19 who had not responded to standard of care therapies after 7 to 10 days of treatment. The standard of care therapies included supplemental oxygen, umifenovir/oseltamivir, antibiotics if indicated, and glucocorticoids. The study was intended as a randomized controlled trial; however, due to the lack of sufficient hUC-MSCs, it was not possible to randomize the participants as originally planned. Among the 41 patients eligible to participate in the study, 12 received hUC-MSC infusion and 29 received standard of care therapies only. The study arms were well balanced with regard to demographic characteristics, laboratory test results, and disease severity. All 12 participants who received hUC-MSC infusion recovered without requiring mechanical ventilation and were discharged to home. Four patients who received only standard of care therapies progressed to critical illness requiring mechanical ventilation; three of these patients died. These results are not statistically significant, and interpretation of the findings is limited by the study's lack of randomization and small sample size.[8]

A double-blind randomized controlled trial investigated the safety and efficacy of hUC-MSC infusions in patients with COVID-19 ARDS. Twenty-four patients were randomized to receive either two infusions of hUC-MSC (prepared at a single site) or placebo on Day 0 and Day 3. The primary endpoints were occurrence of prespecified infusion-associated adverse events within 6 hours of each hUC-MSC infusion; cardiac arrest or death within 24 hours after an infusion; and the incidence of adverse events. Secondary endpoints included survival at 31 days after hUC-MSC infusion and time to recovery.[9]

There were no differences between the arms in the primary safety analysis; however, more deaths occurred in the placebo arm (7 deaths) than in the hUC-MSC arm (2 deaths) by Day 31. Data for one participant in the hUC-MSC arm who died due to a failed intubation was censored from the analysis. Time to recovery was shorter in the hUC-MSC arm than in the placebo arm (HR 0.29; 95% CI, 0.09–0.95). Interpretation of these results is limited by the small sample size and a change in an eligibility criterion from enrolling only individuals on invasive mechanical ventilation to including those receiving high-flow oxygen or on noninvasive ventilation.

### *Clinical Data for Other Viral Infections*

In an open-label study of mesenchymal stem cells for the treatment of H7N9 influenza in China, 17 patients received mesenchymal stem cell treatment plus standard of care, and 44 patients received standard of care only. Three patients (17.6%) in the mesenchymal stem cell arm died versus 24 patients (54.5%) in the standard of care arm. The 5-year follow-up was limited to five patients in the mesenchymal stem cell arm. No safety concerns were identified.[10]

## Clinical Trials

See *ClinicalTrials.gov* for a list of clinical trials evaluating mesenchymal stem cells for the treatment of COVID-19, COVID-19-related ARDS, and COVID-19-associated multisystem inflammatory syndrome in children (MIS-C).

## Adverse Effects

Risks associated with mesenchymal stem cell transfusion appear to be uncommon. The potential risks include the potential for mesenchymal stem cells to multiply or change into inappropriate cell types, product contamination, growth of tumors, infections, thrombus formation, and administration site reactions.[11]

## Considerations in Pregnancy

There are insufficient data to assess the risk of using mesenchymal stem cell therapy during pregnancy.

## Considerations in Children

There are insufficient data to assess the efficacy and safety of using mesenchymal stem cell therapy in children.

## References


1. Samsonraj RM, Raghunath M, Nurcombe V, Hui JH, van Wijnen AJ, Cool SM. Concise review: multifaceted characterization of human mesenchymal stem cells for use in regenerative medicine. *Stem Cells Transl Med*. 2017;6(12):2173-2185. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29076267.
2. Li N,Hua J. Interactions between mesenchymal stem cells and the immune system. *Cell Mol Life Sci*. 2017;74(13):2345-2360. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28214990.
3. Food and Drug Administration. FDA warns about stem cell therapies. 2019. Available at: https://www.fda.gov/consumers/consumer-updates/fda-warns-about-stem-cell-therapies. Accessed January 26, 2021.
4. Food and Drug Administration. Approved cellular and gene therapy products. 2019. Available at: https://www.fda.gov/vaccines-blood-biologics/cellular-gene-therapy-products/approved-cellular-and-gene-therapy-products. Accessed January 26, 2021.
5. Lukomska B, Stanaszek L, Zuba-Surma E, Legosz P, Sarzynska S,Drela K. Challenges and controversies in human mesenchymal stem cell therapy. *Stem Cells Int*. 2019;2019:9628536. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31093291.
6. Shetty AK. Mesenchymal stem cell infusion shows promise for combating coronavirus (COVID-19)-induced pneumonia. *Aging Dis*. 2020;11(2):462-464. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32257554.
7. Leng Z, Zhu R, Hou W, et al. Transplantation of ACE2(-) mesenchymal stem cells improves the outcome of patients with COVID-19 pneumonia. *Aging Dis*. 2020;11(2):216-228. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32257537.
8. Shu L, Niu C, Li R, et al. Treatment of severe COVID-19 with human umbilical cord mesenchymal stem cells. *Stem Cell Res Ther*. 2020;11(1):361. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32811531.
9. Lanzoni G, Linetsky E, Correa D, et al. Umbilical cord mesenchymal stem cells for COVID-19 acute respiratory distress syndrome: A double-blind, Phase 1/2a, randomized controlled trial. *Stem Cells Transl Med*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33400390.
10. Chen J, Hu C, Chen L, et al. Clinical study of mesenchymal stem cell treating acute respiratory distress syndrome induced by epidemic Influenza A (H7N9) infection, a hint for COVID-19 treatment. *Engineering (Beijing)*. 2020;6(10):1153-1161. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32292627.
11. Centers for Disease Control and Prevention. Stem cell and exosome products. 2019. Available at: https://www.cdc.gov/hai/outbreaks/stem-cell-products.html. Accessed January 26, 2021.

# Immunomodulators Under Evaluation for the Treatment of COVID-19

*Last Updated: August 4, 2021*

| Summary Recommendations |
|---|
| See Therapeutic Management of Hospitalized Adults with COVID-19 for the COVID-19 Treatment Guidelines Panel's (the Panel) recommendations on the use of the following immunomodulators for patients according to their disease severity:<br>• Baricitinib with dexamethasone<br>• Dexamethasone<br>• Tocilizumab with dexamethasone<br><br>**Additional Recommendations**<br>There is insufficient evidence for the Panel to recommend either for or against the use of the following immunomodulators for the treatment of COVID-19:<br>• Colchicine for nonhospitalized patients<br>• Fluvoxamine<br>• Granulocyte-macrophage colony-stimulating factor inhibitors for hospitalized patients<br>• Inhaled budesonide<br>• Interleukin (IL)-1 inhibitors (e.g., anakinra)<br>• Interferon beta for the treatment of early (i.e., <7 days from symptom onset) mild to moderate COVID-19<br>• Sarilumab for patients who are within 24 hours of admission to the intensive care unit (ICU) and who require invasive mechanical ventilation, noninvasive ventilation, or high-flow oxygen (>0.4 $FiO_2$/30 L/min of oxygen flow)<br><br>The Panel **recommends against** the use of the following immunomodulators for the treatment of COVID-19, except in a clinical trial:<br>• **Baricitinib** with **tocilizumab (AIII)**<br>• **Interferons (alfa or beta)** for the treatment of severely or critically ill patients with COVID-19 **(AIII)**<br>• Kinase inhibitors:<br>  • Bruton's tyrosine kinase inhibitors (e.g., **acalabrutinib**, **ibrutinib**, **zanubrutinib**) **(AIII)**<br>  • Janus kinase inhibitors other than baricitinib (e.g., **ruxolitinib**, **tofacitinib**) **(AIII)**<br>• **Non-SARS-CoV-2-specific intravenous immunoglobulin (IVIG) (AIII)**. This recommendation should not preclude the use of IVIG when it is otherwise indicated for the treatment of complications that arise during the course of COVID-19.<br>• **Sarilumab** for patients who do not require ICU-level care or who are admitted to the ICU for >24 hours but do not require invasive mechanical ventilation, noninvasive ventilation, or high-flow oxygen **(BIIa)**<br>• The anti-IL-6 monoclonal antibody siltuximab **(BIII)**<br><br>The Panel **recommends against** using **colchicine** for the treatment of COVID-19 in hospitalized patients **(AI)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence: I** = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

# Colchicine

*Last Updated: July 8, 2021*

Colchicine is an anti-inflammatory drug that is used to treat a variety of conditions, including gout, recurrent pericarditis, and familial Mediterranean fever.[1] Recently, the drug has been shown to potentially reduce the risk of cardiovascular events in those with coronary artery disease.[2] Colchicine has several potential mechanisms of action, including mechanisms that reduce the chemotaxis of neutrophils, inhibit inflammasome signaling, and decrease the production of cytokines such as interleukin-1 beta.[3] When colchicine is administered early in the course of COVID-19, these mechanisms may mitigate or prevent inflammation-associated manifestations of the disease. These anti-inflammatory properties (as well as the drug's limited immunosuppressive potential, widespread availability, and favorable safety profile) have prompted investigation of colchicine for the treatment of COVID-19.

## Recommendations

- There is insufficient evidence for the COVID-19 Treatment Guidelines Panel (the Panel) to recommend either for or against the use of colchicine for the treatment of nonhospitalized patients with COVID-19.
- The Panel **recommends against** the use of colchicine for the treatment of hospitalized patients with COVID-19 **(AI)**.

## Rationale

### *For Nonhospitalized Patients With COVID-19*

A large randomized trial evaluating colchicine in outpatients with COVID-19 (COLCORONA) did not reach its primary efficacy endpoint of reducing hospitalizations and death. However, a slight reduction in hospitalizations was observed in the subset of patients whose diagnosis was confirmed by a positive SARS-CoV-2 polymerase chain reaction (PCR) result from a nasopharyngeal (NP) swab. Given that the trial did not reach its primary endpoint, only a very modest effect size was demonstrated in the subgroup of PCR-positive patients, and more gastrointestinal adverse events occurred in the colchicine arm than in the usual care arm, the Panel felt that additional evidence is needed to develop recommendations on using colchicine for the treatment of nonhospitalized patients with COVID-19.[4]

### *For Hospitalized Patients With COVID-19*

In a randomized trial in hospitalized patients with COVID-19 (RECOVERY), colchicine demonstrated no benefit with regards to 28-day mortality or any secondary outcomes.[5] COLCORONA and RECOVERY are described more fully below.

## Clinical Data for COVID-19

### *Colchicine in Nonhospitalized Patients With COVID-19: The COLCORONA Trial*

COLCORONA was a contactless, double-blind, placebo-controlled randomized trial in outpatients who were diagnosed with COVID-19 within 24 hours of enrollment. Participants had to have at least one risk factor for COVID-19 complications, including age ≥70 years, body mass index ≥30, diabetes mellitus, uncontrolled hypertension, known respiratory disease, heart failure or coronary disease, fever ≥38.4°C within the last 48 hours, dyspnea at presentation, bicytopenia, pancytopenia, or the combination of high neutrophil count and low lymphocyte count. Participants were randomized 1:1 to receive colchicine 0.5 mg twice daily for 3 days and then once daily for 27 days or placebo. The primary endpoint was a composite of death or hospitalization by Day 30; secondary endpoints included components of the

primary endpoint, as well as the need for mechanical ventilation by Day 30. Given the contactless design of the study, outcomes were ascertained by participant self-report via telephone at 15 and 30 days after randomization; in some cases, clinical data were confirmed by medical chart reviews.[4]

#### Results

- The study enrolled 4,488 participants.
- The primary endpoint occurred in 104 of 2,235 participants (4.7%) in the colchicine arm and 131 of 2,253 participants (5.8%) in the placebo arm (OR 0.79; 95% CI, 0.61–1.03; $P = 0.08$).
- There were no statistically significant differences in the secondary outcomes between the arms.
- In a prespecified analysis of 4,159 participants who had a SARS-CoV-2 diagnosis confirmed by PCR testing of an NP specimen (93% of those enrolled), those in the colchicine arm were less likely to reach the primary endpoint (96 of 2,075 participants [4.6%]) than those in the placebo arm (126 of 2,084 participants [6.0%]; OR 0.75; 95% CI, 0.57–0.99; $P = 0.04$). In this subgroup of patients with PCR-confirmed SARS-CoV-2 infection, there were fewer hospitalizations (a secondary outcome) in the colchicine arm (4.5% of patients) than in the placebo arm (5.9% of patients; OR 0.75; 95% CI, 0.57–0.99).
- More gastrointestinal adverse events occurred in the colchicine arm, including diarrhea (occurred in 13.7% of patients vs. in 7.3% of patients in the placebo arm; $P < 0.0001$). Unexpectedly, more pulmonary emboli were reported in the colchicine arm than in the placebo arm (11 events [0.5% of patients] vs. 2 events [0.1% of patients]; $P = 0.01$).

#### Limitations

- Due to logistical difficulties with staffing, the trial was stopped at approximately 75% of the target enrollment, which may have limited the study's power to detect differences for the primary outcome.
- There was uncertainty as to the accuracy of COVID-19 diagnoses in presumptive cases.
- Some patient-reported clinical outcomes were potentially misclassified.

### *Colchicine in Hospitalized Patients With COVID-19: The RECOVERY Trial*

*This study has not been peer reviewed.*

RECOVERY randomized hospitalized patients with COVID-19 to receive colchicine (1 mg loading dose, followed by 0.5 mg 12 hours later, and then 0.5 mg twice daily for 9 days or until discharge) or usual care.[5]

#### Results

- The study enrolled 11,340 participants.
- At randomization, 10,603 patients (94%) were receiving corticosteroids.
- The primary endpoint of all-cause mortality at Day 28 occurred in 1,173 of 5,610 participants (21%) in the colchicine arm and 1,190 of 5,730 participants (21%) in the placebo arm (rate ratio 1.01; 95% CI, 0.93–1.10; $P = 0.77$).
- There were no statistically significant differences between the arms for the secondary outcomes of median time to being discharged alive, discharge from the hospital within 28 days, and receipt of invasive mechanical ventilation or death.
- The incidence of new cardiac arrhythmias, bleeding events, and thrombotic events was similar in the two arms. Two serious adverse events were attributed to colchicine: one case of severe acute kidney injury and one case of rhabdomyolysis.

#### Limitations

- The trial's open-label design may have introduced bias for assessing some of the secondary endpoints.

### *Study of the Effects of Colchicine in Hospitalized Patients With COVID-19: The GRECCO-19 Trial*

GRECCO-19 was a small, prospective, open-label randomized clinical trial in 105 patients hospitalized with COVID-19 across 16 hospitals in Greece. Patients were assigned 1:1 to receive standard of care with colchicine (1.5 mg loading dose, followed by 0.5 mg after 60 minutes and then 0.5 mg twice daily until hospital discharge or for up to 3 weeks) or standard of care alone.[6]

#### Results

- Fewer patients in the colchicine arm (1 of 55 patients) than in the standard of care arm (7 of 50 patients) reached the primary clinical endpoint of deterioration in clinical status from baseline by two points on a seven-point clinical status scale (OR 0.11; 95% CI, 0.01–0.96).
- Participants in the colchicine group were significantly more likely to experience diarrhea (occurred in 45.5% vs. 18.0% of participants in the colchicine and standard of care arms, respectively; $P = 0.003$).

#### Limitations

- The overall sample size and the number of clinical events reported were small.
- The study design was open-label treatment assignment.

The results of several small randomized trials and retrospective cohort studies that have evaluated various doses and durations of colchicine in hospitalized patients with COVID-19 have been published in peer-reviewed journals or made available as preliminary, non-peer-reviewed reports.[7-10] Some have shown benefits of colchicine use, including less need for supplemental oxygen, improvements in clinical status on an ordinal clinical scale, and reductions in certain inflammatory markers. In addition, some studies have reported higher discharge rates or fewer deaths among patients who received colchicine than among those who received comparator drugs or placebo. However, the ability to interpret the findings of these studies is also constrained by significant design or methodological limitations, including small sample size, open-label designs, and differences in the clinical and demographic characteristics of participants and permitted use of various cotreatments (e.g., remdesivir, corticosteroids) in the treatment arms.

## Adverse Effects, Monitoring, and Drug-Drug Interactions

Common adverse effects of colchicine include diarrhea, nausea, vomiting, abdominal cramping and pain, bloating, and loss of appetite. In rare cases, colchicine is associated with serious adverse events, such as neuromyotoxicity and blood dyscrasias. Use of colchicine should be avoided in patients with severe renal insufficiency, and patients with moderate renal insufficiency who receive the drug should be monitored for adverse effects. Caution should be used when colchicine is coadministered with drugs that inhibit cytochrome P450 (CYP) 3A4 and/or P-glycoprotein (P-gp) because such use may increase the risk of colchicine-induced adverse effects due to significant increases in colchicine plasma levels. The risk of myopathy may be increased with the concomitant use of certain HMG-CoA reductase inhibitors (e.g., atorvastatin, lovastatin, simvastatin) due to potential competitive interactions mediated by CYP3A4 and P-gp pathways.[11,12] Fatal colchicine toxicity has been reported in individuals with renal or hepatic impairment who received colchicine in conjunction with P-gp inhibitors or strong CYP3A4 inhibitors.

## Considerations in Pregnancy

There are limited data on the use of colchicine in pregnancy. Fetal risk cannot be ruled out based on data from animal studies and the drug's mechanism of action. Colchicine crosses the placenta and has

antimitotic properties, which raises a theoretical concern for teratogenicity. However, a recent meta-analysis did not find that colchicine exposure during pregnancy increased the rates of miscarriage or major fetal malformations. There are no data for colchicine use in pregnant women with acute COVID-19. Risks of use should be balanced against potential benefits.[11,13]

## Considerations in Children

Colchicine use in children is limited to the treatment of periodic fever syndromes, primarily familial Mediterranean fever. There are no data on the use of colchicine to treat pediatric acute COVID-19 or multisystem inflammatory syndrome in children (MIS-C).

## References


1. van Echteld I, Wechalekar MD, Schlesinger N, Buchbinder R, Aletaha D. Colchicine for acute gout. *Cochrane Database Syst Rev*. 2014(8):CD006190. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25123076.
2. Xia M, Yang X, Qian C. Meta-analysis evaluating the utility of colchicine in secondary prevention of coronary artery disease. *Am J Cardiol*. 2021;140:33-38. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33137319.
3. Reyes AZ, Hu KA, Teperman J, et al. Anti-inflammatory therapy for COVID-19 infection: the case for colchicine. *Ann Rheum Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33293273.
4. Tardif JC, Bouabdallaoui N, L'Allier PL, et al. Efficacy of colchicine in non-hospitalized patients with COVID-19. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.01.26.21250494v1.
5. RECOVERY Collaborative Group, Horby PW, Campbell M, et al. Colchicine in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.05.18.21257267v1.full.
6. Deftereos SG, Giannopoulos G, Vrachatis DA, et al. Effect of colchicine vs standard care on cardiac and inflammatory biomarkers and clinical outcomes in patients hospitalized with coronavirus disease 2019: the GRECCO-19 randomized clinical trial. *JAMA Netw Open*. 2020;3(6):e2013136. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32579195.
7. Brunetti L, Diawara O, Tsai A, et al. Colchicine to weather the cytokine storm in hospitalized patients with COVID-19. *J Clin Med*. 2020;9(9). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32937800.
8. Sandhu T, Tieng A, Chilimuri S, Franchin G. A case control study to evaluate the impact of colchicine on patients admitted to the hospital with moderate to severe COVID-19 infection. *Can J Infect Dis Med Microbiol*. 2020;2020:8865954. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33133323.
9. Lopes MI, Bonjorno LP, Giannini MC, et al. Beneficial effects of colchicine for moderate to severe COVID-19: a randomised, double-blinded, placebo-controlled clinical trial. *RMD Open*. 2021;7(1). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33542047.
10. Salehzadeh F, Pourfarzi F, Ataei S. The impact of colchicine on the COVID-19 patients; a clinical trial. *Research Square*. 2020;Preprint. Available at: https://www.researchsquare.com/article/rs-69374/v1.
11. Colchicine (colcrys) [package insert]. Food and Drug Administration. 2012. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2014/022352s017lbl.pdf.
12. American College of Cardiology. AHA statement on drug-drug interactions with statins. 2016. Available at: https://www.acc.org/latest-in-cardiology/ten-points-to-remember/2016/10/20/21/53/recommendations-for-management-of-clinically-significant-drug. Accessed June 24, 2021.
13. Indraratna PL, Virk S, Gurram D, Day RO. Use of colchicine in pregnancy: a systematic review and meta-analysis. *Rheumatology (Oxford)*. 2018;57(2):382-387. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29029311.

# Corticosteroids

*Last Updated: August 4, 2021*

Patients with severe COVID-19 can develop a systemic inflammatory response that can lead to lung injury and multisystem organ dysfunction. It has been proposed that the potent anti-inflammatory effects of corticosteroids might prevent or mitigate these deleterious effects.

Both beneficial and deleterious clinical outcomes have been reported with use of corticosteroids (mostly prednisone or methylprednisolone) in patients with pulmonary infections. In patients with *Pneumocystis jirovecii* pneumonia and hypoxemia, prednisone therapy reduced the risk of death.[1] However, in outbreaks of previous novel coronavirus infections (i.e., Middle East respiratory syndrome [MERS] and severe acute respiratory syndrome [SARS]), corticosteroid therapy was associated with delayed virus clearance.[2,3] In severe pneumonia caused by influenza viruses, corticosteroid therapy appears to result in worse clinical outcomes, including secondary bacterial infection and death.[4]

Corticosteroids have also been studied in critically ill patients with acute respiratory distress syndrome (ARDS) with conflicting results.[5-7] Use of corticosteroids in patients with ARDS was evaluated in seven randomized controlled trials that included a total of 851 patients.[6-12] A meta-analysis of these trial results demonstrated that, compared with placebo, corticosteroid therapy reduced the risk of all-cause mortality (risk ratio 0.75; 95% CI, 0.59–0.95) and duration of mechanical ventilation (mean difference -4.93 days; 95% CI, -7.81 to -2.06 days).[13,14]

## The COVID-19 Treatment Guidelines Panel's Recommendations for the Use of Corticosteroids in Patients with COVID-19

For nonhospitalized patients with COVID-19:

- See Therapeutic Management of Nonhospitalized Adults with COVID-19 for the COVID-19 Treatment Guidelines Panel's (the Panel) recommendations on the use of dexamethasone or other systemic corticosteroids in certain nonhospitalized patients.
- There is insufficient evidence for the Panel to recommend either for or against the use of inhaled budesonide for the treatment of COVID-19.

For hospitalized patients with COVID-19:

- See Therapeutic Management of Hospitalized Adults with COVID-19 for the Panel's recommendations on the use of dexamethasone or other systemic corticosteroids in certain hospitalized patients.

## Rationale for Use of Corticosteroids in Patients With COVID-19

Recommendations on the use of corticosteroids for COVID-19 in nonhospitalized patients reflect a lack of data in this population. In the RECOVERY trial (described below), dexamethasone was shown to reduce mortality in hospitalized patients with COVID-19 who required supplemental oxygen. In this trial, dexamethasone was stopped at the time of hospital discharge. However, nonhospitalized patients were not included in the RECOVERY trial; thus, the safety and efficacy of corticosteroids in this population have not been established. Moreover, the use of corticosteroids can lead to adverse events (e.g., hyperglycemia, neuropsychiatric symptoms, secondary infections), which may be difficult to detect and monitor in an outpatient setting (see General Management of Nonhospitalized Patients With Acute COVID-19 for further information).

Recommendations on the use of corticosteroids for COVID-19 in hospitalized patients are largely based on data from the RECOVERY trial, a large, multicenter, open-label randomized trial performed in the United Kingdom. This trial randomized 6,425 hospitalized patients to receive up to 10 days of dexamethasone or standard of care. Mortality at 28 days was lower among the patients who received dexamethasone than among those who received the standard of care.[15] This benefit was observed in patients who were mechanically ventilated or required supplemental oxygen at enrollment. No benefit of dexamethasone was seen in patients who did not require supplemental oxygen at enrollment. Details from the RECOVERY trial are discussed in Table 4a.[15]

Systemic corticosteroids used in combination with other agents including antivirals and immunomodulators such as tocilizumab (see Interleukin-6 Inhibitors)[16,17] or baricitinib (see Kinase Inhibitors)[18] have demonstrated clinical benefit in subsets of hospitalized patients with COVID-19.

Systemic corticosteroids used in various formulations and doses for varying durations have been studied in patients with COVID-19 in several smaller randomized controlled trials.[19-23] Some of these trials were stopped early due to under enrollment following the release of the results from the RECOVERY trial. Consequently, the sample size of many these trials was insufficient to assess efficacy, and therefore evidence to support the use of methylprednisolone and hydrocortisone for the treatment of COVID-19 is not as strong as that demonstrated for dexamethasone in the RECOVERY trial.

Please see Tables 4a and 4b for data from clinical trials on corticosteroid use for COVID-19.

## Systemic Corticosteroids Other Than Dexamethasone

- If dexamethasone is not available, alternative glucocorticoids (e.g., prednisone, methylprednisolone, hydrocortisone) can be used.
- For these drugs, the total daily dose equivalencies to dexamethasone 6 mg (oral or intravenous)[24] are:
  - Prednisone 40 mg
  - Methylprednisolone 32 mg
  - Hydrocortisone 160 mg
- Half-life, duration of action, and frequency of administration vary among corticosteroids.
  - *Long-acting corticosteroid:* Dexamethasone; half-life 36 to 72 hours, administer once daily.
  - *Intermediate-acting corticosteroids:* Prednisone and methylprednisolone; half-life 12 to 36 hours, administer once daily or in two divided doses daily.
  - *Short-acting corticosteroid:* Hydrocortisone; half-life 8 to 12 hours, administer in two to four divided doses daily.
- Hydrocortisone is commonly used to manage septic shock in patients with COVID-19; see Hemodynamics for more information. Unlike other corticosteroids previously studied in patients with ARDS, dexamethasone lacks mineralocorticoid activity and thus has minimal effect on sodium balance and fluid volume.[9]

## Inhaled Corticosteroids

Budesonide is a synthetic, inhaled corticosteroid with potent glucocorticoid activity and weak mineralocorticoid activity. It has broad anti-inflammatory properties and has Food and Drug Administration-labeled indications in the management of chronic respiratory diseases including asthma and chronic obstructive pulmonary disease. Certain inhaled corticosteroids have been shown to impair

viral replication of SARS-CoV-2[25] and downregulate expression of the receptors used for cell entry.[26,27] These mechanisms support the potential of inhaled corticosteroids as therapeutic agents for COVID-19. However, observational studies of individuals who were chronic inhaled corticosteroid users have found that its use either had no effect on COVID-19 outcomes or increased risk of hospitalization.[28,29]

### *Recommendation*

There is insufficient evidence for the Panel to recommend either for or against the use of inhaled budesonide for the treatment of COVID-19.

### *Rationale*

Inhaled budesonide was studied in two open-label trials in outpatients with mild symptoms of COVID-19 (see Table 4b).[30,31] Results of these trials suggest that in adult outpatients with mild COVID-19, initiation of inhaled budesonide may reduce the need for urgent care or emergency department assessment or hospitalization and reduce time to recovery. The findings from these trials should be interpreted with caution given the open-label design of the studies, incomplete data, and other limitations. Additional trials of inhaled corticosteroids are ongoing.

## Monitoring, Adverse Effects, and Drug-Drug Interactions

- Clinicians should closely monitor patients with COVID-19 who are receiving dexamethasone for adverse effects (e.g., hyperglycemia, secondary infections, psychiatric effects, avascular necrosis).
- The use of systemic corticosteroids may increase the risk of opportunistic fungal infections (e.g., mucormycosis, aspergillosis) and reactivation of latent infections (e.g., hepatitis B virus [HBV], herpesvirus infections, strongyloidiasis, tuberculosis).[32-35] When initiating dexamethasone, clinicians should consider appropriate screening and treatment to reduce the risk of *Strongyloides* hyperinfection in patients at high risk of strongyloidiasis (e.g., patients from tropical, subtropical, or warm, temperate regions or those engaged in agricultural activities)[36-38] or fulminant reactivations of HBV.[39]
- Combining systemic corticosteroids with other immunosuppressants, such as tocilizumab or baricitinib, could theoretically increase the risk of secondary infections. However, this adverse effect has not been reported in clinical trials to date.
- Dexamethasone is a moderate cytochrome P450 (CYP) 3A4 inducer. As such, it may reduce the concentration and potential efficacy of concomitant medications that are CYP3A4 substrates. Clinicians should review a patient's medication regimen to assess potential interactions.
- Dexamethasone should be continued for up to 10 days or until hospital discharge, whichever comes first (see Therapeutic Management of Hospitalized Adults With COVID-19).

## Considerations in Pregnancy

A short course of betamethasone and dexamethasone, which are known to cross the placenta, is routinely used to decrease neonatal complications of prematurity in women with threatened preterm delivery.[40,41]

Given the potential benefit of decreased maternal mortality and the low risk of fetal adverse effects for a short course of dexamethasone therapy, the Panel recommends using **dexamethasone** in hospitalized pregnant patients with COVID-19 who are mechanically ventilated **(AIII)** or who require supplemental oxygen but who are not mechanically ventilated **(BIII)**.

## Considerations in Children

The safety and effectiveness of dexamethasone or other corticosteroids for COVID-19 treatment have not been sufficiently evaluated in pediatric patients and caution is warranted when extrapolating recommendations for adults to patients aged <18 years. The Panel recommends using **dexamethasone** for children with COVID-19 who require high-flow oxygen, noninvasive ventilation, invasive mechanical ventilation, or extracorporeal membrane oxygenation **(BIII)**. Corticosteroids are not routinely recommended for pediatric patients who require only low levels of oxygen support (i.e., administered via a nasal cannula only). Use of dexamethasone for the treatment of severe COVID-19 in children who are profoundly immunocompromised has not been evaluated and may be harmful; therefore, such use should be considered only on a case-by-case basis. The dexamethasone dosing regimen for pediatric patients is dexamethasone 0.15 mg/kg/dose (maximum dose 6 mg) once daily for up to 10 days. Corticosteroid use has been described in the treatment of multisystem inflammatory syndrome in children (MIS-C) in multiple case series. It is the second most used therapy after intravenous immunoglobulin for MIS-C.[42,43] Please refer to Special Considerations in Children for more information on the management of MIS-C.

## Clinical Trials

Several clinical trials evaluating corticosteroids for the treatment of COVID-19 are currently underway or in development. Please see *ClinicalTrials.gov* for the latest information.

## References


1. Bozzette SA, Sattler FR, Chiu J, et al. A controlled trial of early adjunctive treatment with corticosteroids for Pneumocystis carinii pneumonia in the acquired immunodeficiency syndrome. California Collaborative Treatment Group. *N Engl J Med*. 1990;323(21):1451-1457. Available at: https://www.ncbi.nlm.nih.gov/pubmed/2233917.
2. Arabi YM, Mandourah Y, Al-Hameed F, et al. Corticosteroid therapy for critically ill patients with Middle East respiratory syndrome. *Am J Respir Crit Care Med*. 2018;197(6):757-767. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29161116.
3. Stockman LJ, Bellamy R, Garner P. SARS: systematic review of treatment effects. *PLoS Med*. 2006;3(9):e343. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16968120.
4. Rodrigo C, Leonardi-Bee J, Nguyen-Van-Tam J, Lim WS. Corticosteroids as adjunctive therapy in the treatment of influenza. *Cochrane Database Syst Rev*. 2016;3:CD010406. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26950335.
5. Meduri GU, Bridges L, Shih MC, Marik PE, Siemieniuk RAC, Kocak M. Prolonged glucocorticoid treatment is associated with improved ARDS outcomes: analysis of individual patients' data from four randomized trials and trial-level meta-analysis of the updated literature. *Intensive Care Med*. 2016;42(5):829-840. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26508525.
6. Meduri GU, Golden E, Freire AX, et al. Methylprednisolone infusion in early severe ARDS: results of a randomized controlled trial. *Chest*. 2007;131(4):954-963. Available at: https://www.ncbi.nlm.nih.gov/pubmed/17426195.
7. Steinberg KP, Hudson LD, Goodman RB, et al. Efficacy and safety of corticosteroids for persistent acute respiratory distress syndrome. *N Engl J Med*. 2006;354(16):1671-1684. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16625008.
8. Liu L, Li J, Huang YZ, et al. The effect of stress dose glucocorticoid on patients with acute respiratory distress syndrome combined with critical illness-related corticosteroid insufficiency. *Zhonghua Nei Ke Za Zhi*. 2012;51(8):599-603. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23158856.
9. Villar J, Ferrando C, Martinez D, et al. Dexamethasone treatment for the acute respiratory distress syndrome: a

multicentre, randomised controlled trial. *Lancet Respir Med*. 2020;8(3):267-276. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32043986.

10. Rezk NA, Ibrahim AM. Effects of methyl prednisolone in early ARDS. *Egyptian Journal of Chest Diseases and Tuberculosis*. 2013;62(1):167-172. Available at: https://www.sciencedirect.com/science/article/pii/S0422763813000265.
11. Tongyoo S, Permpikul C, Mongkolpun W, et al. Hydrocortisone treatment in early sepsis-associated acute respiratory distress syndrome: results of a randomized controlled trial. *Crit Care*. 2016;20(1):329. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27741949.
12. Zhao WB, Wan SX, Gu DF, Shi B. Therapeutic effect of glucocorticoid inhalation for pulmonary fibrosis in ARDS patients. *Medical Journal of Chinese People's Liberation Army*. 2014;39(9):741-745. Available at: http://www.plamj.org/index.php/plamj/article/view/1009.
13. Mammen MJ, Aryal K, Alhazzani W, Alexander PE. Corticosteroids for patients with acute respiratory distress syndrome: a systematic review and meta-analysis of randomized trials. *Pol Arch Intern Med*. 2020;130(4):276-286. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32186831.
14. Alhazzani W, Moller MH, Arabi YM, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). *Crit Care Med*. 2020;48(6):e440-e469. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32224769.
15. RECOVERY Collaborative Group, Horby P, Lim WS, et al. Dexamethasone in hospitalized patients with COVID-19—preliminary report. *N Engl J Med*. 2021;384(8):693-704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32678530.
16. RECOVERY Collaborative Group. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *Lancet*. 2021;397(10285):1637-1645. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33933206.
17. REMAP-CAP Investigators, Gordon AC, Mouncey PR, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19. *N Engl J Med*. 2021;384(16):1491-1502. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33631065.
18. Marconi VC, Ramanan AV, de Bono S, et al. Baricitinib plus standard of care for hospitalized adults with COVID-19. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.30.21255934v1.
19. Jeronimo CMP, Farias MEL, Val FFA, et al. Methylprednisolone as adjunctive therapy for patients hospitalized with coronavirus disease 2019 (COVID-19; Metcovid): a randomized, double-blind, Phase IIb, placebo-controlled trial. *Clin Infect Dis*. 2021 May 4;72(9):e373-e381. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32785710.
20. Tomazini BM, Maia IS, Cavalcanti AB, et al. Effect of dexamethasone on days alive and ventilator-free in patients with moderate or severe acute respiratory distress syndrome and COVID-19: the CoDEX randomized clinical trial. *JAMA*. 2020;324(13):1307-1316. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876695.
21. Dequin PF, Heming N, Meziani F, et al. Effect of hydrocortisone on 21-day mortality or respiratory support among critically ill patients with COVID-19: a randomized clinical trial. *JAMA*. 2020;324(13):1298-1306. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876689.
22. Angus DC, Derde L, Al-Beidh F, et al. Effect of hydrocortisone on mortality and organ support in patients with severe COVID-19: the REMAP-CAP COVID-19 corticosteroid domain randomized clinical trial. *JAMA*. 2020;324(13):1317-1329. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876697.
23. WHO Rapid Evidence Appraisal for COVID-19 Therapies Working Group, Sterne JAC, Murthy S, et al. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. *JAMA*. 2020;324(13):1330-1341. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876694.
24. Czock D, Keller F, Rasche FM, Haussler U. Pharmacokinetics and pharmacodynamics of systemically administered glucocorticoids. *Clin Pharmacokinet*. 2005;44(1):61-98. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/15634032.

25. Matsuyama S, Kawase M, Nao N, et al. The inhaled steroid ciclesonide blocks SARS-CoV-2 RNA replication by targeting the viral replication-transcription complex in cultured cells. *J Virol*. 2020;95(1). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33055254.
26. Finney LJ, Glanville N, Farne H, et al. Inhaled corticosteroids downregulate the SARS-CoV-2 receptor ACE2 in COPD through suppression of type I interferon. *J Allergy Clin Immunol*. 2021;147(2):510-519 e515. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33068560.
27. Peters MC, Sajuthi S, Deford P, et al. COVID-19-related genes in sputum cells in asthma. Relationship to demographic features and corticosteroids. *Am J Respir Crit Care Med*. 2020;202(1):83-90. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32348692.
28. Choi JC, Jung SY, Yoon UA, et al. Inhaled corticosteroids and COVID-19 risk and mortality: a nationwide cohort study. *J Clin Med*. 2020;9(11). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33114246.
29. Schultze A, Walker AJ, MacKenna B, et al. Risk of COVID-19-related death among patients with chronic obstructive pulmonary disease or asthma prescribed inhaled corticosteroids: an observational cohort study using the OpenSAFELY platform. *Lancet Respir Med*. 2020;8(11):1106-1120. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32979987.
30. Ramakrishnan S, Nicolau DV, Jr., Langford B, et al. Inhaled budesonide in the treatment of early COVID-19 (STOIC): a Phase 2, open-label, randomised controlled trial. *Lancet Respir Med*. 2021;9(7):763-772. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33844996.
31. PRINCIPLE Collaborative Group, Yu L, Bafadhel M, et al. Inhaled budesonide for COVID-19 in people at higher risk of adverse outcomes in the community: interim analyses from the PRINCIPLE trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.10.21254672v1.
32. Garg D, Muthu V, Sehgal IS, et al. Coronavirus Disease (COVID-19) associated mucormycosis (CAM): case report and systematic review of literature. *Mycopathologia*. 2021;186(2):289-298. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33544266.
33. Moorthy A, Gaikwad R, Krishna S, et al. SARS-CoV-2, Uncontrolled diabetes and corticosteroids-an unholy trinity in invasive fungal infections of the maxillofacial region? A retrospective, multi-centric analysis. *J Maxillofac Oral Surg*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33716414.
34. Machado M, Valerio M, Alvarez-Uria A, et al. Invasive pulmonary aspergillosis in the COVID-19 era: an expected new entity. *Mycoses*. 2021;64(2):132-143. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33210776.
35. Chauvet P, Mallat J, Arumadura C, et al. Risk factors for invasive pulmonary aspergillosis in critically ill patients with coronavirus disease 2019-induced acute respiratory distress syndrome. *Crit Care Explor*. 2020;2(11):e0244. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33205046.
36. Centers for Disease Control and Prevention. Parasites—strongyloides: resources for health professionals. 2020. Available at: https://www.cdc.gov/parasites/strongyloides/health_professionals/index.html. Accessed July 27, 2021.
37. Lier AJ, Tuan JL, Davis MW, et al. Case report: disseminated strongyloidiasis in a patient with COVID-19. *Am J Trop Med Hyg*. 2020;103(4):1590-1592. Available at: https://pubmed.ncbi.nlm.nih.gov/32830642/.
38. Stauffer WM, Alpern JD, Walker PF. COVID-19 and dexamethasone: a potential strategy to avoid steroid-related strongyloides hyperinfection. *JAMA*. 2020;324(7):623-624. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32761166.
39. Liu J, Wang T, Cai Q, et al. Longitudinal changes of liver function and hepatitis B reactivation in COVID-19 patients with pre-existing chronic HBV infection. *Hepatol Res*. 2020;50(11):1211-1221. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32761993.
40. Liggins GC, Howie RN. A controlled trial of antepartum glucocorticoid treatment for prevention of the

respiratory distress syndrome in premature infants. *Pediatrics*. 1972;50(4):515-525. Available at: https://www.ncbi.nlm.nih.gov/pubmed/4561295.

41. Gyamfi-Bannerman C, Thom EA, Blackwell SC, et al. Antenatal betamethasone for women at risk for late preterm delivery. *N Engl J Med*. 2016;374(14):1311-1320. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26842679.
42. Ouldali N, Toubiana J, Antona D, et al. Association of intravenous immunoglobulins plus methylprednisolone vs immunoglobulins alone with course of fever in multisystem inflammatory syndrome in children. *JAMA*. 2021;325(9):855-864. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33523115.
43. Son MBF, Murray N, Friedman K, et al. Multisystem inflammatory syndrome in children—initial therapy and outcomes. *N Engl J Med*. 2021;385(1):23-34. Available at: https://www.ncbi.nlm.nih.gov/pubmed/34133855.

# Table 4a. Systemic Corticosteroids: Selected Clinical Data

*Last Updated: August 4, 2021*

The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing the recommendations for systemic corticosteroids. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **RECOVERY Trial: Dexamethasone in Hospitalized Patients With COVID-19—Preliminary Report[1]** | | | |
| Multicenter, randomized open-label adaptive trial in hospitalized patients with suspected or confirmed COVID-19 in the United Kingdom (n = 6,425) | **Key Inclusion Criteria:**<br>• Hospitalization with clinically suspected or laboratory-confirmed SARS-CoV-2 infection<br>**Key Exclusion Criteria:**<br>• Physician determination that risks of participation were too great based on patient's medical history or an indication for corticosteroid therapy outside of the study<br>**Interventions**<br>*2:1 Randomization:*<br>• Dexamethasone 6 mg PO or IV once daily plus SOC for up to 10 days or until hospital discharge, whichever came first<br>• SOC alone<br>**Primary Endpoint:**<br>• All-cause mortality at 28 days after randomization | **Number of Participants:**<br>• Dexamethasone plus SOC (n = 4,321) and SOC (n = 2,104)<br>**Participant Characteristics:**<br>• Mean age was 66 years.<br>• 64% of patients were men.<br>• 56% of patients had ≥1 comorbidity; 24% had diabetes.<br>• 89% of participants had laboratory-confirmed SARS-CoV-2 infection.<br>• At randomization, 16% of patients received IMV or ECMO, 60% required supplemental oxygen but not IMV, and 24% required no oxygen supplementation.<br>• 0% to 3% of the participants in both arms received RDV, HCQ, LPV/RTV, or tocilizumab; approximately 8% of participants in SOC alone arm received dexamethasone after randomization.<br>**Outcomes:**<br>• 28-day mortality was 22.9% in dexamethasone arm and 25.7% in SOC arm (age-adjusted rate ratio 0.83; 95% CI, 0.75–0.93; $P < 0.001$). | **Key Limitations:**<br>• Open-label study<br>• This preliminary study analysis did not include the results for key secondary endpoints (e.g., cause-specific mortality, need for renal replacement), AEs, and the efficacy of dexamethasone in key subgroups (e.g., patients with comorbidities).<br>• Study participants with COVID-19 who required oxygen (but not mechanical ventilation) had variable disease severity; it is unclear whether all patients in this heterogeneous group derived benefit from dexamethasone, or whether benefit is restricted to those requiring higher levels of supplemental oxygen or oxygen delivered through a high-flow device.<br>• The age distribution of participants differed by respiratory status at randomization.<br>• The survival benefit of dexamethasone for mechanically ventilated patients aged >80 years is unknown because only 1% of the participants in this group were ventilated. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **RECOVERY Trial: Dexamethasone in Hospitalized Patients With COVID-19—Preliminary Report[1]**, continued | | | |
| | | • The treatment effect of dexamethasone varied by baseline severity of COVID-19. Survival benefit appeared greatest among participants who required IMV at randomization. Among these participants, 28-day mortality was 29.3% in dexamethasone arm vs. 41.4% in SOC arm (rate ratio 0.64; 95% CI, 0.51–0.81).<br>• Among patients who required supplemental oxygen but not mechanical ventilation at randomization, 28-day mortality was 23.3% in dexamethasone arm vs. 26.2% in SOC arm (rate ratio 0.82; 95% CI, 0.72–0.94).<br>• No survival benefit in participants who did not require oxygen therapy at enrollment. Among these participants, 28-day mortality was 17.8% in dexamethasone arm vs. 14.0% in SOC arm (rate ratio 1.19; 95% CI, 0.91–1.55). | • It is unclear whether younger patients were more likely to receive mechanical ventilation than patients aged >80 years, given similar disease severity at baseline, with older patients preferentially assigned to oxygen therapy.<br>• The high baseline mortality of this patient population may limit generalizability of the study results to populations with a lower baseline mortality.<br>**Interpretation:**<br>• In hospitalized patients with severe COVID-19 who required oxygen support, using dexamethasone 6 mg daily for up to 10 days reduced mortality at 28 days, with the greatest benefit seen in those who were mechanically ventilated at baseline.<br>• There was no observed survival benefit of dexamethasone in patients who did not require oxygen support at baseline. |
| **Association Between Administration of Systemic Corticosteroids and Mortality Among Critically Ill Patients With COVID-19[2]** | | | |
| Meta-analysis of 7 RCTs of corticosteroids in critically ill patients with COVID-19 in multiple countries (n = 1,703) | **Key Inclusion Criteria:**<br>• RCTs evaluating corticosteroids in critically ill patients with COVID-19 (identified via comprehensive search of *ClinicalTrials.gov*, Chinese Clinical Trial Registry, and EU Clinical Trials Register)<br>**Interventions:**<br>• Corticosteroids (i.e., dexamethasone, hydrocortisone, methylprednisolone)<br>• Usual care or placebo | **Number of Participants:**<br>• Corticosteroids (n = 678) and usual care or placebo (n = 1,025)<br>**Participant Characteristics:**<br>• Median age was 60 years.<br>• 29% of patients were women.<br>• 1,559 patients (91.5%) were on mechanical ventilation.<br>• 47% of patients were on vasoactive agents at randomization across the 6 trials that reported this information. | **Key Limitations:**<br>• The design of the trials included in the meta-analysis differed in several ways, including the following:<br>  • Definition of critical illness<br>  • Specific corticosteroid used<br>  • Dose of corticosteroid<br>  • Duration of corticosteroid treatment<br>  • Type of control group (i.e., usual care or placebo)<br>  • Reporting of SAEs |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Association Between Administration of Systemic Corticosteroids and Mortality Among Critically Ill Patients With COVID-19**[2], continued | | | |
| | **Primary Endpoint:**<br>• All-cause mortality up to 30 days after randomization | **Outcomes:**<br>• Mortality was assessed at 28 days in 5 trials, 21 days in 1 trial, and 30 days in 1 trial.<br>• Reported all-cause mortality at 28 days: Death occurred in 222 of 678 patients (32.7%) in corticosteroids group vs. 425 of 1,025 patients (41.5%) in usual care or placebo group; summary OR 0.66 (95% CI, 0.53–0.82; $P < 0.001$).<br>• The fixed-effect summary ORs for the association with all-cause mortality were:<br>  • Dexamethasone: OR 0.64 (95% CI, 0.50–0.82; $P < 0.001$) in 3 trials with 1,282 patients.<br>  • Hydrocortisone: OR 0.69 (95% CI, 0.43–1.12; $P = 0.13$) in 3 trials with 374 patients.<br>  • Methylprednisolone: OR 0.91 (95% CI, 0.29–2.87; $P = 0.87$) in 1 trial with 47 patients.<br>  • For patients on mechanical ventilation (n = 1,559): OR 0.69 (95% CI, 0.55–0.86), with mortality of 30% for corticosteroids vs. 38% for usual care or placebo.<br>  • For patients not on mechanical ventilation (n = 144): OR 0.41 (95% CI, 0.19–0.88) with mortality of 23% for corticosteroids vs. 42% for usual care or placebo.<br>• Across the 6 trials that reported SAEs, 18.1% of patients randomized to corticosteroids and 23.4% randomized to usual care or placebo experienced SAEs. | • The RECOVERY trial accounted for 59% of the participants, and 3 trials enrolled <50 patients each.<br>• Some studies confirmed SARS-CoV-2 infection for participant inclusion while others enrolled participants with either probable or confirmed infection.<br>• Although the risk of bias was low in 6 of the 7 trials, it was assessed as "some concerns" for 1 trial (which contributed only 47 patients).<br>**Interpretation:**<br>• Systemic corticosteroids decrease 28-day mortality in critically ill patients with COVID-19 without safety concerns.<br>• Most of the participants were from the RECOVERY trial, thus the evidence of benefit in the meta-analysis is strongest for dexamethasone, the corticosteroid used in the RECOVERY trial. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Metcovid: Methylprednisolone as Adjunctive Therapy for Patients Hospitalized With COVID-19[3]** | | | |
| Double-blind, Phase 2b, RCT of short-course methylprednisolone in hospitalized patients with confirmed or suspected COVID-19 pneumonia in a single center in Brazil (n = 416) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Suspected or confirmed COVID-19<br>• $SpO_2$ ≤94% in room air *or* while using supplementary oxygen *or* under IMV<br>**Key Exclusion Criteria:**<br>• Hypersensitivity to methylprednisolone<br>• Chronic use of corticosteroids or immunosuppressive agents<br>• HIV, decompensated cirrhosis, chronic renal failure<br>**Interventions:**<br>• Methylprednisolone IV 0.5 mg/kg twice daily for 5 days<br>• Placebo (saline) IV<br>**Primary Endpoint:**<br>• Mortality by Day 28<br>**Secondary Endpoints:**<br>• Early mortality at Days 7 and 14<br>• Need for mechanical ventilation by Day 7<br>• Need for insulin by Day 28<br>• Positive blood culture at Day 7, sepsis by Day 28<br>• Mortality by Day 28 in specified subgroups | **Number of Participants:**<br>• mITT analysis (n = 393): Methylprednisolone (n = 194) and placebo (n = 199)<br>**Participant Characteristics:**<br>• Mean age was 55 years.<br>• 65% of patients were men.<br>• 29% of patients had diabetes.<br>• At enrollment, 34% of participants in each group required IMV; 51% in methylprednisolone group and 45% in placebo group required supplemental oxygen.<br>• Median time from illness onset to randomization was 13 days (IQR 9–16).<br>• None of the participants received anti-IL-6, anti-IL-1, RDV, or convalescent plasma.<br>• Hydrocortisone use for shock among patients was 8.7% in methylprednisolone group and 7.0% in placebo group.<br>**Primary Outcomes:**<br>• No difference in 28-day mortality: 37.1% in methylprednisolone arm vs. 38.2% in placebo arm (HR 0.92; 95% CI, 0.67–1.28; $P = 0.63$).<br>**Secondary Outcomes:**<br>• No difference between groups in early mortality at Day 7 (HR 0.68; 95% CI, 0.43–1.06) or Day 14 (HR 0.82; 95% CI, 0.57–1.18).<br>• No difference in need for mechanical ventilation by Day 7: 19.4% of methylprednisolone recipients vs. 16.8% of placebo recipients ($P = 0.65$). | **Key Limitations:**<br>• The median days from illness onset to randomization was longer than in other corticosteroid studies.<br>• The high baseline mortality of this patient population may limit generalizability of the study results to populations with a lower baseline mortality.<br>**Interpretation:**<br>• Use of weight-based methylprednisolone for 5 days did not reduce overall 28-day mortality.<br>• In a post hoc subgroup analysis, mortality among those aged >60 years was lower in the methylprednisolone group than in the placebo group. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Metcovid: Methylprednisolone as Adjunctive Therapy for Patients Hospitalized With COVID-19[3]**, continued | | | |
| | | • No significant difference between the methylprednisolone and placebo groups in need for insulin (59.5% vs. 49.4% of patients), positive blood cultures at Day 7 (8.3% vs. 8.0% of patients), or sepsis by Day 28 (38.1% vs. 38.7% of patients).<br>• In post hoc analysis, 28-day mortality in participants aged >60 years was lower in methylprednisolone group than in placebo group (46.6% vs. 61.9%; HR 0.63; 95% CI, 0.41–0.98). | |
| **CoDEX: Effect of Dexamethasone on Days Alive and Ventilator-Free in Patients With Moderate or Severe Acute Respiratory Distress Syndrome and COVID-19[4]** | | | |
| Multicenter RCT in patients with COVID-19 and moderate to severe ARDS in Brazil (n = 299) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Confirmed or suspected COVID-19<br>• On mechanical ventilation within 48 hours of meeting criteria for moderate to severe ARDS with $PaO_2/FiO_2$ ≤200 mm Hg<br>**Key Exclusion Criteria:**<br>• Recent corticosteroid use<br>• Use of immunosuppressive drugs in the past 21 days<br>• Expected death in next 24 hours<br>**Interventions:**<br>• Dexamethasone 20 mg IV daily for 5 days, then 10 mg IV daily for 5 days or until ICU discharge plus SOC<br>• SOC alone<br>**Primary Endpoint:**<br>• Mean number of days alive and free from mechanical ventilation by Day 28 | **Number of Participants:**<br>• ITT analysis (n = 299): Dexamethasone plus SOC (n = 151) and SOC alone (n = 148)<br>**Participant Characteristics:**<br>• Dexamethasone group included more women than the SOC group (40% vs. 35%), more patients with obesity (31% vs. 24%), and fewer patients with diabetes (38% vs. 47%).<br>• Other baseline characteristics were similar for the dexamethasone and SOC groups:<br>  • Mean age of 60 vs. 63 years; vasopressor use by 66% vs. 68% of patients; mean $PaO_2/FiO_2$ of 131 mm Hg vs. 133 mm Hg.<br>  • Median time from symptom onset to randomization was 9–10 days.<br>  • Median time from mechanical ventilation to randomization was 1 day.<br>  • No patients received RDV; anti-IL-6 and convalescent plasma were not widely available.<br>  • Median duration of dexamethasone therapy was 10 days (IQR 6–10 days).<br>  • 35% of patients in SOC alone group also received corticosteroids. | **Key Limitations:**<br>• Open-label study<br>• The study was underpowered to assess some outcomes because it stopped enrollment after data from the RECOVERY trial were released.<br>• During the study, 35% of the patients in the SOC group received corticosteroids for shock, bronchospasm, or other reasons.<br>• Patients who were discharged from the hospital before 28 days were not followed for rehospitalization or mortality.<br>• The high baseline mortality of the patient population may limit generalizability of the study results to populations with a lower baseline mortality. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **CoDEX: Effect of Dexamethasone on Days Alive and Ventilator-Free in Patients With Moderate or Severe Acute Respiratory Distress Syndrome and COVID-19[4]**, continued | | | |
| | **Secondary Endpoints:**<br>• All-cause mortality at Day 28<br>• ICU-free days by Day 28<br>• Duration of mechanical ventilation by Day 28<br>• Score on 6-point WHO ordinal scale at Day 15<br>• SOFA score at 7 days<br>• Components of the primary outcome or in the outcome of discharged alive within 28 days | **Primary Outcomes:**<br>• The mean number of days alive and free from mechanical ventilation by Day 28 was higher in the dexamethasone group than in the SOC group (6.6 vs. 4.0 days, estimated difference of 2.3 days; 95% CI, 0.2–4.4; $P = 0.04$).<br>**Secondary Outcomes:**<br>• There were no differences between the dexamethasone and SOC groups for the following outcomes:<br>  • All-cause mortality at Day 28 (56.3% vs. 61.5%: HR 0.97; 95% CI, 0.72–1.31; $P = 0.85$).<br>  • ICU-free days by Day 28 (mean of 2.1 vs. 2.0 days; $P = 0.50$).<br>  • Duration of mechanical ventilation by Day 28 (mean of 12.5 vs.13.9 days; $P = 0.11$).<br>  • Score on 6-point WHO ordinal scale at Day 15 (median score of 5 for both groups).<br>• The mean SOFA score at 7 days was lower in the dexamethasone group than in the SOC group (6.1 vs. 7.5, difference -1.16; 95% CI, -1.94 to -0.38; $P = 0.004$).<br>• The following safety outcomes were comparable for dexamethasone and SOC groups: need for insulin (31.1% vs. 28.4%), new infections (21.9% vs. 29.1%), bacteremia (7.9% vs. 9.5%), and other SAEs (3.3% vs. 6.1%).<br>• In post hoc analysis, the dexamethasone group had a lower cumulative probability of death or mechanical ventilation at Day 15 than the SOC group (67.5% vs. 80.4%; OR 0.46; 95% CI, 0.26–0.81; $P = 0.01$). | **Interpretation:**<br>• Compared with SOC alone, dexamethasone at a higher dose than used in the RECOVERY trial plus SOC increased the number of days alive and free of mechanical ventilation over 28 days of follow-up in patients with COVID-19 and moderate to severe ARDS.<br>• Dexamethasone was not associated with an increased risk of AEs in this population.<br>• More than one-third of those randomized to the standard care alone group also received corticosteroids; it is impossible to determine the effect of corticosteroid use in these patients on the overall study outcomes. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Hydrocortisone on 21-Day Mortality or Respiratory Support Among Critically Ill Patients With COVID-19[5]** | | | |
| Multicenter, double-blind, sequential RCT in patients with confirmed or suspected COVID-19 and acute respiratory failure in France (n = 149) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Confirmed SARS-CoV-2 infection or radiographically suspected COVID-19, with at least 1 of 4 severity criteria:<br>  • Need for mechanical ventilation with PEEP ≥5 cm $H_2O$<br>  • High-flow oxygen with $PaO_2/FiO_2$ <300 mm Hg and $FiO_2$ ≥50%<br>  • Reservoir mask oxygen with $PaO_2/FiO_2$ <300 mm Hg (estimated)<br>  • Pneumonia severity index >130 (scoring table)<br>**Key Exclusion Criteria:**<br>• Septic shock<br>• Do-not-intubate orders<br>**Interventions:**<br>• Continuous infusion hydrocortisone 200 mg/day until Day 7, then hydrocortisone 100 mg/day for 4 days, and then hydrocortisone 50 mg/day for 3 days, for a total treatment duration of 14 days<br>• Patients who showed clinical improvement by Day 4 were switched to a shorter 8-day regimen<br>**Primary Endpoint:**<br>• Treatment failure (defined as death or persistent dependency on mechanical ventilation or high-flow oxygen) by Day 21 | **Number of Participants:**<br>• ITT analysis (n = 149 participants): Hydrocortisone (n = 76) and placebo (n = 73)<br>**Participant Characteristics:**<br>• Mean age of participants was 62 years; 70% were men; median BMI was 28.<br>• 96% of participants had confirmed SARS-CoV-2 infection.<br>• Median symptom duration before randomization was 9 days in hydrocortisone group vs. 10 days in placebo group.<br>• 81% of the patients overall were mechanically ventilated, and 24% in hydrocortisone group and 18% in placebo group were receiving vasopressors.<br>• Among the patients receiving concomitant COVID-19 treatment, 3% received RDV, 14% LPV/RTV, 13% HCQ, and 34% HCQ plus AZM.<br>• Median treatment duration was 10.5 days in hydrocortisone group vs. 12.8 days in placebo group ($P = 0.25$).<br>**Primary Outcome:**<br>• No difference in the proportion of patients with treatment failure by Day 21, which occurred in 32 of 76 patients (42.1%) in hydrocortisone group and 37 of 73 patients (50.7%) in placebo group (difference -8.6%; 95% CI, -24.9% to 7.7%; $P = 0.29$).<br>**Secondary Outcomes:**<br>• No difference in the need for intubation, rescue strategies, or oxygenation (i.e., change in $PaO_2/FiO_2$).<br>  • Among the patients who did not require mechanical ventilation at baseline, 8 of 16 patients (50%) in hydrocortisone group required subsequent intubation vs. 12 of 16 (75%) in placebo group. | **Key Limitations:**<br>• Small sample size. Planned sample size of 290, but 149 enrolled because study was terminated early after the release of results from the RECOVERY trial.<br>• Limited information about comorbidities (e.g., hypertension)<br>• Participants' race and/or ethnicity were not reported.<br>• Nosocomial infections were recorded but not adjudicated.<br>**Interpretation:**<br>• Compared to placebo, hydrocortisone did not reduce treatment failure (defined as death or persistent respiratory support) at Day 21 in ICU patients with COVID-19 and acute respiratory failure.<br>• Because this study was terminated early, it is difficult to make conclusions about the efficacy and safety of hydrocortisone therapy.<br>• The starting dose of hydrocortisone used in this study were slightly higher than the 6 mg dose of dexamethasone used in the RECOVERY study. The hydrocortisone dose was adjusted according to clinical response. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Hydrocortisone on 21-Day Mortality or Respiratory Support Among Critically Ill Patients With COVID-19[5]**, continued | | | |
| | **Secondary Endpoints:**<br>• Need for intubation, rescue strategies, or oxygenation (i.e., change in $PaO_2/FiO_2$)<br>• Nosocomial infections on Day 28<br>• Clinical status on Day 21 | • 3 SAEs were reported (cerebral vasculitis, cardiac arrest due to PE, and intra-abdominal hemorrhage from anticoagulation for PE); all occurred in the hydrocortisone group, but none were attributed to the intervention.<br>  • No difference between the groups in proportion of patients with nosocomial infections on Day 28.<br>• In post hoc analysis, clinical status on Day 21 did not significantly differ between the groups except for fewer deaths in the hydrocortisone group (14.7% of patients died vs. 27.4% in placebo group; $P = 0.06$):<br>  • By Day 21, 57.3% of patients in hydrocortisone group vs. 43.8% in placebo group were discharged from the ICU and 22.7% in hydrocortisone group vs. 23.3% in placebo group were still mechanically ventilated. | |
| **REMAP-CAP COVID-19 Corticosteroid Domain (CAPE COD): Effect of Hydrocortisone on Mortality and Organ Support in Patients With Severe COVID-19[6]** | | | |
| Randomized, embedded, multifactorial, adaptive platform trial of patients with severe COVID-19 in multiple countries (n = 403) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Presumed or confirmed SARS-CoV-2 infection<br>• ICU admission for respiratory or cardiovascular organ support<br>**Key Exclusion Criteria:**<br>• Presumed imminent death<br>• Systemic corticosteroid use<br>• >36 hours since ICU admission<br>**Interventions:**<br>• Hydrocortisone 50 mg 4 times daily for 7 days | **Number of Participants:**<br>• mITT analysis (n = 384): Fixed-dose hydrocortisone (n = 137), shock-based hydrocortisone (n = 146), and no hydrocortisone (n = 101)<br>**Participant Characteristics:**<br>• Mean age was 60 years.<br>• 71% of patients were men.<br>• Mean BMI was 29.7–30.9.<br>• 50% to 64% of patients received mechanical ventilation.<br>**Primary Outcome:**<br>• No difference in organ-support free-days at Day 21 (median of 0 days in each group). | **Key Limitations:**<br>• Early termination following release of RECOVERY study results<br>• Randomized study, but open label<br>**Interpretation:**<br>• Corticosteroids did not significantly increase support-free days in either the fixed-dose hydrocortisone or the shock-dependent hydrocortisone group, although the early termination of the trial led to limited power to detect difference between the study arms. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **REMAP-CAP COVID-19 Corticosteroid Domain (CAPE COD): Effect of Hydrocortisone on Mortality and Organ Support in Patients With Severe COVID-19[6]**, continued | | | |
| | • Septic shock-based hydrocortisone 50 mg 4 times daily for the duration of shock<br>• No hydrocortisone<br>**Primary Endpoint:**<br>• Days free of respiratory and cardiovascular organ support up to Day 21 (for this ordinal outcome, patients who died were assigned -1 day)<br>**Secondary Endpoints:**<br>• In-hospital mortality<br>• SAEs | • Compared to the no hydrocortisone group, median adjusted OR for the primary outcome:<br>• OR 1.43 (95% CrI, 0.91–2.27) with 93% Bayesian probability of superiority for the fixed-dose hydrocortisone group.<br>• OR 1.22 (95% CrI, 0.76–1.94) with 80% Bayesian probability of superiority for the shock-based hydrocortisone group.<br>**Secondary Outcomes:**<br>• No difference between the groups in mortality; 30%, 26%, and 33% of patients died in the fixed-dose, shock-based, and no hydrocortisone groups, respectively.<br>• SAEs reported in 3%, 3%, and 1% of patients in the fixed-dose, shock-based, and no hydrocortisone groups, respectively. | |
| **Efficacy of Early, Low-Dose, Short-Term Corticosteroids in Adults Hospitalized with Nonsevere COVID-19 Pneumonia[7]** | | | |
| Retrospective cohort study in patients with nonsevere COVID-19 pneumonia and propensity score-matched controls in China (n = 55 matched case-control pairs) | **Key Inclusion Criteria:**<br>• Aged ≥16 years<br>• Confirmed COVID-19<br>• Pneumonia on chest CT scan<br>**Key Exclusion Criteria:**<br>• Severe pneumonia defined as having any of the following: respiratory distress, respiratory rates >30 breaths/min, $SpO_2$ <93%, oxygenation index <300 mm Hg, mechanical ventilation, or shock | **Number of Participants:**<br>• Corticosteroids (n = 55): IV methylprednisolone (n = 50) and prednisone (n = 5)<br>• No corticosteroids (n = 55 matched controls chosen from 420 patients who did not receive corticosteroids)<br>**Participant Characteristics:**<br>• Median age was 58–59 years.<br>• Median $SpO_2$ was 95%.<br>• 42% of patients in corticosteroids group and 46% in no corticosteroids group had comorbidities, 35% to 36% had HTN, and 11% to 13% had diabetes. | **Key Limitations:**<br>• Retrospective, case-control study.<br>• Small sample size (55 case-control pairs).<br>• Corticosteroid therapy was selected preferentially for patients who had more risk factors for severe progression of COVID-19; the propensity score matching may not have adjusted for some of the unmeasured confounders.<br>• Selection bias in favor of the no corticosteroids group may have been introduced by excluding patients who used corticosteroids after progression to severe disease from the study. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Efficacy of Early, Low-Dose, Short-Term Corticosteroids in Adults Hospitalized with Nonsevere COVID-19 Pneumonia**[7], continued | | | |
| | • Immediate ICU admission upon hospitalization<br>• Use of corticosteroids after progression to severe disease<br>**Interventions:**<br>• Early, low-dose corticosteroids:<br>  • Methylprednisolone 20 mg/day IV or 40 mg/day IV for 3–5 days<br>  • Prednisone 20 mg/day PO for 3 days<br>• No corticosteroids<br>**Primary Endpoint:**<br>• Rates of severe disease and death<br>**Secondary Endpoints:**<br>• Duration of fever<br>• Virus clearance time<br>• Length of hospital stay<br>• Use of antibiotics | **Primary Outcomes:**<br>• 7 patients (12.7%) in the corticosteroids group developed severe disease vs. 1 (1.8%) in the no corticosteroids group ($P = 0.03$); time to severe disease: HR 2.2 (95% CI, 2.0–2.3; $P < 0.001$).<br>• 1 death in the methylprednisolone group vs. none in the no corticosteroids group.<br>**Secondary Outcomes:**<br>• Each of the following outcomes was longer in the corticosteroids group than in the no corticosteroids group ($P < 0.001$ for each outcome): duration of fever (5 vs. 3 days), virus clearance time (18 vs. 11 days), and length of hospital stay (23 vs. 15 days).<br>• More patients in the corticosteroids group than in the no corticosteroids group were prescribed antibiotics (89% vs. 24%) and antifungal therapy (7% vs. 0%). | **Interpretation:**<br>• In this nonrandomized, case-control study, methylprednisolone therapy in patients with nonsevere COVID-19 pneumonia was associated with worse outcomes, but this finding is difficult to interpret because of potential confounding factors.<br>• It is unclear whether the results for methylprednisolone therapy can be generalized to therapy with other corticosteroids. |

**Key:** AE = adverse event; ARDS = acute respiratory distress syndrome; AZM = azithromycin; BMI = body mass index; CT = computerized tomography; ECMO = extracorporeal membrane oxygenation; EU = European Union; HCQ = hydroxychloroquine; HTN = hypertension; ICU = intensive care unit; IL = interleukin; ITT = intention-to-treat; IV = intravenous; IMV = invasive mechanical ventilation; LPV/RTV = lopinavir/ritonavir; mITT = modified intention-to-treat; the Panel = the COVID-19 Treatment Guidelines Panel; $PaO_2/FiO_2$ = ratio of arterial partial pressure of oxygen to fraction of inspired oxygen; PE = pulmonary embolism; PEEP = positive end-expiratory pressure; PO = oral; RCT = randomized controlled trial; RDV = remdesivir; SAE = serious adverse event; SOC = standard of care; SOFA = sequential organ failure assessment; $SpO_2$ = saturation of oxygen; WHO = World Health Organization

## References


1. RECOVERY Collaborative Group, Horby P, Lim WS, et al. Dexamethasone in hospitalized patients with COVID-19—preliminary report. *N Engl J Med*. 2021;384(8):693-704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32678530.
2. WHO Rapid Evidence Appraisal for COVID-19 Therapies Working Group, Sterne JAC, Murthy S, et al. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. *JAMA*. 2020;324(13):1330-1341. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/32876694.

3. Jeronimo CMP, Farias MEL, Val FFA, et al. Methylprednisolone as adjunctive therapy for patients hospitalized with COVID-19 (Metcovid): a randomised, double-blind, Phase IIb, placebo-controlled trial. *Clin Infect Dis*. 2021;72(9):e373-e381. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32785710.
4. Tomazini BM, Maia IS, Cavalcanti AB, et al. Effect of dexamethasone on days alive and ventilator-free in patients with moderate or severe acute respiratory distress syndrome and COVID-19: the CoDEX randomized clinical trial. *JAMA*. 2020;324(13):1307-1316. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876695.
5. Dequin PF, Heming N, Meziani F, et al. Effect of hydrocortisone on 21-day mortality or respiratory support among critically ill patients with COVID-19: a randomized clinical trial. *JAMA*. 2020;324(13):1298-1306. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876689.
6. Writing Committee for the REMAP-CAP Investigators, Angus DC, Derde L, et al. Effect of hydrocortisone on mortality and organ support in patients with severe COVID-19: the REMAP-CAP COVID-19 corticosteroid domain randomized clinical trial. *JAMA*. 2020;324(13):1317-1329. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32876697.
7. Li Q, Li W, Jin Y, et al. Efficacy evaluation of early, low-dose, short-term corticosteroids in adults hospitalized with non-severe COVID-19 pneumonia: a retrospective cohort study. *Infect Dis Ther*. 2020;9(4):823-836. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32880102.

# Table 4b. Inhaled Corticosteroids: Selected Clinical Data

*Last Updated: August 4, 2021*

The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing the recommendations for inhaled corticosteroids. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **STOIC: Inhaled Budesonide for the Treatment of Early COVID-19[1]** | | | |
| Open-label, Phase 2, RCT in the United Kingdom (n = 146) | **Key Inclusion Criteria:**<br>• Outpatients aged ≥18 years<br>• Duration of symptoms ≤7 days<br>**Key Exclusion Criteria:**<br>• Use of inhaled or systemic glucocorticoids within the past 7 days<br>• Known allergy or contraindication to budesonide<br>**Interventions**<br>*1:1 Randomization:*<br>• Usual care (supportive therapy)<br>• Usual care plus budesonide 800 mcg inhaled twice daily until symptom resolution<br>**Primary Endpoint:**<br>• COVID-19-related urgent care visit, including ED visit, or hospitalization | **Number of Participants:**<br>• ITT analysis: Budesonide (n = 73) and usual care (n = 73)<br>• Per-protocol analysis: Budesonide (n = 70) and usual care (n = 69)<br>**Participant Characteristics:**<br>• Mean age: 45 years<br>• 58% women<br>• Median number of comorbidities: 1; 9% had CVD, 5% had diabetes<br>• 95% with positive SARS-CoV-2 RT-PCR<br>• Median duration of symptoms prior to randomization: 3 days<br>**Outcomes:**<br>• Median duration of budesonide use: 7 days.<br>• COVID-19-related urgent care visits or hospitalizations occurred in 1 participant (1%) in the budesonide arm and 10 participants (14%) in the usual care arm (difference in proportions 13%; 95% CI, 4–22; $P$ = 0.004). Relative risk reduction of 91% for budesonide, NNT of 8. | **Key Limitations:**<br>• Open-label study<br>• Small sample size<br>• Completed in a single UK region<br>• The study was halted early after an independent statistical analysis determined that having additional participants would not alter the trial outcome.<br>**Interpretation:**<br>• In adult outpatients with mild COVID-19, inhaled budesonide may reduce the need for urgent medical care defined by urgent care or ED assessment and/or hospitalization. These findings should be interpreted with caution given the above limitations. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **PRINCIPLE Trial: Inhaled Budesonide for COVID-19 in Outpatients at Higher Risk of Adverse Outcomes[2]** | | | |
| Multicenter, open-label, multiarm, adaptive platform RCT in outpatients with suspected COVID-19 in the United Kingdom<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Aged ≥65 years, or aged ≥50 years with comorbidities<br>• Duration of COVID-19 symptoms ≤14 days<br>• PCR-confirmed or suspected COVID-19<br>**Key Exclusion Criteria:**<br>• Already taking inhaled or systemic corticosteroids<br>• Unable to use an inhaler<br>• Use of inhaled budesonide contraindicated<br>**Interventions:**<br>• Usual care (supportive therapy)<br>• Usual care plus budesonide 800 mcg inhaled twice daily for 14 days<br>**Coprimary Endpoints:**<br>• Hospitalization or death related to COVID-19 up to Day 28<br>• Time to recovery, defined as participant self-report of feeling recovered, up to Day 28 | **Number of Participants:**<br>• Randomized patients with follow-up data: Budesonide (n = 751), usual care (n = 1,028), and other treatments (n = 643)<br>**Participant Characteristics:**<br>• Mean age: 62.8 years<br>• 53% women<br>• 83% had comorbidities; 18% had lung disease and 20% had diabetes.<br>• Median time from symptom onset to randomization: 6 days<br>**Outcomes:**<br>• Preliminary analysis (n = 1,660): Budesonide (n = 692) and usual care (n = 968)<br>  • COVID-19-related hospitalization or death within 28 days: 8.5% in budesonide arm vs. 10.3% in usual care arm; estimated difference 2.1% (95% CrI, -0.7% to 4.8%), 0.928 probability of superiority for budesonide, which did not meet the specified superiority threshold.<br>  • Median time to recovery (IQR): 11 (5, 27) days in budesonide arm vs. 14 (6, -) days in usual care arm; estimated treatment effect 3.0 (95% CrI, 1.1–5.4), 0.999 probability of superiority for budesonide<br>  • AEs: 2 hospitalizations not related to COVID-19 were reported in the budesonide arm. | **Key Limitations:**<br>• Open-label trial<br>• Control group not fully contemporary; a high proportion of participants did not have follow-up data; and the proportions without follow-up data differed between treatment groups (27% in the budesonide group vs. 47% in the control group). These limitations compromise the interpretation that the treatment difference is due to budesonide.<br>• Bayesian analysis for coprimary endpoints is opaque.<br>• Primary endpoint of time to recovery was based on self-reported assessment of feeling recovered.<br>**Interpretation:**<br>• In adult outpatients with mild COVID-19, inhaled budesonide may reduce time to recovery. Subset analyses (by age, duration of illness, symptom severity) for time to recovery appear to favor budesonide. However, reporting and preliminary analysis of multiple subpopulations complicate interpretation of the primary outcomes. These findings should be interpreted with caution given the above limitations. |

**Key:** AE = adverse event; CVD = cardiovascular disease; ED = emergency department; ITT = intention-to-treat; NNT = number needed to treat; the Panel = the COVID-19 Treatment Guidelines Panel; PCR = polymerase chain reaction; RCT = randomized controlled trial; RT-PCR = reverse transcription polymerase chain reaction; UK = United Kingdom

## References


1. Ramakrishnan S, Nicolau DV, Jr., Langford B, et al. Inhaled budesonide in the treatment of early COVID-19 (STOIC): a Phase 2, open-label, randomised controlled trial. *Lancet Respir Med*. 2021;9(7):763-772. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33844996.
2. PRINCIPLE Collaborative Group, Yu L, Bafadhel M, et al. Inhaled budesonide for COVID-19 in people at higher risk of adverse outcomes in the community: interim analyses from the PRINCIPLE trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.10.21254672v1.

# Fluvoxamine

*Last Updated: April 23, 2021*

Fluvoxamine is a selective serotonin reuptake inhibitor (SSRI) that is approved by the Food and Drug Administration (FDA) for the treatment of obsessive-compulsive disorder and is used for other conditions, including depression. Fluvoxamine is not FDA-approved for the treatment of any infection.

## Anti-Inflammatory Effect of Fluvoxamine and Rationale for Use in COVID-19

In a murine sepsis model, fluvoxamine was found to bind to the sigma-1 receptor in immune cells, resulting in reduced production of inflammatory cytokines.[1] In an in vitro study of human endothelial cells and macrophages, fluvoxamine reduced the expression of inflammatory genes.[2] Further studies are needed to establish whether the anti-inflammatory effects of fluvoxamine observed in nonclinical studies also occur in humans beings and are clinically relevant in the setting of COVID-19.

## Recommendation

There is insufficient evidence for the COVID-19 Treatment Guidelines Panel to recommend either for or against the use of fluvoxamine for the treatment of COVID-19. Results from adequately powered, well-designed, and well-conducted clinical trials are needed to provide more specific, evidence-based guidance on the role of fluvoxamine for the treatment of COVID-19.

## Clinical Trial Data

### *Placebo-Controlled Randomized Trial in Nonhospitalized Adults With Mild COVID-19*

In this contactless, double-blind, placebo-controlled randomized trial, nonhospitalized adults with mild COVID-19 confirmed by SARS-CoV-2 polymerase chain reaction (PCR) assay within 7 days of symptom onset were randomized to receive fluvoxamine up to 100 mg three times daily or matching placebo for 15 days. The primary endpoint was clinical deterioration (defined as having dyspnea or hospitalization for dyspnea or pneumonia and oxygen saturation [$SpO_2$] <92% on room air or requiring supplemental oxygen to attain $SpO_2$ ≥92%) within 15 days of randomization. Participants self-assessed their blood pressure, temperature, oxygen saturation, and COVID-19 symptoms and reported the information by email twice daily.[3]

#### Participant Characteristics

- A total of 152 participants were randomized to receive fluvoxamine (n = 80) or placebo (n = 72).
- The mean age of the participants was 46 years; 72% were women, 25% were Black, and 56% had obesity.

#### Results

- None of 80 participants (0%) who received fluvoxamine and six of 72 participants (8.3%) who received placebo reached the primary endpoint (absolute difference 8.7%; 95% CI, 1.8% to 16.5%; $P = 0.009$).
- Five participants in the placebo arm and one in the fluvoxamine arm required hospitalization.
- Only 76% of the participants completed the study, and 20% of the participants stopped responding to the electronic survey during the study period but were included in the final analysis.

#### Limitations

- The study had a small sample size.

- A limited number of events occurred.
- Ascertaining clinical deterioration was challenging because all assessments were done remotely.

#### Interpretation

In this small placebo-controlled trial, none of the participants who received fluvoxamine and six (8.3%) of those who received placebo reached the primary endpoint. However, due to the study's reliance on participant self-reports and missing data, it is difficult to draw definitive conclusions about the efficacy of fluvoxamine for the treatment of COVID-19.[3]

### *Prospective Observational Study During an Outbreak of SARS-CoV-2 Infections*

A prospective, nonrandomized observational cohort study evaluated fluvoxamine for the treatment of COVID-19 in 113 outpatients who tested positive for SARS-CoV-2 antigen with the result confirmed by a PCR test. The trial was conducted in an occupational setting during an outbreak of COVID-19. Patients were offered the option of receiving fluvoxamine 50 mg twice daily for 14 days or no therapy.[4]

#### Patient Characteristics

- Of the 113 participants with positive SARS-CoV-2 antigen, 65 opted to take fluvoxamine and 48 did not.
- More of the patients who did not take fluvoxamine had hypertension. In addition, more of those who were Latinx and more of those who were initially symptomatic opted to take fluvoxamine.

#### Results

- At Day 14, none of the patients who received fluvoxamine versus 60% of those who did not had persistent symptoms (e.g., anxiety, difficulty concentrating, fatigue) ($P < 0.001$).
- By Day 14, none of the fluvoxamine-treated patients were hospitalized; six patients who did not receive fluvoxamine were hospitalized, including two patients who required care in the intensive care unit.
- No serious adverse events were reported following receipt of fluvoxamine.

#### Limitations

- The study was a nonrandomized trial.
- The study had a small sample size.
- Limited data were collected during the study.

Limitations (e.g., small sample size) and differences in study populations and fluvoxamine doses make it difficult to interpret and generalize the findings of these trials.

Additional studies, including a Phase 3 randomized controlled trial (*ClinicalTrials.gov* Identifier NCT04668950), are ongoing to provide more specific evidence-based guidance on the role of fluvoxamine for the treatment of COVID-19.

## Adverse Effects, Monitoring, and Drug-Drug Interactions

When fluvoxamine is used to treat psychiatric conditions, the most common adverse effect is nausea, but adverse effects can include other gastrointestinal effects (e.g., diarrhea, indigestion), neurologic effects (e.g., asthenia, insomnia, somnolence), dermatologic reactions (sweating), and rarely suicidal ideation.

Fluvoxamine is a cytochrome P450 (CYP) D6 substrate and a potent inhibitor of CYP1A2 and 2C19 and a moderate inhibitor of CYP2C9, 2D6, and 3A4.[5] Fluvoxamine may enhance the anticoagulant effects of antiplatelets and anticoagulants. In addition, it can enhance the serotonergic effects of other SSRIs

or monoamine oxidase inhibitors (MAOIs) resulting in serotonin syndrome. Fluvoxamine **should not be used** within 2 weeks of receipt of other SSRIs or MAOIs and should be used with caution with other QT-interval prolonging medications.

## Considerations in Pregnancy

Fluvoxamine is not thought to increase the risk of congenital abnormalities; however, the data on its use in pregnancy are limited.[6,7] A small, increased risk of primary persistent pulmonary hypertension in the newborn associated with SSRI use in the late third trimester has not been excluded, although the absolute risk is likely low.[8] The risk of fluvoxamine use in pregnancy for the treatment of COVID-19 should be balanced with the potential benefit.

## Considerations in Children

Fluvoxamine is approved by the FDA for the treatment of obsessive compulsive disorder in children aged ≥8 years.[9] Adverse effects due to SSRI use seen in children are similar to those seen in adults, although children and adolescents appear to have higher rates of behavioral activation and vomiting than adults.[10] There are no data on the use of fluvoxamine for the prevention or treatment of COVID-19 in children.

## References


1. Rosen DA, Seki SM, Fernández-Castañeda A, et al. Modulation of the sigma-1 receptor–IRE1 pathway is beneficial in preclinical models of inflammation and sepsis. *Science Translation Medicine*. 2019. Available at: https://stm.sciencemag.org/content/11/478/eaau5266.editor-summary.
2. Rafiee L, Hajhashemi V, Javanmard SH. Fluvoxamine inhibits some inflammatory genes expression in LPS/stimulated human endothelial cells, U937 macrophages, and carrageenan-induced paw edema in rat. *Iran J Basic Med Sci*. 2016;19(9):977-984. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27803785.
3. Lenze EJ, Mattar C, Zorumski CF, et al. Fluvoxamine vs placebo and clinical deterioration in outpatients with symptomatic COVID-19: a randomized clinical trial. *JAMA*. 2020;324(22):2292-2300. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33180097.
4. Seftel D, Boulware DR. Prospective cohort of fluvoxamine for early treatment of coronavirus disease 19. *Open Forum Infect Dis*. 2021;8(2):ofab050. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33623808.
5. Hemeryck A, Belpaire FM. Selective serotonin reuptake inhibitors and cytochrome P-450 mediated drug-drug interactions: an update. *Curr Drug Metab*. 2002;3(1):13-37. Available at: https://www.ncbi.nlm.nih.gov/pubmed/11876575.
6. Einarson A, Choi J, Einarson TR, Koren G. Incidence of major malformations in infants following antidepressant exposure in pregnancy: results of a large prospective cohort study. *Can J Psychiatry*. 2009;54(4):242-246. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19321030.
7. Furu K, Kieler H, Haglund B, et al. Selective serotonin reuptake inhibitors and venlafaxine in early pregnancy and risk of birth defects: population based cohort study and sibling design. *BMJ*. 2015;350:h1798. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25888213.
8. Huybrechts KF, Bateman BT, Palmsten K, et al. Antidepressant use late in pregnancy and risk of persistent pulmonary hypertension of the newborn. *JAMA*. 2015;313(21):2142-51. Available at: https://pubmed.ncbi.nlm.nih.gov/26034955/.
9. Fluvoxamine maleate [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/021519s012lbl.pdf.
10. Safer DJ, Zito JM. Treatment-emergent adverse events from selective serotonin reuptake inhibitors by age group: children versus adolescents. *J Child Adolesc Psychopharmacol*. 2006;16(1-2):159-169. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16553536.

# Granulocyte-Macrophage Colony-Stimulating Factor Inhibitors

*Last Updated: July 8, 2021*

Granulocyte-macrophage colony-stimulating factor (GM-CSF) is a myelopoietic growth factor and proinflammatory cytokine that plays a central role in a broad range of immune-mediated diseases. GM-CSF, secreted by macrophages, T-cells, mast cells, natural killer cells, endothelial cells, and fibroblasts, regulates macrophage number and function. It acts as a pro-inflammatory signal, prompting macrophages to launch an immune cascade that ultimately results in tissue damage.[1,2] GM-CSF is believed to be a key driver of lung inflammation in severe and critical COVID-19 pneumonia, operating upstream of other pro-inflammatory cytokines and chemokines.[1-6] Anti-GM-CSF monoclonal antibodies may mitigate inflammation by inhibiting this signaling axis upstream and thus minimizing downstream production of numerous pro-inflammatory mediators involved in the pathogenesis of COVID-19.[7] Gimsilumab, lenzilumab, namilumab, and otilimab target GM-CSF directly, neutralizing the biological function of GM-CSF by blocking the interaction of GM-CSF with its cell surface receptor.[1,8,9] Mavrilimumab targets the alpha subunit of the GM-CSF receptor, blocking intracellular signaling of GM-CSF.[8,10] None of these agents are currently FDA-approved for any indication.

## Recommendation

- There is insufficient evidence for the COVID-19 Treatment Guidelines Panel (the Panel) to recommend either for or against the use of GM-CSF inhibitors for the treatment of hospitalized patients with COVID-19.

## Rationale

Clinical data are lacking to definitively establish the potential benefits and risks associated with the use of GM-CSF inhibitors in patients with COVID-19. Preliminary data from a double-blind, placebo-controlled randomized trial of lenzilumab did show a significant improvement in the primary endpoint of ventilator-free survival through Day 28 among those who received the GM-CSF inhibitor. However, preliminary data from a large, double-blind randomized trial of otilimab (primary endpoint: alive and free of respiratory failure at Day 28) and published results of a small, double-blind randomized trial of mavrilimumab (primary endpoint: proportion alive and off supplemental oxygen at Day 14) did not show a survival benefit for the GM-CSF inhibitors compared to placebo.[11-13] The study populations differed; the lenzilumab and mavrilimumab studies primarily included patients on room air or low-flow oxygen and excluded patients receiving mechanical ventilation, whereas the otilimab study included only patients receiving high-flow oxygen, noninvasive ventilation, or invasive mechanical ventilation. Each of these GM-CSF inhibitors remains under investigation.

## Clinical Data for COVID-19

Lenzilumab, mavrilimumab, and otilimab have been evaluated in clinical trials in hospitalized adults with SARS-CoV-2 pneumonia.[11-13] Clinical data are not yet available for gimsilumab or namilumab. The Panel's recommendations are based on the results of the available clinical studies. Clinical data on the use of anti-GM-CSF monoclonal antibodies for the treatment of COVID-19 are summarized in Table 4c.

## Clinical Trials

See *ClinicalTrials.gov* for a list of ongoing clinical trials that are evaluating the use of GM-CSF inhibitors for the treatment of COVID-19.

## Adverse Effects

The primary risks associated with GM-CSF inhibitors being reported and evaluated are related to bacterial infection. Other adverse events that have been reported with these agents include acute kidney injury and elevated liver transaminases.[10] Autoimmune pulmonary alveolar proteinosis has been associated with a high-titer of anti-GM-CSF auto-antibodies.[14]

## Considerations in Pregnancy

Pregnant patients have been excluded from clinical trials evaluating GM-CSF inhibitors for the treatment of COVID-19. There is insufficient evidence to recommend for or against their use in pregnant individuals with COVID-19.

## Considerations in Children

There are no data on the use of GM-CSF inhibitors in children.

## References


1. Mehta P, Porter JC, Manson JJ, et al. Therapeutic blockade of granulocyte macrophage colony-stimulating factor in COVID-19-associated hyperinflammation: challenges and opportunities. *Lancet Respir Med*. 2020;8(8):822-830. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32559419.
2. Thwaites RS, Sanchez Sevilla Uruchurtu A, Siggins MK, et al. Inflammatory profiles across the spectrum of disease reveal a distinct role for GM-CSF in severe COVID-19. *Sci Immunol*. 2021;6(57). Available at: https://www.ncbi.nlm.nih.gov/pubmed/33692097.
3. Hamilton JA. GM-CSF in inflammation and autoimmunity. *Trends Immunol*. 2002;23(8):403-408. Available at: https://www.ncbi.nlm.nih.gov/pubmed/12133803.
4. Lotfi N, Thome R, Rezaei N, et al. Roles of GM-CSF in the pathogenesis of autoimmune diseases: an update. *Front Immunol*. 2019;10:1265. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31275302.
5. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497-506. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31986264.
6. Zhou Y, Fu B, Zheng X, et al. Aberrant pathogenic GM-CSF+ T cells and inflammatory CD14+CD16+ monocytes in severe pulmonary syndrome patients of a new coronavirus. *biorxiv*. 2020. Available at: https://www.biorxiv.org/content/10.1101/2020.02.12.945576v1.
7. De Luca G, Cavalli G, Campochiaro C, et al. GM-CSF blockade with mavrilimumab in severe COVID-19 pneumonia and systemic hyperinflammation: a single-centre, prospective cohort study. *Lancet Rheumatol*. 2020;2(8):e465-e473. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32835256.
8. Lang FM, Lee KM, Teijaro JR, Becher B, Hamilton JA. GM-CSF-based treatments in COVID-19: reconciling opposing therapeutic approaches. *Nat Rev Immunol*. 2020;20(8):507-514. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32576980.
9. Temesgen Z, Assi M, Shweta FNU, et al. GM-CSF Neutralization with lenzilumab in severe COVID-19 pneumonia: a case-cohort study. *Mayo Clin Proc*. 2020;95(11):2382-2394. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33153629.
10. Burmester GR, Feist E, Sleeman MA, Wang B, White B, Magrini F. Mavrilimumab, a human monoclonal antibody targeting GM-CSF receptor-alpha, in subjects with rheumatoid arthritis: a randomised, double-blind, placebo-controlled, Phase I, first-in-human study. *Ann Rheum Dis*. 2011;70(9):1542-1549. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21613310.
11. Patel J, Beishuizen A, Ruiz XB, et al. A randomized trial of otilimab in severe COVID-19 pneumonia (OSCAR). *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.14.21255475v1.

12. Temesgen Z, Burger CD, Baker J, et al. Lenzilumab efficacy and safety in newly hospitalized COVID-19 subjects: results from the live-air Phase 3 randomized double-blind placebo-controlled trial. *medRxiv*. 2021;Preprint. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33972949.
13. Cremer PC, Abbate A, Hudock K, et al. Mavrilimumab in patients with severe COVID-19 pneumonia and systemic hyperinflammation (MASH-COVID): an investigator initiated, multicentre, double-blind, randomised, placebo-controlled trial. *Lancet Rheumatol*. 2021;3(6):e410-e418. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33754144.
14. Chaulagain CP, Pilichowska M, Brinckerhoff L, Tabba M, Erban JK. Secondary pulmonary alveolar proteinosis in hematologic malignancies. *Hematol Oncol Stem Cell Ther*. 2014;7(4):127-135. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25300566.

# Table 4c. Granulocyte-Macrophage Colony-Stimulating Factor Inhibitors: Selected Clinical Data

*Last Updated: July 8, 2021*

The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing the recommendations for GM-CSF inhibitors. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Otilimab in Severe COVID-19 Pneumonia (OSCAR Trial)[1]** | | | |
| Phase 2, double-blind RCT in patients with severe COVID-19 pulmonary disease in 17 countries, including the United States (n = 806)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Hospitalized adults with confirmed SARS-CoV-2 pneumonia<br>• New onset of oxygenation impairment requiring high-flow oxygen (≥15 L/min), noninvasive ventilation, or IMV ≤48 hours before dosing<br>• CRP or ferritin >ULN<br>**Key Exclusion Criteria:**<br>• Death considered likely within 48 hours<br>• Multiple organ failure<br>• SOFA score >10 if in the ICU<br>• ECMO<br>• Dialysis<br>• High-dose noradrenaline (>0.15 ug/kg/min) or equivalent<br>• More than 1 vasopressor<br>**Interventions**<br>*1:1 Randomization:*<br>• Otilimab 90 mg IV as a single infusion<br>• Placebo | **Number of Participants:**<br>• mITT analysis (n = 793): otilimab (n = 395) and placebo (n = 398)<br>• Participants were enrolled from May 28–November 15, 2020, across 108 study sites.<br>**Participant Characteristics:**<br>• Mean age was 59 years.<br>• 77% received high-flow oxygen or noninvasive ventilation.<br>• 22% were on IMV.<br>• 52% were in the ICU but not on IMV.<br>• 83% received corticosteroids; 34% received RDV<br>• Participants were stratified by clinical status (ordinal scale 5 or 6) and age (<60 years, 60–69 years, and ≥70 years).<br>**Primary Outcome:**<br>• 277 of 389 participants (71%) in the otilimab arm vs. 262 of 393 participants (67%) in the placebo arm were alive and free of respiratory failure at Day 28 (model-adjusted absolute difference of 5.3%; 95% CI, -0.8 to 11.4; $P$ = 0.09)<br>**Key Secondary Outcomes:**<br>• No difference in all-cause mortality at Day 60 between the otilimab arm and the placebo arm (23% vs. 24%; model-adjusted difference -2.4%; 95% CI, -8.0 to 3.3; $P$ = 0.41) | **Key Limitations:**<br>• Changes in SOC occurred during the study period and may have affected outcomes.<br>• A preplanned subgroup analysis suggested a benefit of otilimab in participants aged ≥70 years, but subgroup analyses were not adjusted for multiple comparisons.<br>**Interpretation:**<br>• In this large study, no differences in outcomes were observed between the otilimab or placebo recipients with severe COVID-19 pneumonia, except for those in a subgroup of participants aged ≥70 years. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Otilimab in Severe COVID-19 Pneumonia (OSCAR Trial)[1]**, continued | | | |
| | **Primary Endpoint:**<br>• Proportion of participants alive and free of respiratory failure at Day 28<br>**Key Secondary Endpoints:**<br>• All-cause mortality at Day 60 and time to all-cause mortality<br>• Time to recovery<br>• Admission to ICU<br>• Time to ICU discharge | • No difference between the arms for other secondary endpoints<br>• In a preplanned analysis, a benefit of otilimab was observed among those aged ≥70 years (n = 180):<br>  • 65.1% of otilimab recipients vs. 45.9% of placebo recipients met the primary endpoint (model-adjusted difference 19.1%; 95% CI, 5.2–33.1; *P* = 0.009)<br>  • Mortality at Day 60 was lower in otilimab arm than in placebo arm (27% vs. 41%; model-adjusted difference of 14.4%; 95% CI, 0.9–27.9; *P* = 0.04). | |
| **Lenzilumab in Hospitalized Patients With COVID-19 Pneumonia (LIVE-AIR Trial)[2]** | | | |
| Phase 3, double-blind RCT in hospitalized patients with severe COVID-19 pneumonia in the United States and Brazil (n = 520 across 29 study sites)<br>*This is a preliminary report that has not yet been peer reviewed.* | **Key Inclusion Criteria:**<br>• Hospitalized adults with confirmed SARS-CoV-2 pneumonia<br>• $SpO_2$ ≤94% on room air or requiring low-flow supplemental oxygen, high-flow oxygen support, or NIPPV<br>**Key Exclusion Criteria:**<br>• Requiring IMV<br>• Pregnancy<br>• Confirmed bacterial pneumonia or active/uncontrolled fungal or viral infection<br>• Not expected to survive the 48 hours following randomization<br>• Use of IL-1 inhibitors, IL-6 inhibitors, kinase inhibitors, or SARS-CoV-2 neutralizing monoclonal antibodies within prior 8 weeks | **Number of Participants:**<br>• mITT (n = 479): lenzilumab (n = 236) and placebo (n = 243)<br>**Participant Characteristics:**<br>• Mean age was 60.5 years.<br>• 64.7% were men.<br>• 43.2% were White.<br>• 55.1% had a BMI ≥30.<br>• 40.5% received high-flow oxygen support or NIPPV at baseline.<br>• 93.7% received corticosteroids; 72.4% received RDV; 69.1% received both corticosteroids and RDV.<br>**Primary Outcome:**<br>• Lenzilumab improved ventilator-free survival through Day 28:<br>  • mITT participants: HR 1.54; 95% CI, 1.02–2.31; *P* = 0.041<br>  • ITT participants: HR 1.90; 95% CI, 1.02–3.52; *P* = 0.043 | **Key Limitations:**<br>• The study was not powered to detect a survival benefit.<br>• There were differences in access to supportive care across the study sites.<br>**Interpretation:**<br>• In this large, unpublished, placebo-controlled study, lenzilumab improved ventilator-free survival in participants who were hypoxic but not mechanically ventilated. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Lenzilumab in Hospitalized Patients With COVID-19 Pneumonia (LIVE-AIR Trial)[2]**, continued | | | |
| | **Interventions**<br>*1:1 Randomization:*<br>• Lenzilumab 600 mg IV every 8 hours for 3 doses<br>• Placebo<br>**Primary Endpoint:**<br>• Ventilator-free survival through Day 28 (composite endpoint of time to death and time to IMV)<br>**Key Secondary Endpoints:**<br>• Survival<br>• Proportion of IMV, ECMO, or death<br>• Time to recovery | • Kaplan-Meier estimate for proportion of participants who had required IMV or died through Day 28:<br>  • mITT lenzilumab arm: 15.6% (95% CI, 11.5–21.0); placebo arm: 22.1% (95% CI, 17.4–27.9)<br>  • ITT lenzilumab arm: 18.9% (95% CI, 14.5–24.3); placebo arm: 23.6% (95% CI, 18.8–29.3)<br>• Primary outcome sensitivity mITT analyses showed lenzilumab improved the likelihood of ventilator-free survival in participants:<br>  • Aged <85 years with CRP <150 mg/L (n = 336): HR 2.96; 95% CI, 1.63–5.37; $P = 0.0003$<br>  • Receiving corticosteroids plus RDV (n = 331): HR 1.92; 95% CI, 1.20–3.07; $P = 0.0067$<br>  • Hospitalized ≤2 days prior to randomization (n = 297): HR 1.88; 95% CI, 1.13–3.12; $P = 0.015$<br>**Key Secondary Outcomes:**<br>• No difference in proportion of participants who died: 9.6% in lenzilumab arm vs. 13.9% in placebo arm (HR 1.38; 95% CI, 0.81–2.37; $P = 0.239$)<br>• No difference between the arms in the incidence of IMV, ECMO, or death: HR 0.67; 95% CI, 0.41–1.10; $P = 0.111$<br>• No difference between the arms in time to recovery: HR 1.09; 95% CI, 0.88–1.35; $P = 0.43$) | |
| **Mavrilimumab in Patients With Severe COVID-19 Pneumonia and Systemic Hyperinflammation (MASH-COVID Trial)[3]** | | | |
| Multicenter, double-blind RCT in hospitalized patients with COVID-19 pneumonia in the United States (n = 40) | **Key Inclusion Criteria:**<br>• Hospitalization with SARS-CoV-2 pneumonia<br>• Hypoxemia ($SpO_2$ <92% or requirement for supplemental oxygen)<br>• CRP >5 mg/dL | **Number of Participants:**<br>• Mavrilimumab (n = 21) and placebo (n = 19)<br>• Study enrollment was from May 28–September 15, 2020.<br>**Participant Characteristics:**<br>• 65% were men.<br>• 40% were African American. | **Key Limitations:**<br>• The small sample size resulted in low power to identify a clinically meaningful treatment effect.<br>• The study was stopped early due to slow enrollment. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Mavrilimumab in Patients With Severe COVID-19 Pneumonia and Systemic Hyperinflammation (MASH-COVID Trial)[3]**, continued | | | |
| Multicenter, double-blind RCT in hospitalized patients with COVID-19 pneumonia in the United States (n = 40) | **Key Exclusion Criteria:**<br>• Mechanical ventilation<br>• ANC <1,500/mm$^3$<br>• Uncontrolled bacterial infection<br>**Interventions**<br>*1:1 Randomization:*<br>• Mavrilimumab 6 mg/kg as a single IV infusion<br>• Placebo<br>**Primary Endpoint:**<br>• Proportion of participants alive and off supplemental oxygen at Day 14<br>**Key Secondary Endpoints:**<br>• Survival at Day 28<br>• Respiratory failure-free survival at Day 28 | • 50% required nasal high-flow oxygen or noninvasive ventilation.<br>• Corticosteroids use: 67% in the mavrilimumab arm, 63% in the placebo arm<br>• RDV use: 76% in the mavrilimumab arm, 74% in the placebo arm<br>**Primary Outcome:**<br>• No significant difference in primary outcome: 12 of 21 participants (57%) in the mavrilimumab arm vs. 9 of 19 participants (47%) in the placebo arm (OR 1.48; 95% CI, 0.43–5.16; *P* = 0.76)<br>**Key Secondary Outcomes:**<br>• No difference in survival: 1 participant in the mavrilimumab arm vs. 3 in the placebo arm had died by Day 28 (HR 3.72; 95% CI, 0.39–35.79; *P* = 0.22)<br>• No difference in respiratory failure free survival at Day 28: 20 participants (95%) in the mavrilimumab arm vs. 15 (79%) in the placebo arm (OR 5.33; 95% CI, 0.54–52.7; *P* = 0.43) | **Interpretation:**<br>• In this small study, no differences in outcomes were observed between the mavrilimumab and placebo arms among participants who were not mechanically ventilated. |

**Key:** ANC = absolute neutrophil count; BMI = body mass index; CRP = C-reactive protein; ECMO = extracorporeal membrane oxygenation; GM-CSF = granulocyte macrophage-colony stimulating factor; ICU = intensive care unit; IL = interleukin; IMV = invasive mechanical ventilation; ITT = intention-to-treat; IV = intravenous; mITT = modified intention-to-treat; NIPPV = noninvasive positive pressure ventilation; the Panel = the COVID-19 Treatment Guidelines Panel; RCT = randomized controlled trial; RDV = remdesivir; SOC = standard of care; SOFA = sequential organ failure assessment; $SpO_2$ = oxygen saturation; ULN = upper limit of normal

## References


1. Patel J, Beishuizen A, Ruiz XB, et al. A randomized trial of otilimab in severe COVID-19 pneumonia (OSCAR). *medRxiv*. 2021. Available at: https://www.medrxiv.org/content/10.1101/2021.04.14.21255475v1.
2. Temesgen Z, Burger CD, Baker J, et al. Lenzilumab efficacy and safety in newly hospitalized COVID-19 subjects: results from the live-air Phase 3 randomized double-blind placebo-controlled trial. *medRxiv*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33972949.
3. Cremer PC, Abbate A, Hudock K, et al. Mavrilimumab in patients with severe COVID-19 pneumonia and systemic hyperinflammation (MASH-COVID): an investigator initiated, multicentre, double-blind, randomised, placebo-controlled trial. *Lancet Rheumatol*. 2021;3(6):e410-e418. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33754144.

# Immunoglobulins: Non-SARS-CoV-2 Specific

*Last Updated: July 17, 2020*

## Recommendation

- The COVID-19 Treatment Guidelines Panel **recommends against** the use of non-severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)-specific **intravenous immunoglobulin (IVIG)** for the treatment of COVID-19, except in a clinical trial **(AIII)**. This recommendation **should not preclude** the use of IVIG when otherwise indicated for the treatment of complications that arise during the course of COVID-19.

## Rationale for Recommendation

It is unknown whether products derived from the plasma of donors without confirmed SARS-CoV-2 infection contain high titer of SARS-CoV-2 neutralizing antibodies. Furthermore, although other blood components in IVIG may have general immunomodulatory effects, it is unclear whether these theoretical effects will benefit patients with COVID-19.

## Clinical Data for COVID-19

*This study has not been peer reviewed.*

A retrospective, non-randomized cohort study of IVIG for the treatment of COVID-19 was conducted across eight treatment centers in China between December 2019 and March 2020. The study showed no difference in 28-day or 60-day mortality between 174 patients who received IVIG and 151 patients who did not receive IVIG.[1] More patients in the IVIG group had severe disease at study entry (71 patients [41%] with critical status in the IVIG group vs. 32 patients [21%] in the non-IVIG group). The median hospital stay was longer in the IVIG group (24 days) than in the non-IVIG group (16 days), and the median duration of disease was also longer (31 days in the IVIG group vs. 23 days in the non-IVIG group). A subgroup analysis that was limited to the critically ill patients suggested a mortality benefit at 28 days, which was no longer significant at 60 days.

The results of this study are difficult to interpret because of important limitations in the study design. In particular, patients were not randomized to receive either IVIG or no IVIG, and the patients in the IVIG group were older and more likely to have coronary heart disease than those in the non-IVG group. In addition, the IVIG group had a higher proportion of patients with severe COVID-19 disease at study entry. Patients in both groups also received many concomitant therapies for COVID-19.

## Considerations in Pregnancy

IVIG is commonly used in pregnancy for other indications such as immune thrombocytopenia with an acceptable safety profile.[2,3]

## Considerations in Children

IVIG has been widely used in children for the treatment of a number of conditions. including Kawasaki disease, and is generally safe.[4] IVIG has been used in pediatric patients with COVID-19 and multiorgan inflammatory syndrome in children (MIS-C), especially those with a Kawasaki disease-like presentation, but the efficacy of IVIG in the management of MIS-C is still under investigation.

## References


1. Shao Z, Feng Y, Zhong L, et al. Clinical efficacy of intravenous immunoglobulin therapy in critical patients with COVID-19: A multicenter retrospective cohort study. *medRxiv*. 2020;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2020.04.11.20061739v2.
2. Committee on Practice Bulletins—Obstetrics. ACOG practice bulletin No. 207: thrombocytopenia in pregnancy. *Obstet Gynecol*. 2019;133(3):e181-e193. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30801473.
3. Neunert C, Lim W, Crowther M, et al. The American Society of Hematology 2011 evidence-based practice guideline for immune thrombocytopenia. *Blood*. 2011;117(16):4190-4207. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21325604.
4. Agarwal S, Agrawal DK. Kawasaki disease: etiopathogenesis and novel treatment strategies. *Expert Rev Clin Immunol*. 2017;13(3):247-258. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27590181.

# Interferons (Alfa, Beta)

*Last Updated: August 27, 2020*

Interferons are a family of cytokines with antiviral properties. They have been suggested as a potential treatment for COVID-19 because of their *in vitro* and *in vivo* antiviral properties.

## Recommendation

The COVID-19 Treatment Guidelines Panel **recommends against** the use of interferons for the treatment of patients with severe or critical COVID-19, except in a clinical trial **(AIII)**. There is insufficient evidence to recommend either for or against the use of **interferon beta** for the treatment of early (i.e., <7 days from symptom onset) mild and moderate COVID-19.

## Rationale

Studies have shown no benefit of interferons in patients with other coronavirus infections (i.e., Middle East respiratory syndrome [MERS], severe acute respiratory syndrome [SARS]) who have severe or critical disease. In addition, interferons have significant toxicities that outweigh the potential for benefit. Interferons may have antiviral activity early in the course of infection. However, there is insufficient data to assess the potential benefit of interferon use during early disease versus the toxicity risks.

## Clinical Data for COVID-19

### *Interferon Beta-1a*

*Press release, July 20, 2020:* A double-blind, placebo-controlled trial conducted in the United Kingdom evaluated inhaled interferon beta-1a (once daily for up to 14 days) in nonventilated patients hospitalized with COVID-19. Compared to the patients receiving placebo (n = 50), the patients receiving inhaled interferon beta-1a (n = 48) were more likely to recover to ambulation without restrictions (HR 2.19; 95% CI, 1.03–4.69; $P = 0.04$), had decreased odds of developing severe disease (OR 0.21; 95% CI, 0.04–0.97; $P = 0.046$), and had less breathlessness. Additional detail is required to fully evaluate these findings and their implications. Of note, inhaled interferon beta-1a as used in this study is not commercially available in the United States.[1]

*Preprint manuscript posted online, July 13, 2020:* An open-label, randomized trial at a single center in Iran evaluated subcutaneous interferon beta-1a (three times weekly for 2 weeks) in patients with severe COVID-19. There was no difference in the primary outcome of time to clinical response between the interferon beta-1a group (n = 42) and the control group (n = 39), and there was no difference between the groups in overall length of hospital stay, length of intensive care unit stay, or duration of mechanical ventilation. The reported 28-day overall mortality was lower in the interferon beta-1a group; however, four patients in the interferon beta-1a group who died before receiving the fourth dose of interferon beta-1a were excluded from the analysis, which makes it difficult to interpret these results.[2]

### *Combination of Interferon Beta-1b, Lopinavir/Ritonavir, and Ribavirin in the Treatment of Hospitalized Patients With COVID-19*

An open-label, Phase 2 clinical trial randomized 127 participants (median age of 52 years) 2:1 to combination antiviral therapy or lopinavir/ritonavir. In the combination antiviral therapy group, the treatment regimen differed by time from symptom onset to hospital admission. Participants hospitalized within 7 days of symptom onset (n = 76) were randomized to triple drug therapy (interferon beta-1b 8 million units administered subcutaneously every other day for up to 7 days total, lopinavir/ritonavir, and ribavirin); those hospitalized ≥7 days after symptom onset (n = 51) were randomized to double

therapy (lopinavir/ritonavir and ribavirin) because of concerns regarding potential inflammatory effects of interferon. Patients in the control group received lopinavir/ritonavir alone regardless of the time from symptom onset to hospitalization. The study participants were patients in Hong Kong with confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection who were hospitalized, regardless of disease severity, until they had two negative nasopharyngeal (NP) swab tests.

The time to a negative result on a polymerase chain reaction SARS-CoV-2 test on an NP swab (the primary endpoint) was shorter in the combination therapy group than in the control group (median of 7 days vs. 12 days; $P = 0.001$). The combination group had more rapid clinical improvement as assessed by the National Early Warning Score (NEWS) 2 and Sequential Organ Failure Assessment (SOFA) score and a shorter hospital stay (median of 9 days for the combination group vs. 14.5 days for the control group; $P = 0.016$). There was no difference in oxygen use between the groups. The antiviral and clinical effect was more pronounced in the patients hospitalized within 7 days of symptom onset, suggesting that interferon beta-1b with or without ribavirin was the critical component of the combination antiviral therapy. The study provides no information about the effect of interferon beta-1b when administered ≥7 days after symptom onset.[3]

### *Interferon Alfa-2b*

In a retrospective cohort study of 77 adults with moderate COVID-19 in China, participants were treated with nebulized interferon alfa-2b, nebulized interferon alfa-2b with umifenovir, or umifenovir only. The time to viral clearance in the upper respiratory tract and reduction in systemic inflammation was faster in the interferon alfa-2b groups than in the umifenovir only group. However, the results of this study are difficult to interpret because participants in the interferon alfa-2b with umifenovir group were substantially younger than those in the umifenovir only group (mean age of 40 years in the interferon alfa-2b with umifenovir group vs. 65 years in the umifenovir only group) and had fewer comorbidities (15% in the interferon alfa-2b with umifenovir group vs. 54% in the umifenovir only group) at study entry. The nebulized interferon alfa-2b formulation is not approved by the Food and Drug Administration for use in the United States.[4]

### *Clinical Data for SARS and MERS*

Interferon beta used alone and in combination with ribavirin in patients with SARS and MERS has failed to show a significant positive effect on clinical outcomes.[5-9]

In a retrospective observational analysis of 350 critically ill patients with MERS[6] from 14 hospitals in Saudi Arabia, the mortality rate was higher among patients who received ribavirin and interferon (beta-1a, alfa-2a, or alfa-2b) than among those who did not receive either drug.

A randomized clinical trial that included 301 patients with acute respiratory distress syndrome[10] found that intravenous interferon beta-1a had no benefit over placebo as measured by ventilator-free days over a 28-day period (median of 10.0 days in the interferon beta-1a group vs. 8.5 days in the placebo group) or mortality (26.4% in the interferon beta-1a group vs. 23.0% in the placebo group).

### *Clinical Trials*

See *ClinicalTrials.gov* for a list of ongoing clinical trials for interferon and COVID-19.

## Adverse Effects

The most frequent adverse effects of interferon alfa include flu-like symptoms, nausea, fatigue, weight loss, hematological toxicities, elevated transaminases, and psychiatric problems (e.g., depression and suicidal ideation). Interferon beta is better tolerated than interferon alfa.[11,12]

## Drug-Drug Interactions

The most serious drug-drug interactions with interferons are the potential for added toxicity with concomitant use of other immunomodulators and chemotherapeutic agents.[11,12]

## Considerations in Pregnancy

Analysis of data from several large pregnancy registries did not demonstrate an association between exposure to interferon beta-1b preconception or during pregnancy and an increased risk of adverse birth outcomes (e.g., spontaneous abortion, congenital anomaly),[13,14] and exposure did not influence birth weight, height, or head circumference.[15]

## Considerations in Children

There are limited data on the use of interferons for the treatment of respiratory viral infections in children.

## References


1. Synairgen announces positive results from trial of SNG001 in hospitalised COVID-19 patients [press release]. July 20, 2020. Available at: https://www.synairgen.com/wp-content/uploads/2020/07/200720-Synairgen-announces-positive-results-from-trial-of-SNG001-in-hospitalised-COVID-19-patients.pdf. Accessed August 24, 2020.
2. Davoudi-Monfared E, Rahmani H, Khalili H, et al. A randomized clinical trial of the efficacy and safety of interferon beta-1a in treatment of severe COVID-19. *Antimicrob Agents Chemother*. 2020;64(9):e01061-20. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32661006.
3. Hung IF, Lung KC, Tso EY, et al. Triple combination of interferon beta-1b, lopinavir-ritonavir, and ribavirin in the treatment of patients admitted to hospital with COVID-19: an open-label, randomised, Phase 2 trial. *Lancet*. 2020;395(10238):1695-1704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32401715.
4. Zhou Q, Chen V, Shannon CP, et al. Interferon-alpha2b treatment for COVID-19. *Front Immunol*. 2020;11:1061. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32574262.
5. Al-Tawfiq JA, Momattin H, Dib J, Memish ZA. Ribavirin and interferon therapy in patients infected with the Middle East respiratory syndrome coronavirus: an observational study. *Int J Infect Dis*. 2014;20:42-46. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24406736.
6. Arabi YM, Shalhoub S, Mandourah Y, et al. Ribavirin and interferon therapy for critically ill patients with Middle East respiratory syndrome: a multicenter observational study. *Clin Infect Dis*. 2020;70(9):1837-1844. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31925415.
7. Chu CM, Cheng VC, Hung IF, et al. Role of lopinavir/ritonavir in the treatment of SARS: initial virological and clinical findings. *Thorax*. 2004;59(3):252-256. Available at: https://www.ncbi.nlm.nih.gov/pubmed/14985565.
8. Omrani AS, Saad MM, Baig K, et al. Ribavirin and interferon alfa-2a for severe Middle East respiratory syndrome coronavirus infection: a retrospective cohort study. *Lancet Infect Dis*. 2014;14(11):1090-1095. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25278221.
9. Shalhoub S, Farahat F, Al-Jiffri A, et al. IFN-alpha2a or IFN-beta1a in combination with ribavirin to treat Middle East respiratory syndrome coronavirus pneumonia: a retrospective study. *J Antimicrob Chemother*. 2015;70(7):2129-2132. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25900158.
10. Ranieri VM, Pettila V, Karvonen MK, et al. Effect of intravenous interferon beta-1a on death and days free from mechanical ventilation among patients with moderate to severe acute respiratory distress syndrome: a randomized clinical trial. *JAMA*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32065831.
11. Interferon alpha-2b (Intron A) [package insert]. Food and Drug Administration. 2018. Available at:

https://www.accessdata.fda.gov/drugsatfda_docs/label/2018/103132Orig1s5199lbl.pdf.

12. Interferon beta-1a (Rebif) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/103780s5204lbl.pdf.
13. Sandberg-Wollheim M, Alteri E, Moraga MS, Kornmann G. Pregnancy outcomes in multiple sclerosis following subcutaneous interferon beta-1a therapy. *Mult Scler*. 2011;17(4):423-430. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21220368.
14. Hellwig K, Duarte Caron F, Wicklein EM, Bhatti A, Adamo A. Pregnancy outcomes from the global pharmacovigilance database on interferon beta-1b exposure. *Ther Adv Neurol Disord*. 2020;13:1756286420910310. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32201504.
15. Burkill S, Vattulainen P, Geissbuehler Y, et al. The association between exposure to interferon-beta during pregnancy and birth measurements in offspring of women with multiple sclerosis. *PLoS One*. 2019;14(12):e0227120. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31887199.

# Interleukin-1 Inhibitors

*Last Updated: July 17, 2020*

## Recommendation

- There is insufficient evidence to recommend for or against the use of interleukin (IL)-1 inhibitors, such as **anakinra**, for the treatment of COVID-19.

## Rationale

There are case series data but no clinical trial data on the use of IL-1 inhibitors in patients with COVID-19.

Anakinra is a recombinant human IL-1 receptor antagonist. It is approved by the Food and Drug Administration (FDA) to treat rheumatoid arthritis and cryopyrin-associated periodic syndromes, specifically neonatal-onset multisystem inflammatory disease.[1] It is also used off-label for severe chimeric antigen receptor T cell (CAR T-cell)-mediated cytokine release syndrome (CRS) and macrophage activation syndrome (MAS)/secondary hemophagocytic lymphohistiocytosis.

## Rationale for Use in Patients with COVID-19

Endogenous IL-1 is elevated in patients with COVID-19 and other conditions, such as severe CAR T-cell-mediated CRS. Case reports and case series have described favorable responses to anakinra in patients with these syndromes, including a survival benefit in patients with sepsis and reversal of cytokine storm after tocilizumab failure in adults with MAS.[2,3]

## Clinical Data for COVID-19

- A case-control study compared outcomes in 52 consecutive patients with COVID-19 treated with anakinra and 44 historical controls. The patients in both groups were all admitted to the same hospital in Paris, France. Case patients were consecutive admissions from March 24 to April 6, 2020, with laboratory-confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection or lung infiltrates on chest imaging typical of COVID-19, and either significant hypoxia ($SpO_2$ ≤93% with ≥6L/min $O_2$) or worsening hypoxia ($SpO_2$ ≤93% with >3L/min $O_2$ and a loss of ≥3% of $O_2$ saturation on room air in the previous 24 hours). The historic controls were patients who fulfilled the same eligibility criteria and admitted to the hospital during the same period. As standard of care for both groups, some patients received hydroxychloroquine, azithromycin, or parenteral beta-lactam antibiotics. Anakinra was dosed as 100 mg subcutaneous (SQ) twice daily for 72 hours, followed by anakinra 100 mg SQ daily for 7 days. Clinical characteristics were similar between the groups, except that the cases had a lower mean body mass index than the controls (25.5 kg/m$^2$ vs. 29.0 kg/m$^2$, respectively), longer duration of symptoms (mean of 8.4 days for cases vs. 6.2 days for controls), and a higher frequency of hydroxychloroquine use (90% for cases vs. 61% for controls) and azithromycin use (49% for cases vs. 34% for controls). The primary outcome of admission to the intensive care unit for mechanical ventilation or death occurred among 13 case patients (25%) and 32 control patients (73%) (hazard ratio 0.22; 95% confidence interval, 0.11 to 0.41). However, within the first 2 days of follow up, in the control group, six patients (14%) had died and 19 patients (43%) had reached the composite primary outcome, which further limited intragroup comparisons and specifically analyses of time to event. C-reactive protein (CRP) levels decreased by Day 4 among those receiving anakinra. Thromboembolic events occurred in 10 patients (19%) who received anakinra and in five control patients (11%). The clinical implications of these findings are uncertain due to limitations in the

study design related to unmeasured confounding combined with the very high early event rate among the retrospective controls.[4]

- A single-center, retrospective cohort study compared outcomes in 29 patients following open-label use of anakinra to outcomes in 16 historical controls enrolled at the same medical center in Italy. All patients had COVID-19 with moderate to severe acute respiratory distress syndrome (ARDS) that required non-invasive ventilation and evidence of hyperinflammation (CRP ≥100 mg/L and/or ferritin ≥900 ng/mL). High-dose intravenous anakinra 5 mg/kg twice daily was administered for a median of 9 days, followed by SQ administration of anakinra 100 mg twice daily for 3 days to avoid inflammatory relapses. Patients in both the anakinra and control groups received hydroxychloroquine and lopinavir/ritonavir. In the anakinra group, reductions in CRP levels were noted over several days following anakinra initiation, and the 21-day survival rate was higher than in the control group (90% vs. 56%, respectively; $P = 0.009$). However, the patients in the anakinra group were younger than those in the control group (median age 62 years vs. 70 years, respectively), and fewer patients in the anakinra group had chronic kidney disease. High-dose anakinra was discontinued in seven patients (24%) because of adverse events (four patients developed bacteremia and three patients had elevated liver enzymes); however, retrospective assessment showed that these events occurred with similar frequency in the control group. An additional group of seven patients received low-dose SQ anakinra 100 mg twice daily; however, treatment in this group was stopped after 7 days because of lack of clinical or anti-inflammatory effects.[5]
- Other small case series have reported anakinra use for the treatment of COVID-19 and anecdotal evidence of improvement in outcomes.[6]

## Clinical Trials

See *ClinicalTrials.gov* for a list of clinical trials evaluating anakinra for the treatment of COVID-19.

## Adverse Effects

Anakinra was not associated with any significant safety concerns when used in clinical trials for the treatment of sepsis.[7-9] Increased rates of infection were reported with prolonged anakinra use in combination with tumor necrosis factor-alpha blockade, but not with short-term use.[10]

## Considerations in Pregnancy

There is limited evidence on which to base a recommendation in pregnancy, but unintentional first trimester exposure is unlikely to be harmful.[11]

## Considerations in Children

Anakinra has been used extensively in the treatment of severely ill children with complications of rheumatologic conditions, including MAS. Pediatric data on the use of anakinra in ARDS/sepsis are limited.

## Drug Availability

Procuring anakinra may be a challenge at some hospitals in the United States. Anakinra is FDA-approved only for SQ injection.

## References

1. Anakinra (kineret) [package insert]. Food and Drug Administration. 2012. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2012/103950s5136lbl.pdf. Accessed April 8, 2020.

2. Shakoory B, Carcillo JA, Chatham WW, et al. Interleukin-1 receptor blockade is associated with reduced mortality in sepsis patients with features of macrophage activation syndrome: reanalysis of a prior Phase III trial. *Crit Care Med*. 2016;44(2):275-281. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26584195.
3. Monteagudo LA, Boothby A, Gertner E. Continuous intravenous anakinra infusion to calm the cytokine storm in macrophage activation syndrome. *ACR Open Rheumatol*. 2020;2(5):276-282. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32267081.
4. Huet T, Beaussier H, Voisin O, et al. Anakinra for severe forms of COVID-19: a cohort study. *Lancet Rheumatology*. 2020;2(7):e393-e400. Available at: https://www.theLancet.com/pdfs/journals/lanrhe/PIIS2665-9913(20)30164-8.pdf.
5. Cavalli G, De Luca G, Campochiaro C, et al. Interleukin-1 blockade with high-dose anakinra in patients with COVID-19, acute respiratory distress syndrome, and hyperinflammation: a retrospective cohort study. *Lancet Rheumatology*. 2020;2(6): e325-e331. Available at: https://www.theLancet.com/journals/lanrhe/article/PIIS2665-9913(20)30127-2/fulltext.
6. Aouba A, Baldolli A, Geffray L, et al. Targeting the inflammatory cascade with anakinra in moderate to severe COVID-19 pneumonia: case series. *Ann Rheum Dis*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32376597.
7. Fisher CJ, Jr., Dhainaut JF, Opal SM, et al. Recombinant human interleukin 1 receptor antagonist in the treatment of patients with sepsis syndrome. Results from a randomized, double-blind, placebo-controlled trial. Phase III rhIL-1ra Sepsis Syndrome Study Group. *JAMA*. 1994;271(23):1836-1843. Available at: https://www.ncbi.nlm.nih.gov/pubmed/8196140.
8. Fisher CJ, Jr., Slotman GJ, Opal SM, et al. Initial evaluation of human recombinant interleukin-1 receptor antagonist in the treatment of sepsis syndrome: a randomized, open-label, placebo-controlled multicenter trial. *Crit Care Med*. 1994;22(1):12-21. Available at: https://www.ncbi.nlm.nih.gov/pubmed/8124953.
9. Opal SM, Fisher CJ, Jr., Dhainaut JF, et al. Confirmatory interleukin-1 receptor antagonist trial in severe sepsis: a Phase III, randomized, double-blind, placebo-controlled, multicenter trial. The Interleukin-1 Receptor Antagonist Sepsis Investigator Group. *Crit Care Med*. 1997;25(7):1115-1124. Available at: https://www.ncbi.nlm.nih.gov/pubmed/9233735.
10. Winthrop KL, Mariette X, Silva JT, et al. ESCMID Study Group for Infections in Compromised Hosts (ESGICH) consensus document on the safety of targeted and biological therapies: an infectious diseases perspective (soluble immune effector molecules [II]: agents targeting interleukins, immunoglobulins and complement factors). *Clin Microbiol Infect*. 2018;24 Suppl 2:S21-S40. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29447987.
11. Flint J, Panchal S, Hurrell A, et al. BSR and BHPR guideline on prescribing drugs in pregnancy and breastfeeding-Part II: analgesics and other drugs used in rheumatology practice. *Rheumatology (Oxford)*. 2016;55(9):1698-1702. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26750125.

# Interleukin-6 Inhibitors

*Last Updated: April 21, 2021*

Interleukin (IL)-6 is a pleiotropic, proinflammatory cytokine produced by a variety of cell types, including lymphocytes, monocytes, and fibroblasts. Infection by the severe acute respiratory syndrome-associated coronavirus (SARS-CoV) induces a dose-dependent production of IL-6 from bronchial epithelial cells.[1] COVID-19-associated systemic inflammation and hypoxic respiratory failure can be associated with heightened cytokine release, as indicated by elevated blood levels of IL-6, C-reactive protein (CRP), D-dimer, and ferritin.[2-4] It is hypothesized that modulating the levels of IL-6 or its effects may reduce the duration and/or severity of COVID-19 illness.

There are two classes of Food and Drug Administration (FDA)-approved IL-6 inhibitors: anti-IL-6 receptor monoclonal antibodies (e.g., sarilumab, tocilizumab) and anti-IL-6 monoclonal antibodies (i.e., siltuximab). These drugs have been evaluated for the management of patients with COVID-19 who have systemic inflammation. The COVID-19 Treatment Guidelines Panel's (the Panel's) recommendations on the use IL-6 inhibitors in patients with COVID-19 and related clinical data to date are described below.

## Recommendations

- The Panel recommends using **tocilizumab** (single intravenous [IV] dose of tocilizumab 8 mg/kg actual body weight up to 800 mg) **in combination with dexamethasone** (6 mg daily for up to 10 days) in certain hospitalized patients who are exhibiting rapid respiratory decompensation due to COVID-19. These patients are:
  - Recently hospitalized patients (i.e., within first 3 days of admission) who have been admitted to the intensive care unit (ICU) within the prior 24 hours and who require invasive mechanical ventilation, noninvasive ventilation, or high-flow nasal canula (HFNC) oxygen (>0.4 $FiO_2$/30 L/min of oxygen flow) **(BIIa)**; *or*
  - Recently hospitalized patients (i.e., within first 3 days of admission) not admitted to the ICU who have rapidly increasing oxygen needs and require noninvasive ventilation or HFNC oxygen and who have significantly increased markers of inflammation (CRP ≥75 mg/L) **(BIIa)**.
- For hospitalized patients with hypoxemia who require conventional oxygen therapy, there is insufficient evidence to specify which of these patients would benefit from the addition of tocilizumab. Some Panel members would also give tocilizumab to patients who are exhibiting rapidly increasing oxygen needs while on dexamethasone and have a CRP ≥75 mg/L, but who do not yet require noninvasive ventilation or HFNC oxygen as described above.
- There is insufficient evidence for the Panel to recommend either for or against the use of sarilumab for hospitalized patients with COVID-19 who are within 24 hours of admission to the ICU and who require invasive mechanical ventilation, noninvasive ventilation, or high-flow oxygen (>0.4 $FiO_2$/30 L/min of oxygen flow).
- The Panel **recommends against** the use of anti-IL-6 monoclonal antibody therapy (i.e., **siltuximab**) for the treatment of COVID-19, except in a clinical trial **(BI)**.

### *Additional Considerations*

- Tocilizumab **should be avoided** in patients who are significantly immunosuppressed, particularly in those with recent use of other biologic immunomodulating drugs, and in patients who have alanine aminotransferase >5 times the upper limit of normal; high risk for gastrointestinal perforation; an uncontrolled serious bacterial, fungal, or non-SARS-CoV-2 viral

infection; absolute neutrophil count <500 cells/μL; platelet count <50,000 cells/μL; or known hypersensitivity to tocilizumab.

- Tocilizumab should only be given in combination with a course of dexamethasone (or an alternative corticosteroid at a dose equivalency to dexamethasone 6 mg) therapy.
- Some clinicians may assess the patient's clinical response to dexamethasone before deciding whether tocilizumab is needed.
- Although some patients in the Randomised, Embedded, Multi-factorial Adaptive Platform Trial for Community-Acquired Pneumonia (REMAP-CAP) and the Randomised Evaluation of COVID-19 Therapy (RECOVERY) trial received a second dose of tocilizumab at the discretion of treating physicians, there is insufficient evidence to indicate which patients, if any, would benefit from an additional dose of tocilizumab.
- Cases of severe and disseminated strongyloidiasis have been reported with use of tocilizumab and corticosteroids in patients with COVID-19.[5,6] Prophylactic treatment with ivermectin should be considered for patients who are from strongyloidiasis endemic areas.[7]

### *Rationale*

The results of the RECOVERY trial and REMAP-CAP provide consistent evidence that tocilizumab, when administered with corticosteroids, offers a modest mortality benefit in certain patients with COVID-19 who are severely ill, rapidly deteriorating with increasing oxygen needs, and have a significant inflammatory response. However, the Panel found it challenging to define the specific patient population(s) that would benefit from this intervention. See an overview of the clinical trial data on the use of tocilizumab in patients with COVID-19 below.

Sarilumab and tocilizumab have a similar mechanism of action. However, in REMAP-CAP, the number of participants who received sarilumab was relatively small. Moreover, the trial evaluated sarilumab for IV administration, which is not the approved formulation in the United States. The results of randomized controlled trials of sarilumab that are underway will further define the role sarilumab plays in the treatment of COVID-19.

There are only limited data describing the potential for efficacy of siltuximab in patients with COVID-19.[11]

## Anti-Interleukin-6 Receptor Monoclonal Antibodies

### *Tocilizumab*

Tocilizumab is a recombinant humanized anti-IL-6 receptor monoclonal antibody that is approved by the FDA for use in patients with rheumatologic disorders and cytokine release syndrome (CRS) induced by chimeric antigen receptor T cell (CAR T-cell) therapy. Tocilizumab can be dosed for IV or subcutaneous (SQ) injection. The IV formulation should be used to treat CRS.[8]

#### Clinical Data for COVID-19

Clinical data on the use of tocilizumab (and other IL-6 inhibitors) for the treatment of COVID-19, including data from several randomized trials and large observational studies, are summarized in Table 4d.

Initial studies that evaluated the use of tocilizumab for the treatment of COVID-19 produced conflicting results. Many of these trials were limited by low power, heterogenous populations, and/or a low frequency of concomitant use of corticosteroids (now the standard of care for patients with severe COVID-19).[9-11] For example, trials that reported a treatment benefit of tocilizumab enrolled patients who

were receiving higher levels of oxygen support (e.g., HFNC oxygen, noninvasive ventilation, invasive mechanical ventilation) and/or included more patients who used corticosteroids.[12,13] Subsequently, REMAP-CAP and the RECOVERY trial—the two largest randomized controlled tocilizumab trials—reported a mortality benefit of tocilizumab in certain patients, including patients exhibiting rapid respiratory decompensation associated with an inflammatory response. REMAP-CAP enrolled a narrowly defined population of critically ill patients who were enrolled within 24 hours of starting respiratory support in an ICU and randomized to receive open-label tocilizumab or usual care.[14] The RECOVERY trial enrolled hospitalized patients with COVID-19 into an open label, platform trial of several treatment options;[15] a subset of participants with hypoxemia and CRP ≥75 mg/L were offered enrollment into a second randomization to tocilizumab versus usual care. Additional findings from REMAP-CAP and the RECOVERY trial and the rationale for using tocilizumab in certain hospitalized patients who are exhibiting rapid respiratory decompensations due to COVID-19 can be found in Therapeutic Management of Hospitalized Adults With COVID-19.

The Panel's recommendations for using tocilizumab are based on the collective evidence from clinical trials reported to date (see Table 4d).

#### Clinical Trials

Ongoing trials are evaluating the use of tocilizumab for the treatment of COVID-19. See *ClinicalTrials.gov* for the latest information.

#### Adverse Effects

The primary laboratory abnormalities reported with tocilizumab treatment are elevated liver enzyme levels that appear to be dose dependent. Neutropenia or thrombocytopenia are uncommon. Additional adverse effects, such as risk for serious infections (e.g., tuberculosis [TB], bacterial or fungal infections) and bowel perforation, have been reported only in the context of tocilizumab use for the treatment of chronic disease.

#### Considerations in Pregnancy

There are insufficient data to determine whether there is a tocilizumab-associated risk for major birth defects or miscarriage. Monoclonal antibodies are actively transported across the placenta as pregnancy progresses (with greatest transfer during the third trimester) and may affect immune responses in utero in the exposed fetus. Given the paucity of data, current recommendations advise against the use of tocilizumab during pregnancy.[16] Decisions about tocilizumab administration during pregnancy must include shared decision-making between the pregnant individual and their health care provider, considering potential maternal benefit and fetal risks.

#### Considerations in Children

There are no systematic observational or randomized controlled trial data available on the effectiveness of tocilizumab for the treatment of COVID-19 or multisystem inflammatory syndrome in children (MIS-C) in children. Tocilizumab has been used for children with CRS associated with CAR T-cell therapy and systemic and polyarticular juvenile idiopathic arthritis.[17] There is insufficient evidence for the Panel to recommend either for or against the use of tocilizumab in hospitalized children with COVID-19 or MIS-C.

### *Sarilumab*

Sarilumab is a recombinant humanized anti-IL-6 receptor monoclonal antibody that is approved by the FDA for use in patients with rheumatoid arthritis. It is available as an SQ formulation and is not approved for the treatment of CRS.

### Clinical Data for COVID-19

Clinical data for sarilumab (and other IL-6 inhibitors) as treatment for COVID-19, including data from several randomized trials and large observational studies, are summarized in Table 4d.

An adaptive Phase 2 and 3 double-blind, placebo-controlled randomized (2:2:1) trial compared the efficacy and safety of sarilumab 400 mg IV and sarilumab 200 mg IV versus placebo in patients hospitalized with COVID-19 (*ClinicalTrials.gov* Identifier NCT04315298). Results from this trial did not support a clinical benefit of sarilumab in hospitalized patients receiving supplemental oxygen.[18] Preliminary efficacy results from REMAP-CAP for sarilumab were similar to those for tocilizumab. Compared to placebo, sarilumab reduced both mortality and time to ICU discharge, and increased the number of organ support-free days; however, the number of participants who received sarilumab in this trial was relatively small, limiting the conclusions and implications of these findings.[19]

### Clinical Trials

Ongoing trials are evaluating the use of sarilumab for the treatment of COVID-19. See *ClinicalTrials.gov* for the latest information.

### Adverse Effects

The primary lab abnormalities that have been reported with sarilumab treatment are transient and/or reversible elevations in liver enzymes that appear to be dose dependent and rare occurrences of neutropenia and thrombocytopenia. Risk for serious infections (e.g., TB, bacterial or fungal infections) and bowel perforation have been reported only with long-term use of sarilumab.

### Considerations in Pregnancy

There are insufficient data to determine whether there is a sarilumab-associated risk for major birth defects or miscarriage. Monoclonal antibodies are actively transported across the placenta as pregnancy progresses (with greatest transfer during the third trimester) and may affect immune responses in utero in the exposed fetus.

### Considerations in Children

There are no data on the use of sarilumab in children other than data from ongoing trials assessing the drug's safety in children with juvenile idiopathic arthritis. There are no systematic observational or randomized controlled trial data available on the efficacy of sarilumab for the treatment of COVID-19 or MIS-C in children.

### Drug Availability

The SQ formulation of sarilumab is not approved for the treatment of CRS. The IV formulation is not approved by the FDA, but it is being studied in a clinical trial of hospitalized patients with COVID-19.

## Anti-Interleukin-6 Monoclonal Antibody

### *Siltuximab*

Siltuximab is a recombinant human-mouse chimeric monoclonal antibody that binds IL-6 and is approved by the FDA for use in patients with multicentric Castleman disease. Siltuximab prevents the binding of IL-6 to both soluble and membrane-bound IL-6 receptors, inhibiting IL-6 signaling. Siltuximab is dosed as an IV infusion.

### Clinical Data for COVID-19

There are limited data describing the efficacy of siltuximab in patients with COVID-19.[20] There are no data describing clinical experiences using siltuximab for patients with other novel coronavirus infections

(i.e., severe acute respiratory syndrome [SARS], Middle East respiratory syndrome [MERS]).

### Clinical Trials

See *ClinicalTrials.gov* for a list of current clinical trials for siltuximab and COVID-19.

### Adverse Effects

The primary adverse effects reported for siltuximab have been related to rash. Additional adverse effects (e.g., serious bacterial infections) have been reported only with long-term dosing of siltuximab once every 3 weeks.

### Considerations in Pregnancy

There are insufficient data to determine whether there is a siltuximab-associated risk for major birth defects or miscarriage. Monoclonal antibodies are transported across the placenta as pregnancy progresses (with greatest transfer during the third trimester) and may affect immune responses in the exposed fetus.

### Considerations in Children

The safety and efficacy of siltuximab have not been established in pediatric patients.

## References


1. Yoshikawa T, Hill T, Li K, Peters CJ,Tseng CT. Severe acute respiratory syndrome (SARS) coronavirus-induced lung epithelial cytokines exacerbate SARS pathogenesis by modulating intrinsic functions of monocyte-derived macrophages and dendritic cells. *J Virol*. 2009;83(7):3039-3048. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19004938.
2. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. 2020;395(10229):1054-1062. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32171076.
3. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497-506. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31986264.
4. Wang Z, Yang B, Li Q, Wen L,Zhang R. Clinical features of 69 cases with coronavirus disease 2019 in Wuhan, China. *Clin Infect Dis*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32176772.
5. Lier AJ, Tuan JL, Davis MW, et al. Case report: disseminated strongyloidiasis in a patient with COVID-19. *Am J Trop Med Hyg*. 2020. Available at: https://pubmed.ncbi.nlm.nih.gov/32830642/.
6. Marchese V, Crosato V, Gulletta M, et al. Strongyloides infection manifested during immunosuppressive therapy for SARS-CoV-2 pneumonia. *Infection*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32910321.
7. Stauffer WM, Alpern JD,Walker PF. COVID-19 and dexamethasone: a potential strategy to avoid steroid-related strongyloides hyperinfection. *JAMA*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32761166.
8. Le RQ, Li L, Yuan W, et al. FDA approval summary: tocilizumab for treatment of chimeric antigen receptor T cell-induced severe or life-threatening cytokine release syndrome. *Oncologist*. 2018;23(8):943-947. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29622697.
9. Stone JH, Frigault MJ, Serling-Boyd NJ, et al. Efficacy of tocilizumab in patients hospitalized with COVID-19. *N Engl J Med*. 2020;383(24):2333-2344. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33085857.
10. Gupta S, Wang W, Hayek SS, et al. Association between early treatment with tocilizumab and mortality among critically ill patients with COVID-19. *JAMA Intern Med*. 2021;181(1):41-51. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33080002.

11. Hermine O, Mariette X, Tharaux PL, et al. Effect of tocilizumab vs usual care in adults hospitalized with COVID-19 and moderate or severe pneumonia: a randomized clinical trial. *JAMA Intern Med*. 2021;181(1):32-40. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33080017.
12. Salama C, Han J, Yau L, et al. Tocilizumab in patients hospitalized with COVID-19 pneumonia. *N Engl J Med*. 2021;384(1):20-30. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33332779.
13. Rosas IO, Brau N, Waters M, et al. Tocilizumab in hospitalized patients with severe COVID-19 pneumonia. *N Engl J Med*. 2021. Available at: https://pubmed.ncbi.nlm.nih.gov/33676590/.
14. REMAP-CAP Investigators, Gordon AC, Mouncey PR, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19. *N Engl J Med*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33631065.
15. RECOVERY Collaborative Group, Horby PW, Pessoa-Amorim G, et al. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): preliminary results of a randomised, controlled, open-label, platform trial. *medRxiv*. 2021;preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.02.11.21249258v1.
16. Sammaritano LR, Bermas BL, Chakravarty EE, et al. 2020 American College of Rheumatology guideline for the management of reproductive health in rheumatic and musculoskeletal diseases. *Arthritis Rheumatol*. 2020;72(4):529-556. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32090480.
17. Tocilizumab (Actemra) [package insert]. Food and Drug Administration. 2021. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2021/125276s131lbl.pdf.
18. Lescure FX, Honda H, Fowler RA, et al. Sarilumab in patients admitted to hospital with severe or critical COVID-19: a randomised, double-blind, placebo-controlled, phase 3 trial. *Lancet Respir Med*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33676590.
19. The REMAP-CAP Investigators, Gordon AC, Mouncey PR, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19–Preliminary report. *medRxiv*. 2021. Available at: https://www.medrxiv.org/content/10.1101/2021.01.07.21249390v1.
20. Gritti G, Raimondi F, Ripamonti D, et al. Use of siltuximab in patients with COVID-19 pneumonia requiring ventilatory support. *medRxiv*. 2020. Available at: https://www.medrxiv.org/content/10.1101/2020.04.01.20048561v1.

# Table 4d. Interleukin-6 Inhibitors: Selected Clinical Data

*Last Updated April 21, 2021*

The clinical trials described in this table do not represent all the trials that the Panel reviewed while developing the recommendations for IL-6 inhibitors. The studies summarized below are those that have had the greatest impact on the Panel's recommendations.

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Tocilizumab in Hospitalized Patients With COVID-19 (RECOVERY Trial)[1]** | | | |
| Second randomization of the RECOVERY trial, an open-label, randomized controlled-platform trial assessing several treatments in hospitalized patients with COVID-19 in the United Kingdom (n = 4,116; 19% of all RECOVERY trial participants [n = 21,550]) | **Key Inclusion Criteria:**<br>• Suspected or laboratory-confirmed COVID-19<br>• Participant within 21 days of enrollment into the initial randomization of the RECOVERY trial<br>• Hypoxia evidenced by $SpO_2$ <92% on room air or receipt of supplemental oxygen<br>• CRP ≥75 mg/L<br>**Key Exclusion Criteria:**<br>• Tocilizumab unavailable at participating hospital<br>• Evidence of active non-SARS-CoV-2 infection, including TB or other bacterial, fungal, or viral infection<br>**Interventions**<br>*1: 1 Randomization:*<br>• Single dose of tocilizumab 8 mg/kg, and possible second dose, *or*<br>• Usual care<br>**Primary Endpoint:**<br>• All-cause mortality through 28 days<br>**Secondary Endpoints:**<br>• Time to discharge alive<br>• Among those not on mechanical ventilation at enrollment, receipt of mechanical ventilation or death | **Number of Participants:**<br>• Tocilizumab (n = 2,022) and usual care (n = 2,094)<br>• Recruitment period: April 14, 2020, through January 24, 2021<br>Participant Characteristics:<br>• Mean age was 63.6 years.<br>• 67% of participants were men.<br>• 68% of participants were white.<br>• 94% of participants had PCR-confirmed SARS-CoV-2 infection.<br>• Median time from hospitalization until enrollment was 2 days (IQR 1–5 days).<br>• Median CRP 143 mg/L (IQR 107–204 mg/L).<br>• At baseline, 45% of participants were on conventional oxygen, 41% on HFNC/noninvasive ventilation, and 14% on mechanical ventilation.<br>• At enrollment, 82% of participants were taking corticosteroids.<br>**Primary Outcomes:**<br>• Mortality by Day 28 was lower in the tocilizumab arm than in the usual care arm (29% vs. 33%; rate ratio 0.86; 95% CI, 0.77–0.96).<br>• Subgroup analysis: Among those who required mechanical ventilation at baseline, mortality by Day 28 was similar in the tocilizumab and usual care arms (47% vs. 48%). | **Limitations:**<br>• Open-label study<br>• Limited collection of AEs<br>• Only a small proportion of the participants were from ethnic or racial minority groups.<br>• Difficult to define exact subset of hospitalized patients in full RECOVERY cohort who were subsequently selected for secondary randomization/ tocilizumab trial.<br>• Arbitrary cut off of CRP ≥75 mg/L<br>**Interpretation:**<br>• Among hospitalized patients with severe or critical COVID-19 with hypoxia and elevated CRP levels (≥75 mg/L), tocilizumab was associated with reduced all-cause mortality and shorter time to discharge. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Tocilizumab in Hospitalized Patients With COVID-19 (RECOVERY Trial)[1]**, continued | | | |
| | | **Secondary Outcomes:**<br>• The proportion of patients who were discharged alive within 28 days was greater in tocilizumab arm than usual care arm (54% vs. 47%; rate ratio 1.22; 95% CI, 1.12–1.34).<br>• Among those not on mechanical ventilation at baseline, the percentage of participants who met the secondary outcome of mechanical ventilation or death was lower in the tocilizumab arm than in the usual care arm (33% vs. 38%; risk ratio 0.85; 95% CI, 0.78–0.93). | |
| **Interleukin-6 Receptor Antagonists in Critically Ill Patients With COVID-19–Preliminary Report (REMAP-CAP)[2]** | | | |
| Multinational RCT in critically ill, hospitalized patients with COVID-19 (n = 865) | **Key Inclusion Criteria:**<br>• Suspected or laboratory-confirmed COVID-19<br>• Admitted to ICU and receiving respiratory or cardiovascular organ support<br>**Key Exclusion Criteria:**<br>• >24 hours since admission to ICU<br>• Presumption of imminent death with lack of commitment to full support<br>• Immunosuppression<br>• ALT >5 times ULN<br>**Interventions**<br>*1:1 Randomization:*<br>• Single dose of tocilizumab 8 mg/kg, and possible second dose, plus SOC, *or*<br>• SOC | **Number of Participants:**<br>• Tocilizumab plus SOC (n = 353), sarilumab plus SOC (n = 48), and SOC (n = 402)<br>• Recruitment period: April 19 through October 28, 2020<br>**Participant Characteristics:**<br>• Mean age was 61.4 years.<br>• 73% of participants were men.<br>• 72% of participants were White.<br>• 84.4% of participants had a positive SARS-CoV-2 PCR test.<br>• Median time from hospitalization until enrollment: 1.2 days (IQR 0.8–2.8 days).<br>• Median time from ICU admission until enrollment: 13.6 hours (IQR 6.6–19.4 hours).<br>• Baseline level of oxygen support: 28.8% of participants on HFNC, 41.5% on noninvasive ventilation, 29.4% on mechanical ventilation.<br>• In mITT analysis, majority of patients (719 of 792 [90%]) received corticosteroids. | **Limitations:**<br>• Open-label study<br>• Very few patients randomized to receive sarilumab.<br>• Limited collection of AEs<br>• Low proportion of participants from ethnic/racial minority populations<br>**Interpretation:**<br>• Among the patients with severe/critical COVID-19 who were on high-flow oxygen or noninvasive ventilation or who were mechanically ventilated and within 24 hours of ICU admission, the tocilizumab arm had lower mortality and shorter duration of organ support. This benefit of tocilizumab may be in conjunction with concomitant corticosteroids given the high rate of corticosteroid use among trial participants. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Interleukin-6 Receptor Antagonists in Critically Ill Patients With Covid-19–Preliminary Report (REMAP-CAP)[2]**, continued | | | |
| | *Alternative 1:1:1 Randomization:*<br>• Single dose of tocilizumab 8 mg/kg, and possible second dose, plus SOC, *or*<br>• Single dose of sarilumab 400 mg IV plus SOC, *or*<br>• SOC<br>**Primary Endpoint:**<br>• Composite endpoint measured on an ordinal scale combining in-hospital mortality (assigned value: -1) and days free of respiratory or cardiovascular organ support up to Day 21 | **Primary Outcomes:**<br>• Median number of organ support-free days was 10 (IQR -1 to 16 days), 11 (IQR 0–16 days), and 0 (IQR -1 to 15 days) for the tocilizumab, sarilumab, and SOC arms, respectively.<br>• Adjusted OR 1.64 (95% CrI, 1.25–2.14) for tocilizumab arm vs. SOC arm<br>• In-hospital mortality: 28.0% for patients receiving tocilizumab and 35.8% for patients receiving SOC (aOR 1.64; 95% CrI, 1.14–2.35).<br>• Percentage of patients who were not mechanically ventilated who progressed to intubation or death: 41.3% in tocilizumab arm vs. 52.7% in SOC arm. | • REMAP-CAP enrolled patients within 24 hours of ICU level care who were undergoing rapid progression of respiratory dysfunction, a key difference to other tocilizumab trials. |
| **Tocilizumab in Hospitalized Patients With COVID-19 Pneumonia (COVACTA)[3]** | | | |
| Multinational, double-blind, placebo-controlled randomized trial in hospitalized patients with COVID-19 (n = 452) | **Key Inclusion Criteria:**<br>• COVID-19 confirmed by positive PCR test<br>• Severe COVID-19 pneumonia evidenced by hypoxemia and bilateral chest infiltrates<br>**Key Exclusion Criteria:**<br>• Death imminent within 24 hours<br>• Active TB or bacterial, fungal, or viral infection (other than SARS-CoV-2)<br>**Interventions**<br>*2:1 Randomization:*<br>• Single dose of tocilizumab 8 mg/kg, and possible second dose, plus SOC<br>• Placebo plus SOC | **Number of Participants:**<br>• mITT analysis: tocilizumab (n = 294) and placebo (n = 144)<br>**Participant Characteristics:**<br>• Mean age was 61 years.<br>• 70% of participants were men.<br>• 58% of participants were White.<br>• Median time from symptom onset to randomization: 11 days<br>• Clinical status at baseline by ordinal scale category: 28% of participants on supplemental oxygen (category 3); 30% on HFNC/noninvasive ventilation (category 4); 14% on mechanical ventilation (category 5); and 25% with multiorgan failure (category 6).<br>• Percentage of participants who received corticosteroids at entry or during follow-up: 36% in tocilizumab arm vs. 55% in placebo arm. | **Limitations:**<br>• Modest power to detect differences in clinical status on Day 28 (the primary outcome) between the study arms<br>• Corticosteroids only used by a subset of patients, which included more patients from the placebo arm; RDV use was rare.<br>• Results mostly generalizable to the sickest patients with COVID-19.<br>**Interpretation:**<br>• There was no difference between tocilizumab and placebo for clinical status (including death) at Day 28 (the primary outcome), but tocilizumab did demonstrate a shorter time to recovery and shorter length of ICU stay (secondary outcomes). |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Tocilizumab in Hospitalized Patients With COVID-19 Pneumonia (COVACTA)[3]**, continued | | | |
| | **Primary Endpoint:**<br>• Clinical status at Day 28 (as measured on a 7-category ordinal scale)<br>**Secondary Endpoints:**<br>• Time to discharge<br>• Length of ICU stay<br>• Mortality at Day 28<br>**Ordinal Scale Definitions:**<br>1. Discharged or ready for discharge<br>2. Hospitalized on medical ward, not on supplemental oxygen<br>3. Hospitalized on medical ward, on supplemental oxygen<br>4. On oxygen by HFNC or noninvasive ventilation<br>5. On mechanical ventilation<br>6. Multiorgan failure (with ECMO or mechanical ventilation plus other support)<br>7. Death | **Primary Outcome:**<br>• There was no significant difference in clinical status on 7-category ordinal scale on Day 28 between the arms: median of category 1 for the tocilizumab arm vs. category 2 for the placebo arm (difference -1.0; 95% CI, -2.5 to 0.0; *P* = 0.31).<br>**Secondary Outcomes:**<br>• The time to discharge was shorter in the tocilizumab arm than in the placebo arm (median of 20 days vs. 28 days; HR 1.35; 95% CI, 1.02–1.79).<br>• ICU stays were shorter in the tocilizumab arm than in the placebo arm (median of 9.8 days vs. 15.5 days; difference of 5.8 days; 95% CI, -15.0 to -2.9).<br>• There was no difference in mortality by Day 28 between the arms (19.7% in tocilizumab arm vs. 19.4% in placebo arm; 95% CI, -7.6 to 8.2; *P* = 0.94).<br>• SAEs occurred in 34.9% of patients in the tocilizumab arm vs. 38.5% in the placebo arm. | |
| **Effect of Tocilizumab on Clinical Outcomes at 15 Days in Patients With Severe or Critical COVID-2019 (TOCIBRAS)[4]** | | | |
| RCT in severe or critically ill hospitalized patients with COVID-19 in Brazil (n = 129) | **Key Inclusion Criteria:**<br>• COVID-19 confirmed by PCR test and radiographic imaging<br>• Receiving oxygen to maintain $SpO_2$ >93% or mechanical ventilation for <24 hours<br>**Key Exclusion Criteria:**<br>• Active, uncontrolled infection<br>• Elevated AST or ALT >5 times ULN<br>• Reduced renal function with eGFR <30 mL/min/1.72 $m^2$ | **Number of Participants:**<br>• Tocilizumab (n = 65) and SOC (n = 64)<br>**Participant Characteristics:**<br>• Mean age was 57 years.<br>• 68% of participants were men.<br>• Mean time from symptom onset to randomization: 10 days<br>• Baseline level of oxygen support: 52% of participants on conventional oxygen, 32% on HFNC or noninvasive ventilation, and 16% on mechanical ventilation. | **Limitations:**<br>• Open-label study<br>• Relatively small sample size<br>• Study was stopped early during the first interim review because of increased risk of death at Day 15.<br>**Interpretation:**<br>• In this study population, tocilizumab demonstrated no benefit with respect to mechanical ventilation or death at Day 15 or key secondary outcomes. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Tocilizumab on Clinical Outcomes at 15 Days in Patients With Severe or Critical COVID-2019 (TOCIBRAS)[4]**, continued | | | |
| | **Interventions:**<br>• Single dose of tocilizumab 8 mg/kg plus SOC<br>• SOC<br>**Primary Endpoints:**<br>• Clinical status at 15 days by ordinal scale category.<br>• Following the statistical analysis plan, the primary outcome for the final analysis was changed to mechanical ventilation or death at Day 15 (categories 6 and 7), because the assumption of proportional odds was not met for the original 7-category ordinal outcome.<br>**Key Secondary Endpoint:**<br>• All-cause mortality to Day 28<br>**Ordinal Scale Definitions:**<br>1. Not hospitalized, no limitation in activities<br>2. Not hospitalized, limitation in activities<br>3. Hospitalized, not receiving supplemental oxygen<br>4. Hospitalized, receiving supplemental oxygen<br>5. Hospitalized, receiving NIPPV or high-flow oxygen through a nasal cannula<br>6. Hospitalized, receiving mechanical ventilation<br>7. Death | • 86% of participants received corticosteroids.<br>• No patient received RDV, which was unavailable in Brazil during the study period.<br>**Primary Outcomes:**<br>• There was no evidence for a treatment difference in the primary outcome: 28% of participants in the tocilizumab arm vs. 20% in the SOC arm had died or received mechanical ventilation at Day 15 (OR 1.54; 95% CI, 0.66–3.66; $P = 0.32$).<br>• The study was stopped early by recommendation of the Data Monitoring Committee because of increased risk of death in the tocilizumab group: by Day 15, 16.9% of participants in the tocilizumab arm vs. 3.1% in SOC arm had died (OR 6.42; 95% CI, 1.59–43.2).<br>**Key Secondary Outcomes:**<br>• Tocilizumab was associated with a trend towards increased mortality at Day 28 (21% in tocilizumab arm vs. 9% in SOC arm; OR 2.70; 95% CI, 0.97–8.35).<br>• AEs were reported in 43% of patients in the tocilizumab arm and 34% in the SOC arm. | • There were more deaths at Day 15 in the tocilizumab arm than in the SOC arm. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Tocilizumab in Nonventilated Patients Hospitalized With COVID-19 Pneumonia (EMPACTA)[5]** | | | |
| Multinational, double-blind, placebo-controlled, Phase 3 randomized trial in hospitalized patients with COVID-19 (n = 389) | **Key Inclusion Criteria:**<br>• COVID-19 confirmed by PCR test and radiographic imaging<br>• Severe COVID-19 pneumonia<br>**Key Exclusion Criteria:**<br>• Receipt of noninvasive ventilation or mechanical ventilation<br>**Interventions**<br>*2:1 Randomization:*<br>• Single dose of tocilizumab 8 mg/kg plus SOC, possible second dose if not improving, *or*<br>• Placebo plus SOC<br>**Primary Endpoint:**<br>• Mechanical ventilation or death by Day 28<br>**Key Secondary Endpoints:**<br>• Time to hospital discharge or readiness for discharge<br>• All-cause mortality by Day 28 | **Number of Participants:**<br>• mITT analysis: Tocilizumab (n = 249) and placebo (n = 128)<br>**Participant Characteristics:**<br>• Mean age was 55.9 years.<br>• 59.2% of participants were men.<br>• 56.0% of participants were Hispanic/Latinx, 14.9% were Black/African American, and 12.7% were American Indian/Alaska Native.<br>• 81% of participants were enrolled at sites in the United States.<br>• Median time from symptom onset to randomization was 8 days.<br>• Percentage of participants who received concomitant medications:<br>  • Tocilizumab arm: 80.3% received corticosteroids (55.4% received dexamethasone) and 52.6% received RDV<br>  • Placebo arm: 87.5% received corticosteroids (67.2% received dexamethasone) and 58.6% received RDV<br>**Primary Outcome:**<br>• By mITT analysis, the cumulative proportion of patients who required mechanical ventilation or who had died by Day 28 was 12.0% in the tocilizumab arm and 19.3% in the placebo arm (HR 0.56; 95% CI, 0.33–0.97; $P = 0.04$)<br>**Key Secondary Outcomes:**<br>• The median time to hospital discharge or readiness for discharge was 6.0 days in the tocilizumab arm and 7.5 days in placebo arm (HR 1.16; 95% CI, 0.91–1.48).<br>• All-cause mortality by Day 28 was 10.4% (95% CI, 7.2% to 14.9%) in the tocilizumab arm and 8.6% (95% CI, 4.9% to 14.7%) in the placebo arm.<br>• SAEs were reported in 15.2% of patients in the tocilizumab arm and 19.7% in the placebo arm. | **Limitation:**<br>• Interaction with steroids not explored<br>**Interpretation:**<br>• Among patients with severe COVID-19, tocilizumab lowered rates of mechanical ventilation or death by Day 28 but provided no benefit in 28-day mortality. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Efficacy of Tocilizumab in Patients Hospitalized With COVID-19 (BACC Bay Tocilizumab Trial)[6]** | | | |
| Double-blind, placebo-controlled randomized trial in hospitalized patients with COVID-19 in the United States (n = 243) | **Key Inclusion Criteria:**<br>• Hospitalized with COVID-19 confirmed by a positive PCR or serum IgM test<br>• Moderate and severe COVID-19 with >2 of the following symptoms: fever >38°C, pulmonary infiltrates, need for oxygen to maintain saturation >92% *and* also 1 of the following: CRP ≥50 mg/L, D-dimer >1,000 ng/mL, LDH ≥250 U/L, ferritin >500 ng/mL<br>**Interventions**<br>*2:1 Randomization:*<br>• Tocilizumab 8 mg/kg once plus usual care; or<br>• Placebo plus usual care<br>**Primary Endpoint:**<br>• Time to intubation or death (if the patient died without intubation)<br>**Key Secondary Endpoints:**<br>• Clinical worsening<br>• Discontinuation of supplemental oxygen among patients receiving it at baseline | **Number of Participants:**<br>• mITT analysis: Tocilizumab (n = 161) and placebo (n = 81)<br>**Participant Characteristics:**<br>• Median age was 59.8 years (range 21.7–85.4 years).<br>• 58% of participants were men.<br>• 45% of participants were Hispanic or Latinx.<br>• 50% of participants had BMI ≥30; 49% had HTN, and 31% had diabetes.<br>• 80% of participants were hospitalized in non-ICU wards and receiving supplemental oxygen ≤6 L/min; 4% received high-flow oxygen; 16% required no supplemental oxygen.<br>• Median time from symptom onset to randomization was 9 days.<br>• Percentage of participants receiving concomitant medications:<br>  • Glucocorticoids: 11% in tocilizumab arm vs. 6% in placebo arm<br>  • RDV: 33% in tocilizumab arm vs. 29% in placebo arm.<br>**Primary Outcomes:**<br>• There was no evidence of a treatment difference (i.e., time to intubation or death) between tocilizumab and placebo (HR 0.83; 95% CI, 0.38–1.81; $P = 0.64$).<br>• By Day 28, 11% of the patients in the tocilizumab arm vs. 13% in the placebo arm had been intubated or had died.<br>**Key Secondary Outcomes:**<br>• By Day 28, 19% of patients in the tocilizumab arm vs. 17% in the placebo arm had experienced worsening of disease (HR 1.11; 95% CI, 0.59–2.10).<br>• The median time to discontinuation of oxygen was 5.0 days in the tocilizumab arm vs. 4.9 days in placebo arm ($P = 0.69$).<br>• Fewer serious infections occurred among participants in the tocilizumab arm than in the placebo arm (8.1% vs. 17.3%; $P = 0.03$). | **Limitations:**<br>• The relatively small sample size and low event rates resulted in wide confidence intervals for primary and secondary outcomes.<br>• Some patients received RDV, and a few patients received steroids.<br>**Interpretation:**<br>• In this study population, tocilizumab provided no benefit in preventing intubation or death (the primary outcome) or reducing the risk of clinical worsening or time to discontinuation of supplemental oxygen (secondary outcomes). |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Tocilizumab Versus Usual Care in Adults Hospitalized With COVID-19 and Moderate or Severe Pneumonia (CORIMUNO-TOCI-1)[7]** | | | |
| Open-label, randomized clinical trial in hospitalized patients with COVID-19 in France (n = 131) | **Key Inclusion Criteria:**<br>• COVID-19 confirmed by positive PCR test and/or findings/ abnormalities typical of COVID-19 on chest CT<br>• Severe disease/pneumonia, requiring ≥3 L oxygen<br>**Key Exclusion Criteria:**<br>• Receipt of high-flow oxygen or mechanical ventilation<br>**Interventions**<br>*1:1 Randomization:*<br>• Single dose of tocilizumab 8 mg/ kg on Day 1, possible second, fixed dose of tocilizumab 400 mg on Day 3 per provider if oxygen requirement not decreased by >50%, plus usual care, *or*<br>• Usual care<br>**Primary Endpoint:**<br>• Scores >5 on the 10-point WHO Clinical Progression Scale on Day 4<br>• Survival without need of ventilation (including noninvasive ventilation) at Day 14<br>**Key Secondary Endpoint:**<br>• Overall survival by Day 28 | **Number of Participants:**<br>• ITT analysis (n = 130): Tocilizumab (n = 63) and placebo (n = 67)<br>**Participant Characteristics:**<br>• Median age was 64 years.<br>• 68% of the participants were men.<br>• Diagnosis of COVID-19 was confirmed by PCR test in 90% of participants.<br>• Median time from symptom onset to randomization: 10 days<br>• Baseline corticosteroids use was balanced (received by approximately 17% of participants in each arm) at randomization, but post randomization, more participants received corticosteroids in the control group (55%) than in the tocilizumab group (30%).<br>**Primary Outcome:**<br>• In the Bayesian analyses, evidence for the superiority of tocilizumab vs. usual care did not reach the prespecified threshold for the proportion of patients who died or needed high-flow oxygen, noninvasive ventilation, or IMV by Day 4 (19% of patients in tocilizumab arm vs. 28% in usual care arm), but did reach the threshold by Day 14 (24% of patients in tocilizumab arm vs. 36% in usual care arm (HR 0.58; 90% CrI, 0.33–1.00).<br>**Secondary Outcomes:**<br>• There was no difference in overall survival by Day 28 between tocilizumab arm and usual care arm (89% vs. 88%; adjusted HR 0.92; 95% CI, 0.33–2.53).<br>• SAEs occurred in 20 patients (32%) in the tocilizumab arm and 29 patients (43%) in the usual care arm ($P$ = 0.21).<br>• There were fewer serious bacterial infections in the tocilizumab arm (2) than in the usual care arm (11). | **Limitations:**<br>• Not blinded<br>• Underpowered<br>• More patients received dexamethasone/corticosteroids in the usual care arm.<br>**Interpretation:**<br>• Among patients with severe COVID-19, tocilizumab led to improved ventilator-free survival at Day 14 suggesting possible benefit, but the clinical implications are unclear as there was no difference in survival for tocilizumab vs. usual care through Day 28. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Effect of Tocilizumab Versus Standard Care on Clinical Worsening in Patients Hospitalized With COVID-19 Pneumonia (RCT-TCZ-C19)[8]** | | | |
| Open-label RCT in hospitalized patients with COVID-19 in Italy (n = 126) | **Key Inclusion Criteria:**<br>• COVID-19 pneumonia confirmed by positive PCR test<br>• Acute respiratory failure (i.e., $PaO_2/FiO_2$ 200–300 mm Hg), fever, *and/or* a CRP ≥10 mg/dL *and/or* CRP level increased to at least twice admission value<br>**Key Exclusion Criteria:**<br>• Advanced age, multiple comorbidities, or any other condition precluding ICU-level care<br>**Interventions**<br>*1:1 Randomization:*<br>• 2 doses of tocilizumab 8 mg/kg (maximum of 800 mg, second dose after 12 hours), *or*<br>• Usual care<br>**Primary Endpoint:**<br>• Composite outcome defined as entry into ICU with IMV, death from all-causes, or clinical aggravation ($PaO_2/FiO_2$ <150 mm Hg) within 14 days<br>**Key Secondary Endpoint:**<br>• Mortality at 30 days | **Number of Participants:**<br>• ITT analysis (n = 123): Tocilizumab (n = 60) and usual care (n = 63)<br>**Participant Characteristics:**<br>• Median age was 60 years.<br>• 61% of participants were men.<br>• Participants in usual care arm had lower CRP, IL-6, ferritin, and D-dimer levels and received more antivirals than participants in tocilizumab arm.<br>**Primary Outcome:**<br>• No difference in the composite primary outcome of entry into ICU with mechanical ventilation, all-cause death, or clinical deterioration ($PaO_2/FiO_2$ <150 mm Hg) within 14 days: Met by 17 participants (28.3%) in tocilizumab arm vs. 17 (27.0%) in usual care arm (rate ratio 1.05; 95% CI, 0.59–1.86; $P = 0.87$)<br>• ICU admissions: 10.0% of participants in tocilizumab arm vs. 7.9% in usual care arm (rate ratio 1.26; 95% CI, 0.41–3.91)<br>• Mortality at 14 days: 1.7% in tocilizumab arm vs. 1.6% in usual care arm (rate ratio 1.05; 95% CI, 0.07–16.4)<br>**Key Secondary Outcomes:**<br>• There was no difference in mortality at 30 days between tocilizumab arm (3.3%) and usual care arm (1.6%; rate ratio 2.10; 95% CI, 0.20–22.6).<br>• There were more AEs among the participants in tocilizumab arm (23.3%) than among those in usual care arm (11.1%). The reported AEs were mostly elevated ALT levels and reduced neutrophil counts. | **Limitations:**<br>• Not blinded<br>• Small sample size<br>• Mortality rate in the study population was significantly lower (2.4%) than in the general population in Italy (13.2%).[9]<br>• Because 14 patients in the control group (22%) received tocilizumab after they reached the primary endpoint, mortality outcomes are difficult to interpret.<br>• There were some differences between the arms in baseline participant characteristics, including higher inflammatory markers in the tocilizumab arm.<br>**Interpretation:**<br>• This study demonstrated no evidence for a benefit of tocilizumab in patients hospitalized with COVID-19 pneumonia. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Sarilumab in Hospitalized Patients With Severe or Critical COVID-19[10]** | | | |
| Multinational, double-blind, placebo-controlled, Phase 3 randomized trial in patients hospitalized with COVID-19 (n = 420) | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• Laboratory-confirmed COVID-19 and clinical or radiographic evidence of pneumonia<br>• Severe or critical disease (i.e., receiving supplemental oxygen, including delivery by nasal cannula or high-flow device, noninvasive ventilation or invasive ventilation, or treatment in ICU)<br>**Key Exclusion Criteria:**<br>• Low probability of surviving or remaining at investigational site beyond 48 hours<br>• Dysfunction of ≥2 organ systems, or need for ECMO or renal replacement therapy at screening<br>**Interventions**<br>*2:2:1 Randomization:*<br>• Sarilumab IV 400 mg, *or*<br>• Sarilumab IV 200 mg, *or*<br>• Placebo<br>**Primary Endpoint:**<br>• Time from baseline to ≥2-point improvement in clinical status on a 7-point ordinal scale<br>**Key Secondary Endpoint:**<br>• Proportion of patients alive at Day 29 | **Number of Participants:**<br>• mITT analysis (n = 416): Sarilumab 400 mg (n = 173), sarilumab 200 mg (n = 159), and placebo (n = 84)<br>**Participant Characteristics:**<br>• Median age was 59 years.<br>• 63% of participants were men.<br>• 77% of participants were White and 36% were Hispanic or Latino.<br>• 42% of participants had BMI ≥30.<br>• 43% of participants had HTN and 26% had type 2 diabetes.<br>• 61% of participants had severe disease and 39% had critical disease.<br>• 20% of participants received systemic corticosteroids before receiving their assigned intervention.<br>**Primary Outcome:**<br>• There was no difference in the median time to ≥2-point improvement in clinical status from baseline on the 7-point ordinal scale for either dose of sarilumab compared to placebo:<br>  • 12 days for placebo vs. 10 days for sarilumab 200 mg (HR 1.03; 95% CI, 0.75–1.40) and 10 days for sarilumab 400 mg (HR 1.14; 95% CI, 0.84–1.54).<br>**Key Secondary Outcome:**<br>• There was no difference among the arms in proportion of patients who were alive at Day 29 (92% in placebo arm, 90% in sarilumab 200 mg arm, 92% in sarilumab 400 mg arm). | **Limitations:**<br>• Low rate of baseline corticosteroid use and varying rate of overall corticosteroid use during the study<br>• Moderate sample size with few participants in placebo arm<br>**Interpretation:**<br>• In hospitalized adults with severe or critical COVID-19, there was no benefit of sarilumab with respect to time to clinical improvement or mortality. |

| Study Design | Methods | Results | Limitations and Interpretation |
|---|---|---|---|
| **Tocilizumab Plus Standard Care Versus Standard Care in Patients With Moderate to Severe COVID-19-Associated Cytokine Release Syndrome (COVINTOC)[11]** | | | |
| Open-label, Phase 3 RCT in patients hospitalized with moderate to severe COVID-19 cytokine release syndrome in India | **Key Inclusion Criteria:**<br>• Aged ≥18 years<br>• SARS-CoV-2 infection confirmed by PCR test<br>• Moderate disease (defined by respiratory rate 15–30 breaths/min, $SpO_2$ 90% to 94%) to severe disease (defined by respiratory rate ≥30 breaths/min, $SpO_2$ <90% on ambient air, ARDS, or septic shock)<br>**Key Exclusion Criteria:**<br>• Low probability of surviving beyond 24 hours<br>• Receipt of immunomodulatory drugs within previous 6 months<br>• Serious medical conditions per judgment of investigators<br>**Interventions**<br>*1:1 Randomization:*<br>• Tocilizumab 6 mg/kg (maximum dose 480 mg), second dose allowable if no improvement or worsening of clinical symptoms in next 7 days, *or*<br>• Usual care<br>**Primary Endpoint:**<br>• Proportion of patients with progression from moderate to severe disease or from severe disease to death by Day 14<br>**Key Secondary Endpoints:**<br>• Incidence of mechanical ventilation<br>• Ventilator-free days | **Number of Participants:**<br>• mITT analysis (n = 179): Tocilizumab (n = 91) and usual care (n = 88)<br>**Participant Characteristics:**<br>• Median age was 55 years.<br>• 85% of participants were men.<br>• The mean BMI was 27.<br>• Approximately 40% of participants had HTN and 41% had type 2 diabetes.<br>• In the tocilizumab arm, 45% of participants had moderate disease and 55% had severe disease. In the usual care arm, 53% of participants had moderate disease and 47% had severe disease.<br>• 91% of participants received systemic corticosteroids during the study.<br>**Primary Outcome:**<br>• Overall, the percentage of patients with disease progression was 12.1% in tocilizumab arm and 18.2% in usual care arm.<br>**Key Secondary Outcomes:**<br>• There was no observed difference between the arms in incidence of mechanical ventilation or number of ventilator-free days.<br>• In post hoc analysis, the percentage of patients who had progressed from severe COVID-19 to death was 16% in tocilizumab arm and 34% in usual care arm ($P = 0.04$). | **Limitations:**<br>• Open-label study<br>• Underpowered<br>• Lower dose of tocilizumab than in other trials<br>**Interpretation:**<br>• There was no demonstrated benefit of tocilizumab in hospitalized adults with moderate to severe COVID-19. |

**Key:** AE = adverse event; ALT = alanine transaminase; ARDS = acute respiratory distress syndrome; AST = aspartate aminotransferase; BMI = body mass index; BACC = Boston Area COVID-19 Consortium; CRP = C-reactive protein; CT = computed tomography; ECMO = extracorporeal membrane oxygenation; eGFR = estimated glomerular filtration rate; EMPACTA = Evaluating Minority Patients With Actemra; HFNC = high-flow nasal cannula; HTN = hypertension; ICU = intensive care unit; IgM = immunoglobulin M; IL-6 = interleukin 6; IMV = invasive mechanical ventilation; ITT = intention to treat; IV = intravenous; LDH = lactate dehydrogenase; mITT = modified intention to treat; NIPPV = noninvasive positive-pressure ventilation; the Panel = the COVID-19 Treatment Guidelines Panel; $PaO_2/FiO_2$ = ratio of arterial partial pressure of oxygen to fraction of inspired oxygen; PCR = polymerase chain reaction; RCT = randomized controlled trial; RDV = remdesivir; RECOVERY = Randomized Evaluation of COVID-19 Therapy; REMAP-CAP = Randomized, Embedded, Multifactorial Adaptive Platform Trial for Community-Acquired Pneumonia; SAE = serious adverse event; SOC = standard of care; $SpO_2$ = saturation of oxygen; TB = tuberculosis; ULN = upper limit of normal; WHO = World Health Organization

## References


1. RECOVERY Collaborative Group, Horby PW, Pessoa-Amorim G, et al. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): preliminary results of a randomised, controlled, open-label, platform trial. *medRxiv*. 2021;preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.02.11.21249258v1.
2. REMAP-CAP Investigators, Gordon AC, Mouncey PR, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19. *N Engl J Med*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33631065.
3. Rosas IO, Brau N, Waters M, et al. Tocilizumab in hospitalized patients with severe COVID-19 pneumonia. *N Engl J Med*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33631066.
4. Veiga VC, Prats J, Farias DLC, et al. Effect of tocilizumab on clinical outcomes at 15 days in patients with severe or critical coronavirus disease 2019: randomised controlled trial. *BMJ*. 2021;372:n84. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33472855.
5. Salama C, Han J, Yau L, et al. Tocilizumab in patients hospitalized with COVID-19 pneumonia. *N Engl J Med*. 2021;384(1):20-30. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33332779.
6. Stone JH, Frigault MJ, Serling-Boyd NJ, et al. Efficacy of tocilizumab in patients hospitalized with COVID-19. *N Engl J Med*. 2020;383(24):2333-2344. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33085857.
7. Hermine O, Mariette X, Tharaux PL, et al. Effect of tocilizumab vs usual care in adults hospitalized with COVID-19 and moderate or severe pneumonia: a randomized clinical trial. *JAMA Intern Med*. 2021;181(1):32-40. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33080017.
8. Salvarani C, Dolci G, Massari M, et al. Effect of tocilizumab vs standard care on clinical worsening in patients hospitalized with COVID-19 pneumonia: a randomized clinical trial. *JAMA Intern Med*. 2021;181(1):24-31. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33080005.
9. Parr JB. Time to reassess tocilizumab's role in COVID-19 pneumonia. *JAMA Intern Med*. 2021;181(1):12-15. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33079980.
10. Lescure FX, Honda H, Fowler RA, et al. Sarilumab in patients admitted to hospital with severe or critical COVID-19: a randomised, double-blind, placebo-controlled, Phase 3 trial. *Lancet Respir Med*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33676590.
11. Soin AS, Kumar K, Choudhary NS, et al. Tocilizumab plus standard care versus standard care in patients in India with moderate to severe COVID-19-associated cytokine release syndrome (COVINTOC): an open-label, multicentre, randomised, controlled, Phase 3 trial. *Lancet Respir Med*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33676589.

# Kinase Inhibitors: Baricitinib and Other Janus Kinase Inhibitors, and Bruton's Tyrosine Kinase Inhibitors

*Last Updated: July 8, 2021*

**This page is currently under revision. For the most recent information regarding baricitinib use in certain hospitalized patients with COVID-19, please see Therapeutic Management of Hospitalized Adults with COVID-19.**

## Janus Kinase Inhibitors

The kinase inhibitors are proposed as treatments for COVID-19 because they can prevent phosphorylation of key proteins involved in the signal transduction that leads to immune activation and inflammation (e.g., the cellular response to proinflammatory cytokines such as interleukin [IL]-6).[1] Janus kinase (JAK) inhibitors interfere with phosphorylation of signal transducer and activator of transcription (STAT) proteins[2,3] that are involved in vital cellular functions, including signaling, growth, and survival.

Immunosuppression induced by this class of drugs could potentially reduce the inflammation and associated immunopathologies observed in patients with COVID-19. Additionally, JAK inhibitors, particularly baricitinib, have theoretical direct antiviral activity through interference with viral endocytosis, potentially preventing entry into and infection of susceptible cells.[4]

### *Recommendations*

- For updated recommendations on baritinib use in certain hospitalized patients, see Therapeutic Management of Hospitalized Adults with COVID-19.
- The Panel **recommends against** the use of **JAK inhibitors other than baricitinib** for the treatment of COVID-19, except in a clinical trial **(AIII)**.

### *Rationale*

For the updated rationale for baritinib use in certain hospitalized patients, see Therapeutic Management of Hospitalized Adults with COVID-19.

The Panel's recommendations for the use of baricitinib are based on data from the Adaptive COVID-19 Treatment Trial 2 (ACTT-2), a multinational, randomized, placebo-controlled trial of baricitinib use in hospitalized patients with COVID-19 pneumonia (see below for a full description of the ACTT-2 data for baricitinib). Participants (n = 1,033) were randomized 1:1 to oral baricitinib 4 mg or placebo, for up to 14 days, in combination with intravenous (IV) remdesivir, for up to 10 days. Participants who received baricitinib had a shorter time to clinical recovery than those who received placebo (median recovery time of 7 vs. 8 days, respectively). This treatment effect was most pronounced among those who required high-flow oxygen or non-invasive ventilation but were not on invasive mechanical ventilation. The difference in mortality between the treatment groups was not statistically significant.[5]

Corticosteroids have established efficacy in the treatment of severe and critical COVID-19 pneumonia (see the Therapeutic Management and Corticosteroids sections). The Panel's recommendations for the use of baricitinib are based on data for the benefit of corticosteroids and the uncertain clinical impact of the modest difference in time to recovery between the placebo-treated and baricitinib-treated patients in the ACTT-2 trial. The Panel also considered the infrequent use of corticosteroids in the ACTT-2 trial, given that patients receiving corticosteroids for the treatment of COVID-19 at study entry were excluded.

On November 19, 2020, the Food and Drug Administration (FDA) issued an Emergency Use Authorization (EUA) for the use of baricitinib in combination with remdesivir in hospitalized adults and children aged ≥2 years with COVID-19 who require supplemental oxygen, invasive mechanical ventilation, or extracorporeal membrane oxygenation (ECMO).[6]

The issuance of an EUA does not constitute FDA approval. An EUA indicates that a product may be effective in treating a serious or life-threatening disease or condition. FDA approval occurs when a product has been determined to provide benefits that outweigh its known and potential risks for the intended population.

### *Monitoring, Adverse Effects, and Drug-Drug Interactions*

Most of the data on adverse effects of JAK inhibitors refer to chronic use of the agents. Adverse effects include infections (typically respiratory and urinary tract infections) and the reactivation of herpes viruses. Additional toxicities include myelosuppression and transaminase elevations. In addition, there may be a slightly higher risk of thrombotic events and gastrointestinal perforation in patients who receive JAK inhibitors.

Complete blood count with differential, liver function tests, and kidney function tests should be obtained in all patients before baricitinib is administered and during treatment as clinically indicated. Screening for viral hepatitis and tuberculosis should be considered. Considering its immunosuppressive effects, all patients receiving baricitinib should also be monitored for new infections.

The ACTT-2 study evaluated oral baricitinib 4 mg once daily;[5] however, the standard dosage of baricitinib for FDA-approved indications is 2 mg once daily. Baricitinib use is not recommended in patients with impaired hepatic or renal function (estimated GFR <60 mL/min/1.73 $m^2$).[7] There are limited clinical data on the use of baricitinib in combination with strong organic anion transporter 3 inhibitors, and, in general, coadministration is not advised.[7,8]

### *Considerations in Pregnancy*

There is a paucity of data on the use of JAK inhibitors in pregnancy. As small molecule-drugs, JAK inhibitors are likely to pass through the placenta, and therefore fetal risk cannot be ruled out.[9] Decisions about the administration of JAK inhibitors must include shared decision-making with the pregnant individual, considering potential maternal benefit and fetal risks. Factors that may weigh into the decision-making process include maternal COVID-19 severity, comorbidities, and gestational age. When the benefits outweigh the risks, use of JAK inhibitors may be considered.

### *Considerations in Children*

An EUA has been issued for the use of baricitinib in combination with remdesivir in hospitalized adults and children aged ≥2 years with COVID-19 who require supplemental oxygen, invasive mechanical ventilation, or ECMO. The safety and efficacy of baricitinib or other JAK inhibitors has not been evaluated in pediatric patients with COVID-19, and data on the use of the drugs in children with other conditions are extremely limited. Thus, there is insufficient evidence to recommend either for or against the use of baricitinib in combination with remdesivir for the treatment of COVID-19 in hospitalized children when corticosteroids cannot be used. Use of JAK inhibitors other than baricitinib for the treatment of COVID-19 in pediatric patients is not recommended, except in a clinical trial.

### *Baricitinib*

Baricitinib is an oral JAK inhibitor that is selective for JAK1 and JAK2 and FDA approved for the treatment of rheumatoid arthritis.[7] Baricitinib can modulate downstream inflammatory responses

via JAK1/JAK2 inhibition and has exhibited dose-dependent inhibition of IL-6-induced STAT3 phosphorylation.[10] Baricitinib has postulated antiviral effects by blocking severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from entering and infecting lung cells.[11] Baricitinib reduced inflammation and lung pathology in macaques infected with SARS-CoV-2 but an antiviral effect was not confirmed.[12]

### Clinical Data for COVID-19

For additional clinical trial data on baritinib use in certain hospitalized patients, see Therapeutic Management of Hospitalized Adults with COVID-19.

The multicenter, randomized, double-blind ACTT-2 trial compared (1:1 allocation) oral baricitinib 4 mg daily (for up to 14 days or until hospital discharge) versus placebo, both given in combination with IV remdesivir (for 10 days or until hospital discharge). The trial included 1,033 patients hospitalized with moderate to severe COVID-19. The primary endpoint was time to recovery, which was defined as reaching Category 1 (not hospitalized, no limitations), Category 2 (not hospitalized, with limitations), or Category 3 (hospitalized, no active medical problems) on an eight-category ordinal scale within 28 days of treatment initiation. Patients who were using a medication off-label as a specific treatment for COVID-19, including corticosteroids, at study entry were excluded from the trial. In the overall cohort, the median time to recovery was shorter in the baricitinib plus remdesivir arm (7 days) than in the placebo plus remdesivir arm (8 days) (rate ratio for recovery 1.16; 95% CI, 1.01–1.32; $P = 0.03$). In subgroup analyses according to disease severity, the difference in time to recovery was greatest among the participants who required high-flow oxygen or non-invasive ventilation (10 vs. 18 days for the baricitinib and placebo recipients, respectively; rate ratio for recovery 1.51; 95% CI, 1.10–2.08). However, the treatment effect within this subgroup should be interpreted with caution given the relatively small sample size. Within the subgroup of patients on invasive mechanical ventilation or ECMO at study entry, it was not possible to estimate the median time to recovery within the first 28 days following treatment initiation, and there was no evidence of benefit with baricitinib use (rate ratio for recovery 1.08; 95% CI, 0.59–1.97). Improvement across ordinal categories at Day 15 was a key secondary endpoint, and again baricitinib demonstrated a significant benefit only in the subgroup of patients requiring high-flow oxygen or non-invasive ventilation (OR 2.3; 95% CI, 1.4–3.7). Mortality by 28 days was lower in the baricitinib arm than in the placebo arm, but the difference was not statistically significant (OR 0.65; 95% CI, 0.39–1.09). There was no evidence that the risk of serious adverse events or new infections was higher in the baricitinib arm than in the placebo arm (16% vs. 20% for adverse events and 6% vs. 11% for new infections in the baricitinib and placebo arms, respectively).[5]

Even though the use of corticosteroids for the treatment of COVID-19 was prohibited at study entry, the protocol allowed for the adjunctive use of corticosteroids at the discretion of the treating provider for the treatment of standard medical indications (e.g., asthma exacerbation, acute respiratory distress syndrome, chronic obstructive pulmonary disease). During the study, 10.9% of the patients in the baricitinib group and 12.9% in the placebo group were prescribed corticosteroids. Overall, the incidence of serious or non-serious infections was lower in the baricitinib group (30 patients [6%]) than in the placebo group (57 patients [11%]) (RD -5; 95% CI, -9 to -2). There were no statistically significant differences between the baricitinib and placebo arms in the frequency of pulmonary embolism (5 vs. 2 patients, respectively) or deep vein thrombosis (11 vs. 9 patients, respectively).

Preliminary results of this study suggest that baricitinib improves time to recovery in patients who require supplemental oxygen but not invasive mechanical ventilation. However, a key limitation of the study is the inability to evaluate the treatment effect of baricitinib in addition to, or in comparison to, corticosteroids used as standard treatment for severe or critical COVID-19 pneumonia.

### Clinical Trials

Please check *ClinicalTrials.gov* for the latest information on studies of baricitinib and COVID-19.

## *Ruxolitinib*

Ruxolitinib is an oral JAK inhibitor selective for JAK1 and JAK2 that is currently approved for myelofibrosis, polycythemia vera, and acute graft-versus-host disease.[13] Like baricitinib, it can modulate downstream inflammatory responses via JAK1/JAK2 inhibition and has exhibited dose-dependent inhibition of IL-6-induced STAT3 phosphorylation.[10] Ruxolitinib also has postulated antiviral effects by blocking SARS-CoV-2 from entering and infecting lung cells.[11]

### Clinical Data for COVID-19

A small, single-blind, randomized, controlled Phase 2 trial in patients with COVID-19 in China compared ruxolitinib 5 mg orally twice daily (n = 20) with placebo (administered as vitamin C 100 mg; n = 21), both given in combination with SOC therapy. The median age of the patients was 63 years. There were no significant demographic differences between the two arms. Treatment with ruxolitinib was associated with a nonsignificant reduction in the median time to clinical improvement (12 days for ruxolitinib vs. 15 days for placebo; $P = 0.15$), defined as a two-point improvement on a seven-category ordinal scale or as hospital discharge. There was no difference between the groups in the median time to discharge (17 days for ruxolitinib vs. 16 days for placebo; $P = 0.94$). More patients in the ruxolitinib group than in the placebo group had radiographic improvement on computed tomography scans of the chest at Day 14 (90% for ruxolitinib vs. 61.9% for placebo; $P = 0.05$) and a shorter time to recovery from initial lymphopenia (5 days for ruxolitinib vs. 8 days for placebo; $P = 0.03$), when it was present. The use of ruxolitinib was not associated with an increased risk of adverse events or mortality (no deaths in the ruxolitinib arm vs. three deaths [14% of patients] in the control arm). Despite the theoretical antiviral properties of JAK inhibitors, there was no significant difference in the time to viral clearance among the patients who had detectable viral loads at the time of randomization to ruxolitinib treatment (n = 8) or placebo (n = 9). Limitations of this study include the small sample size, the exclusion of ventilated patients at study entry, and the concomitant use of antivirals and steroids by 70% of the patients.[14]

### Clinical Trials

Please check *ClinicalTrials.gov* for the latest information on studies of ruxolitinib and COVID-19.

## *Tofacitinib*

Tofacitinib is the prototypical JAK inhibitor, predominantly selective for JAK1 and JAK3, with modest activity against JAK2, and, as such, can block signaling from gamma-chain cytokines (e.g., IL-2, IL-4) and gp 130 proteins (e.g., IL-6, IL-11, interferons). It is an oral agent first approved by the FDA for the treatment of rheumatoid arthritis and has been shown to decrease levels of IL-6 in patients with this disease.[15] Tofacitinib is also FDA approved for the treatment of psoriatic arthritis, juvenile idiopathic arthritis, and ulcerative colitis.[16]

### Clinical Data for COVID-19

There are no clinical data on the use of tofacitinib to treat COVID-19.

### Considerations in Pregnancy

Pregnancy registries provide some outcome data on tofacitinib used during pregnancy for other conditions (e.g., ulcerative colitis, rheumatoid arthritis, psoriasis). Among the 33 cases reported, pregnancy outcomes were similar to those among the general pregnant population.[17-19]

#### Clinical Trials

Please check *ClinicalTrials.gov* for the latest information on studies of tofacitinib and COVID-19.

## Bruton's Tyrosine Kinase Inhibitors

Bruton's tyrosine kinase (BTK) is a signaling molecule of the B-cell antigen receptor and cytokine receptor pathways.

### *Recommendation*

- The Panel **recommends against** the use of **BTK inhibitors** for the treatment of COVID-19, except in a clinical trial **(AIII)**.

### *Acalabrutinib*

Acalabrutinib is a second-generation, oral BTK inhibitor that is FDA approved to treat B-cell malignancies (i.e., chronic lymphocytic leukemia/small lymphocytic lymphoma, mantle cell lymphoma). It has a better toxicity profile than first-generation BTK inhibitors (e.g., ibrutinib) because of less off-target activity for other kinases.[20] Acalabrutinib is proposed for use in patients with COVID-19 because it can modulate signaling that promotes inflammation.

#### Clinical Data for COVID-19

Data regarding acalabrutinib are limited to the results from a retrospective case series of 19 patients with severe COVID-19.[21] Evaluation of the data to discern any clinical benefit is limited by the study's small sample size and lack of a control group.

#### Clinical Trials

Please check *ClinicalTrials.gov* for the latest information on studies of acalabrutinib and COVID-19.

### *Ibrutinib*

Ibrutinib is a first-generation BTK inhibitor that is FDA approved to treat various B-cell malignancies[22] and to prevent chronic graft-versus-host disease in stem cell transplant recipients.[23] Based on results from a small case series, ibrutinib has been theorized to reduce inflammation and protect against ensuing lung injury in patients with COVID-19.[24]

#### Clinical Data for COVID-19

Data regarding ibrutinib are limited to those from an uncontrolled, retrospective case series of six patients with COVID-19 who were receiving the drug for a condition other than COVID-19.[24] Evaluation of the data for any clinical benefit is limited by the series' small sample size and lack of a control group.

#### Clinical Trials

Please check *ClinicalTrials.gov* for the latest information on studies of ibrutinib and COVID-19.

### *Zanubrutinib*

Zanubrutinib is a second-generation, oral BTK inhibitor that is FDA approved to treat mantle cell lymphoma.[25] It has been shown to have fewer toxicities than first-generation BTK inhibitors (e.g., ibrutinib) because of less off-target activity for other kinases.[26] Zanubrutinib is proposed to benefit patients with COVID-19 by modulating signaling that promotes inflammation.

### Clinical Data for COVID-19

There are no clinical data on the use of zanubrutinib to treat COVID-19.

### Clinical Trials

Please check *ClinicalTrials.gov* for the latest information on studies of zanubrutinib and COVID-19.

## *Adverse Effects and Monitoring*

Hemorrhage and cardiac arrhythmia have occurred in patients who received BTK inhibitors.

## *Considerations in Pregnancy*

There is a paucity of data on human pregnancy and BTK inhibitor use. In animal studies, acalabrutinib and ibrutinib in doses exceeding the therapeutic human dose were associated with interference with embryofetal development.[22,27] Based on these data, use of BTK inhibitors that occurs during organogenesis may be associated with fetal malformations. The impact of use later in pregnancy is unknown. Risks of use should be balanced against potential benefits.

## *Considerations in Children*

The safety and efficacy of BTK inhibitors have not been evaluated in pediatric patients with COVID-19, and data on the use of the drugs in children with other conditions are extremely limited. Use of BTK inhibitors for the treatment of COVID-19 in pediatric patients is **not recommended**, except in a clinical trial.

## References


1. Zhang W, Zhao Y, Zhang F, et al. The use of anti-inflammatory drugs in the treatment of people with severe coronavirus disease 2019 (COVID-19): the perspectives of clinical immunologists from China. *Clin Immunol*. 2020;214:108393. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32222466.
2. Babon JJ, Lucet IS, Murphy JM, Nicola NA, Varghese LN. The molecular regulation of Janus kinase (JAK) activation. *Biochem J*. 2014;462(1):1-13. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25057888.
3. Bousoik E, Montazeri Aliabadi H. "Do we know jack" about JAK? A closer look at JAK/STAT signaling pathway. *Front Oncol*. 2018;8:287. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30109213.
4. Stebbing J, Phelan A, Griffin I, et al. COVID-19: combining antiviral and anti-inflammatory treatments. *Lancet Infect Dis*. 2020;20(4):400-402. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32113509.
5. Kalil AC, Patterson TF, Mehta AK, et al. Baricitinib plus remdesivir for hospitalized adults with COVID-19. *N Engl J Med*. 2020;Published online ahead of print. Available at: https://pubmed.ncbi.nlm.nih.gov/33306283/.
6. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of baricitinib. 2020. Available at: https://www.fda.gov/media/143823/download. Accessed December 11, 2020.
7. Baricitinib (Olumiant) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/207924s001lbl.pdf.
8. Posada MM, Cannady EA, Payne CD, et al. Prediction of transporter-mediated drug-drug interactions for baricitinib. *Clin Transl Sci*. 2017;10(6):509-519. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28749581.
9. Sammaritano LR, Bermas BL, Chakravarty EE, et al. 2020 American College of Rheumatology guideline for the management of reproductive health in rheumatic and musculoskeletal diseases. *Arthritis Rheumatol*. 2020;72(4):529-556. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32090480.
10. McInnes IB, Byers NL, Higgs RE, et al. Comparison of baricitinib, upadacitinib, and tofacitinib mediated regulation of cytokine signaling in human leukocyte subpopulations. *Arthritis Res Ther*. 2019;21(1):183.

Available at: https://www.ncbi.nlm.nih.gov/pubmed/31375130.

11. Richardson P, Griffin I, Tucker C, et al. Baricitinib as potential treatment for 2019-nCoV acute respiratory disease. *Lancet*. 2020;395(10223):e30-e31. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32032529.
12. Hoang TN, Pino M, Boddapati AK, et al. Baricitinib treatment resolves lower-airway macrophage inflammation and neutrophil recruitment in SARS-CoV-2-infected rhesus macaques. *Cell*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33278358.
13. Ruxolitinib (JAKAFI) [package insert]. 2020. Available at: https://www.jakafi.com/pdf/prescribing-information.pdf. Accessed: May 28, 2020.
14. Cao Y, Wei J, Zou L, et al. Ruxolitinib in treatment of severe coronavirus disease 2019 (COVID-19): A multicenter, single-blind, randomized controlled trial. *J Allergy Clin Immunol*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32470486.
15. Migita K, Izumi Y, Jiuchi Y, et al. Effects of Janus kinase inhibitor tofacitinib on circulating serum amyloid A and interleukin-6 during treatment for rheumatoid arthritis. *Clin Exp Immunol*. 2014;175(2):208-214. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24665995.
16. Tofacitinib (Xeljanz) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/203214s024,208246s010lbl.pdf.
17. Clowse ME, Feldman SR, Isaacs JD, et al. Pregnancy outcomes in the tofacitinib safety databases for rheumatoid arthritis and psoriasis. *Drug Saf.* 2016;39(8):755-762. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27282428.
18. Mahadevan U, Dubinsky MC, Su C, et al. Outcomes of pregnancies with maternal/paternal exposure in the tofacitinib safety databases for ulcerative colitis. *Inflamm Bowel Dis*. 2018;24(12):2494-2500. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29982686.
19. Wieringa JW, van der Woude CJ. Effect of biologicals and JAK inhibitors during pregnancy on health-related outcomes in children of women with inflammatory bowel disease. *Best Pract Res Clin Gastroenterol*. 2020;44-45:101665. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32359679.
20. Owen C, Berinstein NL, Christofides A, Sehn LH. Review of Bruton tyrosine kinase inhibitors for the treatment of relapsed or refractory mantle cell lymphoma. *Curr Oncol*. 2019;26(2):e233-e240. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31043832.
21. Roschewski M, Lionakis MS, Sharman JP, et al. Inhibition of Bruton tyrosine kinase in patients with severe COVID-19. *Sci Immunol*. 2020;5(48). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32503877.
22. Ibrutinib (Imbruvica) [package insert]. Food and Drug Administration. 2015. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2015/205552s002lbl.pdf.
23. Food and Drug Administration. FDA expands ibrutinib indications to chronic GVHD. 2017. Available at: https://www.fda.gov/drugs/resources-information-approved-drugs/fda-expands-ibrutinib-indications-chronic-gvhd. Accessed February 1, 2021.
24. Treon SP, Castillo JJ, Skarbnik AP, et al. The BTK inhibitor ibrutinib may protect against pulmonary injury in COVID-19-infected patients. *Blood*. 2020;135(21):1912-1915. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32302379.
25. Zanubrutinib (Brukinsa) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/213217s000lbl.pdf.
26. Tam C, Grigg AP, Opat S, et al. The BTK inhibitor, Bgb-3111, is safe, tolerable, and highly active in patients with relapsed/refractory B-cell malignancies: initial report of a Phase 1 first-in-human trial. *Blood*. 2015;126(23):832. Available at: https://ashpublications.org/blood/article/126/23/832/136525/The-BTK-Inhibitor-Bgb-3111-Is-Safe-Tolerable-and.
27. Acalabrutinib (Calquence) [package insert]. Food and Drug Administration. 2017. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2017/210259s000lbl.pdf.

# Table 4e. Characteristics of Immunomodulators Under Evaluation for the Treatment of COVID-19

*Last Updated: August 4, 2021*

- The information in this table is derived from data on the use of these drugs for FDA-approved indications or in investigational trials, and it is supplemented with data on their use in patients with COVID-19, when available.
- For dose modifications for patients with organ failure or those who require extracorporeal devices, please refer to product labels, when available.
- There are currently not enough data to determine whether certain medications can be safely coadministered with therapies for the treatment of COVID-19. When using concomitant medications with similar toxicity profiles, consider performing additional safety monitoring.
- The potential additive, antagonistic, or synergistic effects and the safety of using certain combination therapies for the treatment of COVID-19 are unknown. Clinicians are encouraged to report AEs to the FDA *Medwatch* program.
- For the Panel's recommendations for the drugs listed in this table, please refer to the drug-specific sections of the Guidelines and to Therapeutic Management of Hospitalized Adults With COVID-19.

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Colchicine** | | | | | |
| **Colchicine** | **Dose for COVID-19 in Clinical Trial**<br>*COLCORONA:*<br>• Colchicine 0.5 mg twice daily for 3 days then once daily for 27 days | • Diarrhea<br>• Nausea<br>• Vomiting<br>• Cramping<br>• Abdominal pain<br>• Bloating<br>• Loss of appetite<br>• Neuromyotoxicity (rare)[1]<br>• Blood dyscrasias (rare) | • CBC<br>• Renal function<br>• Hepatic function | • P-gp and CYP3A4 substrate<br>• The risk of myopathy may be increased with the concomitant use of certain HMG-CoA reductase inhibitors (e.g., atorvastatin, lovastatin, simvastatin) due to potential competitive interactions mediated by P-gp and CYP3A4 pathways.<br>• Fatal colchicine toxicity has been reported in individuals with renal or hepatic impairment who used colchicine in conjunction with P-gp inhibitors or strong CYP3A4 inhibitors. | • Colchicine **should be avoided** in patients with severe renal insufficiency, and those with moderate renal insufficiency should be monitored for AEs.<br>• A list of clinical trials is available: Colchicine<br>**Availability:**<br>• COLCORONA used 0.5 mg tablets for dosing; in the United States, colchicine is available as 0.6 mg tablets. |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Corticosteroids** | | | | | |
| **Budesonide (Inhaled)** | **Dose for COVID-19 in Clinical Trials:**<br>• Budesonide 800 mcg inhaled twice daily until symptom resolution or for up to 14 days[2,3] | • Secondary infections<br>• Oral thrush<br>• Systemic adverse effects (less common) | • Signs of adverse effects involving the oral mucosa or throat including thrush<br>• Signs of systemic corticosteroid effects (e.g., adrenal suppression) | • CYP3A4 substrate<br>• **Do not use** with strong CYP3A4 inhibitors. | • A list of clinical trials is available: Inhaled budesonide |
| **Dexamethasone (Systemic)** | **Dose for COVID-19:**<br>• Dexamethasone 6 mg IV or PO once daily, for up to 10 days or until hospital discharge, whichever comes first[4] | • Hyperglycemia<br>• Secondary infections<br>• Reactivation of latent infections (e.g., HBV, HSV, strongyloidiasis, TB)<br>• Psychiatric disturbances<br>• Avascular necrosis<br>• Adrenal insufficiency<br>• Increased blood pressure<br>• Peripheral edema<br>• Myopathy (particularly if used with neuromuscular blocking agents) | • Blood glucose<br>• Blood pressure<br>• Signs and symptoms of new infection<br>• When initiating dexamethasone, consider appropriate screening and treatment to reduce the risk of *Strongyloides* hyperinfection in patients at high risk of strongyloidiasis or fulminant reactivations of HBV.[5-7] | • Moderate CYP3A4 inducer<br>• CYP3A4 substrate<br>• Although coadministration of RDV and dexamethasone has not been formally studied, a clinically significant PK interaction is not predicted (Gilead, written communication, August 2020). | • If dexamethasone is not available, an alternative corticosteroid (e.g., prednisone, methylprednisolone, hydrocortisone) can be used.<br>• The approximate total daily dose equivalencies for these glucocorticoids to dexamethasone 6 mg (PO or IV) are: prednisone 40 mg, methylprednisolone 32 mg, and hydrocortisone 160 mg.<br>• A list of clinical trials is available: Dexamethasone |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Fluvoxamine** | | | | | |
| **Fluvoxamine** | **Dose for COVID-19 in Clinical Trials:**<br>• Various dosing regimens used | • Nausea<br>• Diarrhea<br>• Dyspepsia<br>• Asthenia<br>• Insomnia<br>• Somnolence<br>• Sweating<br>• Suicidal ideation (rare) | • Hepatic function<br>• Drug interactions<br>• Monitor for withdrawal symptoms when tapering dose. | • CYP2D6 substrate<br>• Fluvoxamine inhibits several CYP450 isoenzymes (CYP1A2, CYP2C9, CYP3A4, CYP2C19, CYP2D6).<br>• Coadministration of tizanidine, thioridazine, alosetron, or pimozide with fluvoxamine is **contraindicated**. | • Fluvoxamine may enhance anticoagulant effects of antiplatelets and anticoagulants; consider additional monitoring when these drugs are used concomitantly with fluvoxamine.<br>• The use of MAOIs concomitantly with fluvoxamine or within 14 days of treatment with fluvoxamine is **contraindicated**.<br>• A list of clinical trials is available: Fluvoxamine |
| **Granulocyte-Macrophage Colony-Stimulating Factor Inhibitors** | | | | | |
| **Lenzilumab** | **Dose for COVID-19 in Clinical Trials:**<br>• Lenzilumab 600 mg times 3 doses, administered 8 hours apart by IV infusion over 1 hour[8] | • No treatment emergent SAEs were reported in clinical trials. | • CBC with differential<br>• Liver enzymes<br>• Infusion reactions<br>• HSR | • Data not available | • A list of clinical trials is available: Lenzilumab |
| **Mavrilimumab** | **Dose for COVID-19 in Clinical Trials:**<br>• Mavrilimumab 6 mg/kg IV infusion once[9] | • No treatment emergent SAEs were reported in clinical trials. | • CBC with differential<br>• Liver enzymes<br>• Infusion reactions<br>• HSR | • Data not available | • A list of clinical trials is available: Mavrilimumab |
| **Otilimab** | **Dose for COVID-19 in Clinical Trials:**<br>• Otilimab 90 mg IV infusion once[10] | • No treatment emergent SAEs were reported in clinical trials. | • CBC with differential<br>• Liver enzymes<br>• Infusion reactions<br>• HSR | • Data not available | • A list of clinical trials is available: Otilimab |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Interferons** | | | | | |
| **Interferon Alfa** | **Peg-IFN Alfa-2a**<br>*Dose for MERS:*<br>• Peg-IFN alfa-2a 180 µg SQ once weekly for 2 weeks[11,12]<br>**IFN Alfa-2b**<br>*Dose for COVID-19 in Clinical Trials:*<br>• Nebulized IFN alfa-2b 5 million international units twice daily (no duration listed in the study methods)[13] | • Flu-like symptoms (e.g., fever, fatigue, myalgia)[14]<br>• Injection site reactions<br>• Liver function abnormalities<br>• Decreased blood counts<br>• Worsening depression<br>• Insomnia<br>• Irritability<br>• Nausea<br>• Vomiting<br>• HTN<br>• Induction of autoimmunity | • CBC with differential<br>• Liver enzymes; **avoid** use if Child-Pugh Score >6.<br>• Renal function; reduce dose if CrCl <30 mL/min.<br>• Depression, psychiatric symptoms | • Low potential for drug-drug interactions<br>• Inhibition of CYP1A2 | • For COVID-19, IFN alfa has primarily been used as nebulization and usually as part of a combination regimen.<br>• **Use with caution** with other hepatotoxic agents.<br>• Reduce dose if ALT >5 times ULN; discontinue if bilirubin level also increases.<br>• Reduce dose or discontinue if neutropenia or thrombocytopenia occur.<br>• A list of clinical trials is available: Interferon<br>**Availability:**<br>• Neither nebulized IFN alfa-2b nor IFN alfa-1b are FDA-approved for use in the United States. |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Interferons**, continued | | | | | |
| **Interferon Beta** | **IFN Beta-1a**<br>*Dose for MERS:*<br>• IFN beta-1a 44 mcg SQ 3 times weekly[12]<br>*Dose for COVID-19:*<br>• Dose and duration unknown<br>**IFN Beta-1b**<br>*Dose for COVID-19:*<br>• IFN beta-1b 8 million international units SQ every other day, up to 7 days total[15] | • Flu-like symptoms (e.g., fever, fatigue, myalgia)[16]<br>• Leukopenia, neutropenia, thrombocytopenia, lymphopenia<br>• Liver function abnormalities (ALT > AST)<br>• Injection site reactions<br>• Headache<br>• Hypertonia<br>• Pain<br>• Rash<br>• Worsening depression<br>• Induction of autoimmunity | • CBC with differential<br>• Liver enzymes<br>• Worsening CHF<br>• Depression, suicidal ideation | • Low potential for drug-drug interactions | • **Use with caution** with other hepatotoxic agents.<br>• Reduce dose if ALT >5 times ULN.<br>• A list of clinical trials is available: Interferon<br>**Availability:**<br>• Several products are available in the United States; product doses differ.<br>*IFN Beta-1a Products:*<br>• Avonex, Rebif<br>*IFN Beta-1b Products:*<br>• Betaseron, Extavia |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Interleukin-1 Inhibitor** | | | | | |
| **Anakinra** | **Dose for Rheumatoid Arthritis:**<br>• Anakinra 100 mg SQ once daily<br>**Dose for COVID-19:**<br>• Dose and duration vary by study<br>• Has also been used as IV infusion | • Neutropenia (particularly with concomitant use of other agents that can cause neutropenia)<br>• Anaphylaxis and angioedema<br>• Headache<br>• Nausea<br>• Diarrhea<br>• Sinusitis<br>• Arthralgia<br>• Flu-like symptoms<br>• Abdominal pain<br>• Injection site reactions<br>• Liver enzyme elevations | • CBC with differential<br>• Liver enzymes<br>• Renal function; reduce dose if CrCl <30 mL/min. | • Use with TNF-blocking agents **is not recommended** due to increased risk of infection.<br>• **Avoid** concomitant administration of live vaccines. | • A list of clinical trials is available: Anakinra |
| **Interleukin-6 Inhibitors** | | | | | |
| *Anti-Interleukin-6 Receptor Monoclonal Antibodies* | | | | | |
| **Sarilumab**[17] | **Dose for COVID-19 in Clinical Trial (See *ClinicalTrials.gov* Identifier NCT04315298):**<br>• Sarilumab 400 mg IV (single dose)[18] | • Neutropenia, thrombocytopenia<br>• GI perforation<br>• HSR<br>• Increased liver enzymes<br>• HBV reactivation<br>• Infusion-related reaction | • HSR<br>• Infusion reactions<br>• Neutrophils<br>• Platelets<br>• Liver enzymes | • Elevated IL-6 may downregulate CYP enzymes; use of sarilumab may lead to increased metabolism of drugs that are CYP450 substrates.<br>• Effects on CYP450 may persist for weeks after therapy. | • Treatment with sarilumab may mask signs of acute inflammation or infection (i.e., by suppressing fever and CRP levels).<br>• A list of clinical trials is available: Sarilumab<br>**Availability:**<br>• Sarilumab for IV administration is not an approved formulation in the United States. |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Interleukin-6 Inhibitors**, continued | | | | | |
| *Anti-Interleukin-6 Receptor Monoclonal Antibodies*, continued | | | | | |
| **Tocilizumab**[19] | **Dose for COVID-19 in Clinical Trial:**<br>• Single dose of tocilizumab 8 mg/kg actual body weight IV<br>• Dose **should not exceed** tocilizumab 800 mg.<br>• Administer in combination with dexamethasone.<br>• In clinical trials, some patients received a second dose of tocilizumab at the discretion of treating physicians; however, there is insufficient evidence to determine which patients, if any, would benefit from an additional dose of the drug. | • Infusion-related reaction<br>• HSR<br>• GI perforation<br>• Hepatotoxicity<br>• Treatment-related changes on laboratory tests for neutrophils, platelets, lipids, and liver enzymes<br>• HBV reactivation | • HSR<br>• Infusion reactions<br>• Neutrophils<br>• Platelets<br>• Liver enzymes<br>• Cases of severe and disseminated strongyloidiasis have been reported with the use of tocilizumab and corticosteroids in patients with COVID-19.[20,21] Prophylactic treatment with IVM should be considered for persons who are from areas where strongyloidiasis is endemic.[5] | • Elevated IL-6 may downregulate CYP enzymes; use of tocilizumab may lead to increased metabolism of drugs that are CYP450 substrates.<br>• Effects on CYP450 may persist for weeks after therapy. | • Tocilizumab use **should be avoided** in patients who are significantly immunocompromised. The safety of using tocilizumab plus a corticosteroid in immunocompromised patients is unknown.<br>• Treatment with tocilizumab may mask signs of acute inflammation or infection (i.e., by suppressing fever and CRP levels).<br>• The SQ formulation of tocilizumab **is not intended** for IV administration.<br>• A list of clinical trials is available: Tocilizumab |
| *Anti-Interleukin-6 Monoclonal Antibody* | | | | | |
| **Siltuximab** | **Dose for Multicentric Castleman Disease:**<br>• Siltuximab 11 mg/kg administered over 1 hour by IV infusion every 3 weeks[22]<br>**Dose for COVID-19:**<br>• Dose and duration unknown | • Infusion-related reaction<br>• HSR<br>• GI perforation<br>• Neutropenia<br>• HTN<br>• Dizziness<br>• Rash<br>• Pruritus<br>• Hyperuricemia | • Neutrophils<br>• HSR<br>• Infusion reactions | • Elevated IL-6 may downregulate CYP enzymes; use of siltuximab may lead to increased metabolism of drugs that are CYP450 substrates.<br>• Effects on CYP450 may persist for weeks after therapy. | • Treatment with siltuximab may mask signs of acute inflammation or infection (i.e., by suppressing fever and CRP levels).<br>• A list of clinical trials is available: Siltuximab |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Kinase Inhibitors** | | | | | |
| *Bruton's Tyrosine Kinase Inhibitors* | | | | | |
| **Acalabrutinib** | **Dose for FDA-Approved Indications:**<br>• Acalabrutinib 100 mg PO every 12 hours<br>**Dose for COVID-19:**<br>• Dose and duration unknown | • Hemorrhage<br>• Cytopenias (neutropenia, anemia, thrombocytopenia, lymphopenia)<br>• Atrial fibrillation and flutter<br>• Infection<br>• Headache<br>• Diarrhea<br>• Fatigue<br>• Myalgia | • CBC with differential<br>• Signs and symptoms of bleeding (particularly when coadministered with anticoagulant or antiplatelet therapy)<br>• Cardiac arrhythmias<br>• New infections | • **Avoid** concomitant use with strong CYP3A inhibitors or inducers.<br>• Dose reduction may be necessary with moderate CYP3A4 inhibitors.<br>• **Avoid** concomitant PPI use.<br>• H2-receptor antagonist should be administered 2 hours after acalabrutinib. | • **Avoid** use in patients with severe hepatic impairment.<br>• Patients with underlying cardiac risk factors, hypertension, or acute infections may be predisposed to atrial fibrillation.<br>• A list of clinical trials is available: Acalabrutinib |
| **Ibrutinib** | **Dose for FDA-Approved Indications:**<br>• Ibrutinib 420 mg or 560 mg PO once daily<br>**Dose for COVID-19:**<br>• Dose and duration unknown | • Hemorrhage<br>• Cardiac arrhythmias<br>• Serious infections<br>• Cytopenias (thrombocytopenia, neutropenia, anemia)<br>• HTN<br>• Diarrhea<br>• Musculoskeletal pain<br>• Rash | • CBC with differential<br>• Blood pressure<br>• Signs and symptoms of bleeding (particularly when coadministered with anticoagulant or antiplatelet therapy)<br>• Cardiac arrhythmias<br>• New infections | • **Avoid** concomitant use with strong CYP3A inhibitors or inducers.<br>• Dose reduction may be necessary with moderate CYP3A4 inhibitors. | • **Avoid** use in patients with severe baseline hepatic impairment. Dose modifications required in patients with mild or moderate hepatic impairment.<br>• Patients with underlying cardiac risk factors, HTN, or acute infections may be predisposed to cardiac arrhythmias.<br>• A list of clinical trials is available: Ibrutinib |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Kinase Inhibitors**, contined | | | | | |
| *Bruton's Tyrosine Kinase Inhibitors*, continued | | | | | |
| **Zanubrutinib** | **Dose for FDA-Approved Indications:**<br>• Zanubrutinib 160 mg PO twice daily or 320 mg PO once daily<br>**Dose for COVID-19:**<br>• Dose and duration unknown | • Hemorrhage<br>• Cytopenias (neutropenia, thrombocytopenia, anemia, leukopenia)<br>• Atrial fibrillation and flutter<br>• Infection<br>• Rash<br>• Bruising<br>• Diarrhea<br>• Cough<br>• Musculoskeletal pain | • CBC with differential<br>• Signs and symptoms of bleeding<br>• Cardiac arrhythmias<br>• New infections | • **Avoid** concomitant use with moderate or strong CYP3A inducers.<br>• Dose reduction required with moderate and strong CYP3A4 inhibitors. | • Dose reduction required in patients with severe hepatic impairment.<br>• A list of clinical trials is available: Zanubrutinib |
| **Janus Kinase Inhibitors** | | | | | |
| **Baricitinib**[23] | **Dose for COVID-19**[24]<br>*For Adults and Children Aged ≥9 Years Based on eGFR:*<br>• eGFR ≥60 mL/min/1.73 $m^2$: Baricitinib 4 mg PO once daily<br>• eGFR 30 to <60 mL/min/1.73 $m^2$: Baricitinib 2 mg PO once daily<br>• eGFR 15 to <30 mL/min/1.73 $m^2$: Baricitinib 1 mg PO once daily<br>• eGFR <15 mL/min/1.73 $m^2$: **Not recommended** | • Lymphoma and other malignancies<br>• Thrombosis<br>• GI perforation<br>• Treatment-related changes in lymphocytes, neutrophils, Hgb, liver enzymes<br>• HSV reactivation<br>• Herpes zoster | • CBC with differential<br>• Renal function<br>• Liver enzymes<br>• New infections | • Dose modification is recommended when concurrently administering a strong OAT3 inhibitor.<br>• **Avoid** concomitant administration of live vaccines. | • Baricitinib is available through an FDA EUA. See the EUA for dosing guidance for patients with:<br>• ALC <200 cells/μL<br>• ANC <500 cells/μL<br>• If increases in ALT or AST are observed and DILI is suspected, interrupt baricitinib treatment until the diagnosis of DILI is excluded. |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Janus Kinase Inhibitors**, continued | | | | | |
| | *For Children Aged 2 to <9 Years Based on eGFR:*<br>• eGFR ≥60 mL/min/1.73m$^2$: Baricitinib 2 mg PO once daily<br>• eGFR 30 to <60 mL/min/1.73m$^2$: Baricitinib 1 mg PO once daily<br>• eGFR <30 mL/min/1.73m$^2$: **Not recommended**<br>**Duration of Therapy:**<br>• For up to 14 days or until hospital discharge | | | | • A list of clinical trials is available: Baricitinib<br>**Availability:**<br>• The baricitinib EUA allows for the use of baricitinib, in combination with RDV, for the treatment of COVID-19 for hospitalized adults and pediatric patients aged ≥2 years who require supplemental oxygen, IMV, or ECMO.[24] |
| **Ruxolitinib** | **Dose for FDA-Approved Indications:**<br>• Ruxolitinib 5 mg–20 mg PO twice daily<br>**Dose for COVID-19 in Clinical Trials:**<br>• Ruxolitinib 5 mg–20 mg PO twice daily, for 14 days | • Thrombocytopenia<br>• Anemia<br>• Neutropenia<br>• Liver enzyme elevations<br>• Risk of infection<br>• Dizziness<br>• Headache<br>• Diarrhea<br>• CPK elevation<br>• Herpes zoster | • CBC with differential<br>• Liver enzymes<br>• New infections | • Dose modifications required when administered with strong CYP3A4 inhibitors.<br>• **Avoid** use with doses of fluconazole >200 mg. | • Dose modification may be required in patients with hepatic impairment, moderate or severe renal impairment, or thrombocytopenia.<br>• A list of clinical trials is available: Ruxolitinib |

| Drug Name | Dosing Regimen<br>*There are no approved doses for the treatment of COVID-19. The doses listed here are for approved indications or from reported clinical experience or clinical trials.* | Adverse Events | Monitoring Parameters | Drug-Drug Interaction Potential | Comments and Links to Clinical Trials |
|---|---|---|---|---|---|
| **Janus Kinase Inhibitors**, continued | | | | | |
| **Tofacitinib** | **Dose for FDA-Approved Indications:**<br>• Tofacitinib 5 mg PO twice daily for rheumatoid and psoriatic arthritis<br>• Tofacitinib 10 mg PO twice daily for ulcerative colitis<br>**Dose for COVID-19:**<br>• Dose and duration unknown; a planned COVID-19 clinical trial will evaluate tofacitinib 10 mg twice daily for 14 days. | • Thrombotic events (pulmonary embolism, DVT, arterial thrombosis)<br>• Anemia<br>• Risk of infection<br>• GI perforation<br>• Diarrhea<br>• Headache<br>• Herpes zoster<br>• Lipid elevations<br>• Liver enzyme elevations<br>• Lymphoma and other malignancies | • CBC with differential<br>• Liver enzymes<br>• New infections | • Dose modifications required when administered with strong CYP3A4 inhibitors or when used with a moderate CYP3A4 inhibitor that is coadministered with a strong CYP2C19 inhibitor.<br>• **Avoid** administration of live vaccines. | • **Avoid** use in patients with ALC <500 cells/mm$^3$, ANC <1,000 cells/mm$^3$, or Hgb <9 grams/dL.<br>• Dose modification may be required in patients with moderate or severe renal impairment or moderate hepatic impairment.<br>• A list of clinical trials is available: Tofacitinib |
| **Non-SARS-CoV-2 Specific Immunoglobulin** | | | | | |
| **Non-SARS-CoV-2 Specific Immunoglobulin** | • Dose varies based on indication and formulation. | • Allergic reactions, including anaphylaxis<br>• Renal failure<br>• Thrombotic events<br>• Aseptic meningitis syndrome<br>• Hemolysis<br>• TRALI<br>• Transmission of infectious pathogens<br>• AEs may vary by formulation.<br>• AEs may be increased with high-dose, rapid infusion, or in patients with underlying conditions. | • Transfusion-related reactions<br>• Vital signs at baseline and during and after infusion<br>• Renal function. Discontinue treatment if function deteriorates. | • IVIG may interfere with immune response to certain vaccines. | • A list of clinical trials is available: Intravenous Immunoglobulin |

**Key:** AE = adverse event; ALC = absolute lymphocyte count; ALT = alanine transaminase; ANC = absolute neutrophil count; AST = aspartate aminotransferase; CBC = complete blood count; CHF = congestive heart failure; CPK = creatine phosphokinase; CrCl = creatinine clearance; CRP = C-reactive protein; CYP = cytochrome P; DILI = drug induced liver injury; DVT = deep vein thrombosis; ECMO = extracorporeal membrane oxygenation; eGFR = estimated glomerular filtration rate; EUA = Emergency Use Authorization; FDA = Food and Drug Administration; GI = gastrointestinal; HBV = hepatitis B; Hgb = hemoglobin; HSR = hypersensitivity reaction; HSV = herpes simplex virus; HTN = hypertension; IFN = interferon; IL = interleukin; IMV = invasive mechanical ventilation; IV = intravenous; IVIG = intravenous immunoglobulin; IVM = ivermectin; MAOI = monoamine oxidase inhibitor; MERS = Middle East respiratory syndrome; OAT = organic anion transporter; the Panel = the COVID-19 Treatment Guidelines Panel; Peg-IFN = pegylated interferon; P-gp= P-glycoprotein; PK = pharmacokinetic; PO = orally; PPI = proton pump inhibitor; RDV = remdesivir; SAE = serious adverse event; SQ = subcutaneous; TB = tuberculosis; TNF = tumor necrosis factor; TRALI = transfusion-related acute lung injury; ULN = upper limit of normal

## References


1. Colchicine (Colcrys) [package insert]. Food and Drug Administration. 2009. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2009/022351lbl.pdf.
2. Ramakrishnan S, Nicolau DV, Jr., Langford B, et al. Inhaled budesonide in the treatment of early COVID-19 (STOIC): a Phase 2, open-label, randomised controlled trial. *Lancet Respir Med*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33844996.
3. PRINCIPLE Trial Collaborative Group, Yu L, Bafadhel M, et al. Inhaled budesonide for COVID-19 in people at higher risk of adverse outcomes in the community: interim analyses from the PRINCIPLE trial. *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.10.21254672v1.
4. Randomised Evaluation of COVID-19 Therapy (RECOVERY). Low-cost dexamethasone reduces death by up to one third in hospitalised patients with severe respiratory complications of COVID-19. 2020. Available at: https://www.recoverytrial.net/news/low-cost-dexamethasone-reduces-death-by-up-to-one-third-in-hospitalised-patients-with-severe-respiratory-complications-of-covid-19. Accessed July 30, 2021.
5. Stauffer WM, Alpern JD,Walker PF. COVID-19 and dexamethasone: a potential strategy to avoid steroid-related strongyloides hyperinfection. *JAMA*. 2020;324(7):623-624. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32761166.
6. Liu J, Wang T, Cai Q, et al. Longitudinal changes of liver function and hepatitis B reactivation in COVID-19 patients with pre-existing chronic HBV infection. *Hepatol Res*. 2020;50(11):1211-1221. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32761993.
7. Centers for Disease Control and Prevention. Parasites—strongyloides: resources for health professionals. 2020. Available at: https://www.cdc.gov/parasites/strongyloides/health_professionals/index.html. Accessed July 30, 2021.
8. Temesgen Z, Burger CD, Baker J, et al. Lenzilumab efficacy and safety in newly hospitalized COVID-19 subjects: results from the live-air Phase 3 randomized double-blind placebo-controlled trial. *medRxiv*. 2021;Preprint. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33972949.
9. Cremer PC, Abbate A, Hudock K, et al. Mavrilimumab in patients with severe COVID-19 pneumonia and systemic hyperinflammation (MASH-COVID): an investigator initiated, multicentre, double-blind, randomised, placebo-controlled trial. *Lancet Rheumatol*. 2021;3(6):e410-e418. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33754144.
10. Patel J, Beishuizen A, Ruiz XB, et al. A randomized trial of otilimab in severe COVID-19 pneumonia (OSCAR). *medRxiv*. 2021;Preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.04.14.21255475v1.

11. Omrani AS, Saad MM, Baig K, et al. Ribavirin and interferon alfa-2a for severe Middle East respiratory syndrome coronavirus infection: a retrospective cohort study. *Lancet Infect Dis*. 2014;14(11):1090-1095. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25278221.

12. Shalhoub S, Farahat F, Al-Jiffri A, et al. IFN-alfa2a or IFN-beta1a in combination with ribavirin to treat Middle East respiratory syndrome coronavirus pneumonia: a retrospective study. *J Antimicrob Chemother*. 2015;70(7):2129-2132. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25900158.

13. Zhou Q, Chen V, Shannon CP, et al. Interferon-alfa2b Treatment for COVID-19. *Front Immunol*. 2020;11:1061. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32574262.

14. Peginterferon alfa-2a (Pegasys) [package insert]. Food and Drug Administration. 2017. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2017/103964s5270lbl.pdf.

15. Hung IF, Lung KC, Tso EY, et al. Triple combination of interferon beta-1b, lopinavir-ritonavir, and ribavirin in the treatment of patients admitted to hospital with COVID-19: an open-label, randomised, Phase 2 trial. *Lancet*. 2020;395(10238):1695-1704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32401715.

16. Interferon beta-1a (Rebif) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/103780s5204lbl.pdf.

17. Sarilumab (Kevzara) [package insert]. Food and Drug Administration. 2018. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2018/761037s001lbl.pdf.

18. Regeneron. Regeneron and Sanofi provide update on U.S. Phase 2/3 adaptive-designed trial of KEVZARA® (sarilumab) in hospitalized COVID-19 patients. 2020.

19. Tocilizumab (Actemra) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/125276s127,125472s040lbl.pdf.

20. Lier AJ, Tuan JL, Davis MW, et al. Case report: disseminated strongyloidiasis in a patient with COVID-19. *Am J Trop Med Hyg*. 2020. Available at: http://www.ajtmh.org/docserver/fulltext/10.4269/ajtmh.20-0699/tpmd200699.pdf?expires=1598276702&id=id&accname=guest&checksum=D8AA596942F31C34007E0FE065AF1F5F.

21. Marchese V, Crosato V, Gulletta M, et al. Strongyloides infection manifested during immunosuppressive therapy for SARS-CoV-2 pneumonia. *Infection*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32910321.

22. Siltuximab (Sylvant) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/125496s018lbl.pdf.

23. Baricitinib (Olumiant) [package insert]. Food and Drug Administration. 2019. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2019/207924s001lbl.pdf.

24. Food and Drug Administration. Fact sheet for healthcare providers: Emergency Use Authorization (EUA) of baricitinib. 2020; Available at: https://www.fda.gov/media/143823/download. Accessed July 30, 2021.

# Antithrombotic Therapy in Patients with COVID-19

*Last Updated: February 11, 2021*

| Summary Recommendations |
|---|
| **Laboratory Testing**<br>• In nonhospitalized patients with COVID-19, there are currently no data to support the measurement of coagulation markers (e.g., D-dimers, prothrombin time, platelet count, fibrinogen) **(AIII)**.<br>• In hospitalized patients with COVID-19, hematologic and coagulation parameters are commonly measured, although there is currently insufficient evidence to recommend either for or against using this data to guide management decisions.<br>**Chronic Anticoagulant and Antiplatelet Therapy**<br>• Patients who are receiving anticoagulant or antiplatelet therapies for underlying conditions should continue these medications if they receive a diagnosis of COVID-19 **(AIII)**.<br>**Venous Thromboembolism Prophylaxis and Screening**<br>• For nonhospitalized patients with COVID-19, anticoagulants and antiplatelet therapy should not be initiated for the prevention of venous thromboembolism (VTE) or arterial thrombosis unless the patient has other indications for the therapy or is participating in a clinical trial **(AIII)**.<br>• Hospitalized nonpregnant adults with COVID-19 should receive prophylactic dose anticoagulation **(AIII)** (see the recommendations for pregnant individuals below). Anticoagulant or antiplatelet therapy should not be used to prevent arterial thrombosis outside of the usual standard of care for patients without COVID-19 **(AIII)**.<br>• There is currently insufficient evidence to recommend either for or against the use of thrombolytics or higher than the prophylactic dose of anticoagulation for VTE prophylaxis in hospitalized COVID-19 patients outside of a clinical trial.<br>• Hospitalized patients with COVID-19 should not routinely be discharged from the hospital while on VTE prophylaxis **(AIII)**. Continuing anticoagulation with a Food and Drug Administration-approved regimen for extended VTE prophylaxis after hospital discharge can be considered for patients who are at low risk for bleeding and high risk for VTE, as per the protocols for patients without COVID-19 (see details on defining at-risk patients below) **(BI)**.<br>• There is currently insufficient evidence to recommend either for or against routine deep vein thrombosis screening in COVID-19 patients without signs or symptoms of VTE, regardless of the status of their coagulation markers.<br>• For hospitalized COVID-19 patients who experience rapid deterioration of pulmonary, cardiac, or neurological function, or of sudden, localized loss of peripheral perfusion, the possibility of thromboembolic disease should be evaluated **(AIII**).<br>**Hospitalized Children With COVID-19**<br>• For hospitalized children with COVID-19, indications for VTE prophylaxis should be the same as those for children without COVID-19 **(BIII)**.<br>**Treatment**<br>• When diagnostic imaging is not possible, patients with COVID-19 who experience an incident thromboembolic event or who are highly suspected to have thromboembolic disease should be managed with therapeutic doses of anticoagulant therapy **(AIII)**.<br>• Patients with COVID-19 who require extracorporeal membrane oxygenation or continuous renal replacement therapy or who have thrombosis of catheters or extracorporeal filters should be treated with antithrombotic therapy as per the standard institutional protocols for those without COVID-19 **(AIII)**.<br>**Special Considerations During Pregnancy and Lactation**<br>• If antithrombotic therapy is prescribed during pregnancy prior to a diagnosis of COVID-19, this therapy should be continued **(AIII)**.<br>• For pregnant patients hospitalized for severe COVID-19, prophylactic dose anticoagulation is recommended unless contraindicated (see below) **(BIII)**. |

- Like for nonpregnant patients, VTE prophylaxis after hospital discharge **is not recommended** for pregnant patients **(AIII)**. Decisions to continue VTE prophylaxis in the pregnant or postpartum patient after discharge should be individualized, considering concomitant VTE risk factors.
- Anticoagulation therapy use during labor and delivery requires specialized care and planning. It should be managed in pregnant patients with COVID-19 in a similar way as in pregnant patients with other conditions that require anticoagulation in pregnancy **(AIII)**.
- Unfractionated heparin, low molecular weight heparin, and warfarin do not accumulate in breast milk and do not induce an anticoagulant effect in the newborn; therefore, they can be used by breastfeeding individuals with or without COVID-19 who require VTE prophylaxis or treatment **(AIII)**. In contrast, use of direct-acting oral anticoagulants during pregnancy is not routinely recommended due to lack of safety data **(AIII)**.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

## Association Between COVID-19 and Thromboembolism

Infection with the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the resulting syndrome, COVID-19, have been associated with inflammation and a prothrombotic state, with increases in fibrin, fibrin degradation products, fibrinogen, and D-dimers.[1,2] In some studies, elevations in these markers have been associated with worse clinical outcomes.[3,4]

A number of studies have reported varying incidences of venous thromboembolism (VTE) in patients with COVID-19. A meta-analysis of studies in hospitalized patients with COVID-19 found an overall VTE prevalence of 14.1% (95% CI, 11.6–16.9).[5] The VTE prevalence was higher in studies that used ultrasound screening (40.3%; 95% CI, 27.0–54.3) than in studies that did not (9.5%; 95% CI, 7.5–11.7). In randomized controlled trials conducted prior to the COVID-19 pandemic, the incidence of VTE in non-COVID-19 hospitalized patients who received VTE prophylaxis ranged from 0.3% to 1% for symptomatic VTE and from 2.8% to 5.6% for VTE overall.[6-8] The VTE incidence in randomized trials in critically ill non-COVID-19 patients who received prophylactic dose anticoagulants ranged from 5% to 16%, and a prospective cohort study of critically ill patients with sepsis reported a VTE incidence of 37%.[9-12] VTE guidelines for non-COVID-19 patients have recommended against routine screening ultrasounds in critically ill patients because no study has shown that this strategy reduces the rate of subsequent symptomatic thromboembolic complications.[13] Although the incidence of thromboembolic events, especially pulmonary emboli, can be high among hospitalized patients with COVID-19, there are no published data demonstrating the clinical utility of routine surveillance for deep vein thrombosis using lower extremity ultrasound in this population.

A meta-analysis performed by an American Society of Hematology guidelines panel compared the odds of bleeding and thrombotic outcomes in patients with COVID-19 treated with prophylactic dose anticoagulation versus in those treated with intermediate or therapeutic dose anticoagulation.[14] Overall, the odds of VTE and mortality were not different between the patients treated with prophylactic dose anticoagulation and those treated with higher doses of anticoagulation. In critically ill patients, intermediate or therapeutic dose anticoagulation was associated with a lower odds of pulmonary embolism (OR 0.09; 95% CI, 0.02–0.57) but a higher odds of major bleeding (OR 3.84; 95% CI, 1.44–10.21). In studies in patients with COVID-19, incidences of symptomatic VTE between 0% to 0.6% at 30 to 42 days after hospital discharge have been reported.[15-17] Epidemiologic studies that control for clinical characteristics, underlying comorbidities, prophylactic anticoagulation, and COVID-19-related therapies are needed.

There are limited prospective data demonstrating the safety and efficacy of using therapeutic doses of anticoagulants to prevent VTE in patients with COVID-19. A retrospective analysis of 2,773

hospitalized COVID-19 patients from a single center in the United States reported in-hospital mortality in 22.5% of patients who received therapeutic anticoagulation and 22.8% of patients who did not receive anticoagulation. The study further reported that in a subset of 395 mechanically ventilated patients, 29.1% of the patients who received anticoagulation and 62.7% of those who did not receive anticoagulation died. The study had important limitations: it lacked details on patient characteristics, indications for anticoagulant initiation, and descriptions of other therapies that the patients received that may have influenced mortality. In addition, the authors did not discuss the potential impact of survival bias on the study results. For these reasons, the data are not sufficient to influence standard of care, and this study further emphasizes the need for prospective trials to define the risks and potential benefits of therapeutic anticoagulation in patients with COVID-19.[18] Three international trials (Antithrombotic Therapy to Ameliorate Complications of COVID-19 [ATTACC], Therapeutic Anticoagulation; Accelerating COVID-19 Therapeutic Interventions and Vaccines-4 [ACTIV-4], and the Randomized, Embedded, Multi-factorial Adaptive Platform Trial for Community-Acquired Pneumonia [REMAP-CAP]) compared the effectiveness of therapeutic dose anticoagulation and prophylactic dose anticoagulation in reducing the need for organ support over 21 days in moderately ill or critically ill adults hospitalized for COVID-19. The need for organ support was defined as requiring high-flow nasal oxygen, invasive or noninvasive mechanical ventilation, vasopressor therapy, or extracorporeal membrane oxygenation (ECMO). The trials paused enrollment of patients requiring intensive care unit (ICU)-level care after an interim pooled analysis demonstrated futility of therapeutic anticoagulation in improving organ support, and a concern for safety. The results of the interim analysis are available on the ATTACC website. Unblinded data and additional study outcomes, including the occurrence of thrombosis, are expected to be reported soon.[19]

A small, single-center randomized trial (n = 20) compared therapeutic and prophylactic anticoagulation in mechanically ventilated patients with D-dimers >1,000 µg/L (as measured by the VIDAS D-dimer Exclusion II assay). Only the patients treated with therapeutic anticoagulation showed improvement in the ratio of arterial oxygen partial pressure of oxygen to fraction of inspired oxygen ($PaO_2/FiO_2$). The number of ventilator-free days was higher in the therapeutic anticoagulation arm than in the prophylactic anticoagulation arm (15 days [IQR 6–16] vs. 0 days [IQR 0–11]; $P = 0.028$). There was no difference between the arms in in-hospital or 28-day mortality. Two patients treated with therapeutic anticoagulation had minor bleeding, and two patients in each arm experienced thrombosis.[20] Additional evidence from large, multicenter trials is needed, and the trial results are expected soon.

Several randomized controlled trials have been developed to evaluate the risks and benefits of anticoagulation in patients with COVID-19 (visit *ClinicalTrials.gov* for the current list of trials). Guidelines about coagulopathy and prevention and management of VTE in patients with COVID-19 have been released by multiple organizations, including the Anticoagulation Forum,[21] the American College of Chest Physicians,[22] the American Society of Hematology,[23] the International Society of Thrombosis and Haemostasis (ISTH),[24] the Italian Society on Thrombosis and Haemostasis,[25] and the Royal College of Physicians.[26] In addition, a paper that outlines issues related to thrombotic disease with implications for prevention and therapy has been endorsed by the ISTH, the North American Thrombosis Forum, the European Society of Vascular Medicine, and the International Union of Angiology.[27]

All of the guidelines referenced above agree that hospitalized patients with COVID-19 should receive prophylactic dose anticoagulation for VTE. Some guidelines note that intermediate dose anticoagulation can be considered for critically ill patients.[21,23,26,28] Given the variation in VTE incidence and the unknown risk of bleeding in critically ill patients with COVID-19, the COVID-19 Treatment Guidelines Panel and guideline panels of the American Society of Hematology and the American College of Chest Physician recommend treating all hospitalized patients with COVID-19, including critically ill patients, with prophylactic dose anticoagulation.[22,29] Results from clinical trials that assess the safety and efficacy

of different anticoagulant doses will provide further information on the best prophylactic strategies for patients with COVID-19.

## Monitoring Coagulation Markers in Patients With COVID-19

In nonhospitalized patients with COVID-19, markers of coagulopathy, such as D-dimer level, prothrombin time, fibrinogen level, and platelet count, should not routinely be obtained **(AIII)**. Although abnormalities in these coagulation markers have been associated with worse outcomes, prospective data demonstrating that the markers can be used to predict the risk of VTE in those who are asymptomatic or who have mild SARS-CoV-2 infection is lacking.

In hospitalized patients with COVID-19, hematologic and coagulation parameters are commonly measured; however, there is currently insufficient evidence to recommend either for or against using such data to guide management decisions.

## Managing Antithrombotic Therapy in Patients With COVID-19

### *Selection of Anticoagulant or Antiplatelet Drugs for Patients With COVID-19*

Whenever anticoagulant or antiplatelet therapy is used, potential drug-drug interactions with other concomitant drugs must be considered **(AIII)**. The University of Liverpool has collated a list of drug interactions. In hospitalized, critically ill patients, low molecular weight heparin or unfractionated heparin is preferred over oral anticoagulants because the two types of heparin have shorter half-lives, can be administered intravenously or subcutaneously, and have fewer drug-drug interactions **(AIII)**.

### *Chronic Anticoagulant or Antiplatelet Therapy*

COVID-19 outpatients receiving warfarin who are in isolation and thus unable to have international normalized ratio monitoring may be candidates for switching to direct oral anticoagulant therapy. Patients receiving warfarin who have a mechanical heart valve, ventricular assist device, valvular atrial fibrillation, or antiphospholipid antibody syndrome or who are lactating should continue treatment with warfarin **(AIII)**. Hospitalized patients with COVID-19 who are taking anticoagulant or antiplatelet therapy for underlying medical conditions should continue this treatment unless significant bleeding develops, or other contraindications are present **(AIII)**.

### *Patients with COVID-19 Who Are Managed as Outpatients*

For nonhospitalized patients with COVID-19, anticoagulants and antiplatelet therapy should not be initiated for the prevention of VTE or arterial thrombosis unless the patient has other indications for the therapy or is participating in a clinical trial **(AIII)**.

### *Hospitalized Patients With COVID-19*

For hospitalized patients with COVID-19, prophylactic dose anticoagulation should be prescribed unless contraindicated (e.g., a patient has active hemorrhage or severe thrombocytopenia) **(AIII)**. Although data supporting this recommendation are limited, a retrospective study showed reduced mortality in patients who received prophylactic anticoagulation, particularly if the patient had a sepsis-induced coagulopathy score ≥4.[4] For those without COVID-19, anticoagulant or antiplatelet therapy should not be used to prevent arterial thrombosis outside of the standard of care **(AIII)**. Anticoagulation is routinely used to prevent arterial thromboembolism in patients with heart arrhythmias. Although there are reports of strokes and myocardial infarction in patients with COVID-19, the incidence of these events is unknown.

When imaging is not possible, patients with COVID-19 who experience an incident thromboembolic event or who are highly suspected to have thromboembolic disease should be managed with therapeutic doses of anticoagulant therapy as per the standard of care for patients without COVID-19 **(AIII)**.

There is currently insufficient evidence to recommend either for or against the use of thrombolytic agents or higher than the prophylactic dose of anticoagulation for VTE prophylaxis for hospitalized patients with COVID-19 outside of a clinical trial. Three international trials (ACTIV-4, REMAP-CAP, and ATTACC) compared the effectiveness of therapeutic dose anticoagulation and prophylactic dose anticoagulation in reducing the need for organ support over 21 days in moderately ill or critically ill adults hospitalized for COVID-19. The need for organ support was defined as requiring high-flow nasal oxygen, invasive or noninvasive mechanical ventilation, vasopressor therapy, or ECMO. The trials paused enrollment of patients requiring ICU-level care at enrollment after an interim pooled analysis demonstrated futility of therapeutic anticoagulation in reducing the need for organ support and a concern for safety. The results of the interim analysis are available on the ATTACC website. Unblinded data and additional study outcomes, including the occurrence of thrombosis, are expected to be reported soon.[19]

Although there is evidence that multi-organ failure is more likely in patients with sepsis who develop coagulopathy,[30] there is no convincing evidence to show that any specific antithrombotic treatment will influence outcomes in those with or without COVID-19. Participation in randomized trials is encouraged.

Patients with COVID-19 who require ECMO or continuous renal replacement therapy or who have thrombosis of catheters or extracorporeal filters should be treated as per the standard institutional protocols for those without COVID-19 **(AIII)**.

### *Hospitalized Children With COVID-19*

A recent meta-analysis of publications on COVID-19 in children did not discuss VTE.[31] Indications for VTE prophylaxis in hospitalized children with COVID-19 should be the same as those for hospitalized children without COVID-19 **(BIII)**.

### *Patients With COVID-19 Who Are Discharged from the Hospital*

VTE prophylaxis after hospital discharge **is not recommended** for patients with COVID-19 **(AIII)**. For certain high-VTE risk patients without COVID-19, post-discharge prophylaxis has been shown to be beneficial. The Food and Drug Administration approved the use of rivaroxaban 10 mg daily for 31 to 39 days in these patients.[32,33] Inclusion criteria for the trials that studied post-discharge VTE prophylaxis included:

- Modified International Medical Prevention Registry on Venous Thromboembolism (IMPROVE) VTE risk score ≥4; *or*
- Modified IMPROVE VTE risk score ≥2 and D-dimer level >2 times the upper limit of normal.[32]

Any decision to use post-discharge VTE prophylaxis for patients with COVID-19 should include consideration of the individual patient's risk factors for VTE, including reduced mobility, bleeding risks, and feasibility. Participation in clinical trials is encouraged.

## Special Considerations During Pregnancy and Lactation

Because pregnancy is a hypercoagulable state, the risk of thromboembolism is greater in pregnant individuals than in nonpregnant individuals.[34] It is not yet known whether COVID-19 increases this risk. In several cohort studies of pregnant women with COVID-19 in the United States and Europe,

VTE was not reported as a complication even among women with severe disease, although the receipt of prophylactic or therapeutic anticoagulation varied across the studies.[35-37] The American College of Obstetricians and Gynecologists (ACOG) advises that, although there are no data for or against thromboprophylaxis in the setting of COVID-19 in pregnancy, VTE prophylaxis can reasonably be considered for pregnant women hospitalized with COVID-19, particularly for those who have severe disease.[38] If there are no contraindications to use, the Society of Maternal Fetal Medicine recommends prophylactic heparin or low molecular weight heparin in critically ill or mechanically ventilated pregnant patients.[39] Several professional societies, including the American Society of Hematology and ACOG, have guidelines that specifically address the management of VTE in the context of pregnancy.[40,41] If delivery is threatened, or if there are other risks for bleeding, the risk of bleeding may outweigh the potential benefit of VTE prophylaxis in pregnancy.

There are no data on the use of scoring systems to predict VTE risk in pregnant individuals. Additionally, during pregnancy, the D-dimer level may not be a reliable predictor of VTE because there is a physiologic increase of D-dimer levels throughout gestation.[42-44]

In general, the preferred anticoagulants during pregnancy are heparin compounds. Because of its reliability and ease of administration, low-molecular weight heparin is recommended, rather than unfractionated heparin, for the prevention and treatment of VTE in pregnancy.[41]

Direct-acting anticoagulants are not routinely used during pregnancy due to the lack of safety data in pregnant individuals.[40] The use of warfarin to prevent or treat VTE should be avoided in pregnant individuals, regardless of their COVID-19 status, and especially during the first trimester due to the concern for teratogenicity.

Specific recommendations for pregnant or lactating individuals with COVID-19 include:

- If antithrombotic therapy is prescribed during pregnancy prior to a diagnosis of COVID-19, this therapy should be continued **(AIII)**.
- For pregnant patients hospitalized for severe COVID-19, prophylactic dose anticoagulation is recommended unless contraindicated **(BIII)**.
- Like for nonpregnant patients, VTE prophylaxis after hospital discharge **is not recommended** for pregnant patients **(AIII)**. Decisions to continue VTE prophylaxis in the pregnant or postpartum patient should be individualized, considering concomitant VTE risk factors.
- Anticoagulation therapy use during labor and delivery requires specialized care and planning. It should be managed in pregnant patients with COVID-19 in a similar way as in pregnant patients with other conditions that require anticoagulation in pregnancy **(AIII)**.
- Unfractionated heparin, low molecular weight heparin, and warfarin do not accumulate in breast milk and do not induce an anticoagulant effect in the newborn; therefore, they can be used by breastfeeding women with or without COVID-19 who require VTE prophylaxis or treatment **(AIII)**. In contrast, use of direct-acting oral anticoagulants during pregnancy is not routinely recommended due to lack of safety data **(AIII)**.[40]

## References


1. Han H, Yang L, Liu R, et al. Prominent changes in blood coagulation of patients with SARS-CoV-2 infection. *Clin Chem Lab Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32172226.
2. Driggin E, Madhavan MV, Bikdeli B, et al. Cardiovascular considerations for patients, health care workers, and health systems during the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Cardiol*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32201335.

3. Guan WJ, Ni ZY, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32109013.
4. Tang N, Bai H, Chen X, Gong J, Li D, Sun Z. Anticoagulant treatment is associated with decreased mortality in severe coronavirus disease 2019 patients with coagulopathy. *J Thromb Haemost*. 2020;18(5):1094-1099. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32220112.
5. Nopp S, Moik F, Jilma B, Pabinger I, Ay C. Risk of venous thromboembolism in patients with COVID-19: a systematic review and meta-analysis. *Res Pract Thromb Haemost*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33043231.
6. Cohen AT, Davidson BL, Gallus AS, et al. Efficacy and safety of fondaparinux for the prevention of venous thromboembolism in older acute medical patients: randomised placebo controlled trial. *BMJ*. 2006;332(7537):325-329. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16439370.
7. Leizorovicz A, Cohen AT, Turpie AG, et al. Randomized, placebo-controlled trial of dalteparin for the prevention of venous thromboembolism in acutely ill medical patients. *Circulation*. 2004;110(7):874-879. Available at: https://www.ncbi.nlm.nih.gov/pubmed/15289368.
8. Samama MM, Cohen AT, Darmon JY, et al. A comparison of enoxaparin with placebo for the prevention of venous thromboembolism in acutely ill medical patients. Prophylaxis in Medical Patients with Enoxaparin Study Group. *N Engl J Med*. 1999;341(11):793-800. Available at: https://www.ncbi.nlm.nih.gov/pubmed/10477777.
9. Fraisse F, Holzapfel L, Couland JM, et al. Nadroparin in the prevention of deep vein thrombosis in acute decompensated COPD. The Association of Non-University Affiliated Intensive Care Specialist Physicians of France. *Am J Respir Crit Care Med*. 2000;161(4 Pt 1):1109-1114. Available at: https://www.ncbi.nlm.nih.gov/pubmed/10764298.
10. PROTECT Investigators for the Canadian Critical Care Trials Group and the Australian and New Zealand Intensive Care Society Clinical Trials Group, et al. Dalteparin versus unfractionated heparin in critically ill patients. *N Engl J Med*. 2011;364(14):1305-1314. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21417952.
11. Shorr AF, Williams MD. Venous thromboembolism in critically ill patients. Observations from a randomized trial in sepsis. *Thromb Haemost*. 2009;101(1):139-144. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19132200.
12. Kaplan D, Casper TC, Elliott CG, et al. VTE incidence and risk factors in patients with severe sepsis and septic shock. *Chest*. 2015;148(5):1224-1230. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26111103.
13. Kahn SR, Lim W, Dunn AS, et al. Prevention of VTE in nonsurgical patients: Antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*. 2012;141(2 Suppl):e195S-e226S. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22315261.
14. American Society of Hematology. Should DOACs, LMWH, UFH, Fondaparinux, Argatroban, or Bivalirudin at intermediate-intensity or therapeutic-intensity vs. prophylactic intensity be used for patients with COVID-19 related critical illness who do not have suspected or confirmed VTE? 2020. Available at: https://guidelines.ash.gradepro.org/profile/3CQ7J0SWt58. Accessed December 7, 2020.
15. Roberts LN, Whyte MB, Georgiou L, et al. Postdischarge venous thromboembolism following hospital admission with COVID-19. *Blood*. 2020;136(11):1347-1350. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32746455.
16. Engelen MM, Vanassche T, Balthazar T, et al. Incidence of venous thromboembolism in patients discharged after COVID-19 Hostpialization [abstract]. *Res Pract Thromb Haemost*. 2020;4 (Suppl 1). Available at: https://abstracts.isth.org/abstract/incidence-of-venous-thromboembolism-in-patients-discharged-after-covid-19-hospitalisation/.
17. Patell R, Bogue T, Koshy A, et al. Postdischarge thrombosis and hemorrhage in patients with COVID-19. *Blood*. 2020;136(11):1342-1346. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32766883.

18. Paranjpe I, Fuster V, Lala A, et al. Association of treatment dose anticoagulation with in-hospital survival among hospitalized patients with COVID-19. *Journal of the American College of Cardiology*. 2020;In press. Available at: https://www.sciencedirect.com/science/article/pii/S0735109720352189?via%3Dihub.

19. NIH ACTIV Trial of blood thinners pauses enrollment of critically ill COVID-19 patients [press release]. 2020. Available at: https://www.nih.gov/news-events/news-releases/nih-activ-trial-blood-thinners-pauses-enrollment-critically-ill-covid-19-patients. Accessed February 8, 2021.

20. Lemos ACB, do Espirito Santo DA, Salvetti MC, et al. Therapeutic versus prophylactic anticoagulation for severe COVID-19: a randomized Phase II clinical trial (HESACOVID). *Thromb Res*. 2020;196:359-366. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32977137.

21. Barnes GD, Burnett A, Allen A, et al. Thromboembolism and anticoagulant therapy during the COVID-19 pandemic: interim clinical guidance from the anticoagulation forum. *J Thromb Thrombolysis*. 2020;50(1):72-81. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32440883.

22. Moores LK, Tritschler T, Brosnahan S, et al. Prevention, diagnosis, and treatment of VTE in patients with coronavirus disease 2019: CHEST guideline and expert panel report. *Chest*. 2020;158(3):1143-1163. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32502594.

23. American Society of Hematology. ASH guidelines on use of anticoagulation in patients with COVID-19. 2020. Available at: https://www.hematology.org/education/clinicians/guidelines-and-quality-care/clinical-practice-guidelines/venous-thromboembolism-guidelines/ash-guidelines-on-use-of-anticoagulation-in-patients-with-covid-19. Accessed November 13, 2020.

24. Thachil J, Tang N, Gando S, et al. ISTH interim guidance on recognition and management of coagulopathy in COVID-19. *J Thromb Haemost*. 2020;18(5):1023-1026. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32338827.

25. Marietta M, Ageno W, Artoni A, et al. COVID-19 and haemostasis: a position paper from Italian Society on Thrombosis and Haemostasis (SISET). *Blood Transfus*. 2020;18(3):167-169. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32281926.

26. Royal College of Physicians. Clinical guide for the prevention, detection and management of thromboembolic disease in patients with COVID-19. 2020. Available at: https://icmanaesthesiacovid-19.org/clinical-guide-prevention-detection-and-management-of-vte-in-patients-with-covid-19. Accessed November 13, 2020.

27. Bikdeli B, Madhavan MV, Jimenez D, et al. COVID-19 and thrombotic or thromboembolic disease: Implications for prevention, antithrombotic therapy, and follow-up. *J Am Coll Cardiol*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32311448.

28. Spyropoulos AC, Levy JH, Ageno W, et al. Scientific and Standardization Committee communication: clinical guidance on the diagnosis, prevention, and treatment of venous thromboembolism in hospitalized patients with COVID-19. *J Thromb Haemost*. 2020;18(8):1859-1865. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32459046.

29. American Society of Hematology. COVID-19 and VTE/anticoagulation: frequently asked questions. 2020. Available at: https://www.hematology.org/covid-19/covid-19-and-vte-anticoagulation. Accessed February 8, 2021.

30. Iba T, Nisio MD, Levy JH, Kitamura N, Thachil J. New criteria for sepsis-induced coagulopathy (SIC) following the revised sepsis definition: a retrospective analysis of a nationwide survey. *BMJ Open*. 2017;7(9):e017046. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28963294.

31. Ludvigsson JF. Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. *Acta Paediatr*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32202343.

32. Spyropoulos AC, Lipardi C, Xu J, et al. Modified IMPROVE VTE risk score and elevated D-dimer identify a high venous thromboembolism risk in acutely ill medical population for extended thromboprophylaxis. *TH Open*. 2020;4(1):e59-e65. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32190813.

33. Cohen AT, Harrington RA, Goldhaber SZ, et al. Extended thromboprophylaxis with betrixaban in acutely ill

medical patients. *N Engl J Med*. 2016;375(6):534-544. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27232649.

34. Heit JA, Kobbervig CE, James AH, Petterson TM, Bailey KR, Melton LJ 3rd. Trends in the incidence of venous thromboembolism during pregnancy or postpartum: a 30-year population-based study. *Ann Intern Med*. 2005;143(10):697-706. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16287790.
35. Breslin N, Baptiste C, Gyamfi-Bannerman C, et al. Coronavirus disease 2019 infection among asymptomatic and symptomatic pregnant women: two weeks of confirmed presentations to an affiliated pair of New York City hospitals. *Am J Obstet Gynecol MFM*. 2020;2(2):100118. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32292903.
36. Knight M, Bunch K, Vousden N, et al. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study. *BMJ*. 2020;369:m2107. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32513659.
37. Delahoy MJ, Whitaker M, O'Halloran A, et al. Characteristics and maternal and birth outcomes of hospitalized pregnant women with laboratory-confirmed COVID-19 - COVID-NET, 13 states, March 1–August 22, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(38):1347-1354. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32970655.
38. The American College of Obstetricians and Gynecologists. COVID-19 FAQs for obstetrician-gynecologists, obstetrics. 2020. Available at: https://www.acog.org/clinical-information/physician-faqs/covid-19-faqs-for-ob-gyns-obstetrics. Accessed February 8, 2021.
39. Society for Maternal Fetal Medicine. Management considerations for pregnant patients with COVID-19. 2020. Available at: https://s3.amazonaws.com/cdn.smfm.org/media/2336/SMFM_COVID_Management_of_COVID_pos_preg_patients_4-30-20_final.pdf. Accessed February 8, 2021.
40. Bates SM, Rajasekhar A, Middeldorp S, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: venous thromboembolism in the context of pregnancy. *Blood Adv*. 2018;2(22):3317-3359. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30482767.
41. ACOG practice bulletin no. 196 summary: thromboembolism in pregnancy. *Obstet Gynecol*. 2018;132(1):243-248. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29939933.
42. Wang M, Lu S, Li S, Shen F. Reference intervals of D-dimer during the pregnancy and puerperium period on the STA-R evolution coagulation analyzer. *Clin Chim Acta*. 2013;425:176-180. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23954836.
43. Reger B, Peterfalvi A, Litter I, et al. Challenges in the evaluation of D-dimer and fibrinogen levels in pregnant women. *Thromb Res*. 2013;131(4):e183-187. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23481480.
44. Hu W, Wang Y, Li J, et al. The predictive value of D-dimer test for venous thromboembolism during puerperium: a prospective cohort study. *Clin Appl Thromb Hemost*. 2020;26:1076029620901786. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32090610.

# Supplements

*Last Updated: February 11, 2021*

| Summary Recommendations |
| --- |
| **Vitamin C**<br>• There is insufficient evidence for the COVID-19 Treatment Guidelines Panel (the Panel) to recommend either for or against the use of vitamin C for the treatment of COVID-19.<br>**Vitamin D**<br>• There is insufficient evidence for the Panel to recommend either for or against the use of vitamin D for the treatment of COVID-19.<br>**Zinc**<br>• There is insufficient evidence for the Panel to recommend either for or against the use of zinc for the treatment of COVID-19.<br>• The Panel **recommends against** using zinc supplementation above the recommended dietary allowance for the prevention of COVID-19, except in a clinical trial **(BIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

In addition to the antiviral medications and the immune-based therapies that are discussed elsewhere in the COVID-19 Treatment Guidelines, adjunctive therapies are frequently used in the prevention and/or treatment of COVID-19 or its complications. Some of these agents are being studied in clinical trials.

Some clinicians advocate for the use of vitamin and mineral supplements to treat respiratory viral infections. Ongoing studies are evaluating the use of vitamin and mineral supplements for both the treatment and prevention of SARS-CoV-2 infection.

The following sections describe the underlying rationale for using adjunctive therapies and summarize the existing clinical trial data. Other adjunctive therapies will be added as new evidence emerges.

# Vitamin C

*Last Updated: April 21, 2021*

Vitamin C (ascorbic acid) is a water-soluble vitamin that is thought to have beneficial effects in patients with severe and critical illnesses. It is an antioxidant and free radical scavenger that has anti-inflammatory properties, influences cellular immunity and vascular integrity, and serves as a cofactor in the generation of endogenous catecholamines.[1,2] Because humans may require more vitamin C in states of oxidative stress, vitamin C supplementation has been evaluated in numerous disease states, including serious infections and sepsis. Because SARS-CoV-2 infection may cause sepsis and acute respiratory distress syndrome (ARDS), the potential role of high doses of vitamin C in ameliorating inflammation and vascular injury in patients with COVID-19 is being studied.

## Recommendation for Non-Critically Ill Patients With COVID-19

- There is insufficient evidence for the COVID-19 Treatment Guidelines Panel (the Panel) to recommend either for or against the use of vitamin C for the treatment of COVID-19 in non-critically ill patients.

## Rationale

Because patients who are not critically ill with COVID-19 are less likely to experience oxidative stress or severe inflammation, the role of vitamin C in this setting is unknown.

## Clinical Data on Vitamin C in Outpatients With COVID-19

### *Oral Ascorbic Acid Versus Zinc Gluconate Versus Both Agents Versus Standard of Care*

In an open-label clinical trial that was conducted at two sites in the United States, outpatients with laboratory-confirmed SARS-CoV-2 infection were randomized to receive either 10 days of oral ascorbic acid 8,000 mg, zinc gluconate 50 mg, both agents, or standard of care.[3] The primary end point was the number of days required to reach a 50% reduction in the patient's symptom severity score. The study was stopped early by an operational and safety monitoring board due to futility after 40% of the planned 520 participants were enrolled (n = 214).

Patients who received standard of care achieved a 50% reduction in their symptom severity scores at a mean of 6.7 days (SD 4.4 days) compared with 5.5 days (SD 3.7 days) for the ascorbic acid arm, 5.9 days (SD 4.9 days) for the zinc gluconate arm, and 5.5 days (SD 3.4 days) for the arm that received both agents (overall $P = 0.45$). Nonserious adverse effects occurred more frequently in patients who received supplements than in those who did not; 39.5% of patients in the ascorbic acid arm, 18.5% in the zinc gluconate arm, and 32.1% in the arm that received both agents experienced nonserious adverse effects compared with 0% of patients in the standard of care arm (overall $P < 0.001$). The most common nonserious adverse effects in this study were gastrointestinal events.

The limitations of this study include the small sample size and the lack of a placebo control. In outpatients with COVID-19, treatment with high-dose zinc gluconate, ascorbic acid, or a combination of the two supplements did not significantly decrease the number of days required to reach a 50% reduction in a symptom severity score compared with standard of care.

## Recommendation for Critically Ill Patients With COVID-19

- There is insufficient evidence for the Panel to recommend either for or against the use of vitamin C for the treatment of COVID-19 in critically ill patients.

## Rationale

There are no controlled trials that have definitively demonstrated a clinical benefit for vitamin C in critically ill patients with COVID-19, and the available observational data are inconclusive. Studies of vitamin C regimens in sepsis patients and ARDS patients have reported variable efficacy and few safety concerns.

## Clinical Data on Vitamin C in Critically Ill Patients

### *Intravenous Vitamin C Alone in Patients With COVID-19*

A pilot clinical trial in China randomized 56 adults with COVID-19 in the intensive care unit to receive intravenous (IV) vitamin C 24 g per day or placebo for 7 days. The study was terminated early due to a reduction in the number of cases of COVID-19 in China. Overall, the study found no differences between the arms in mortality, the duration of mechanical ventilation, or the change in median sequential organ failure assessment (SOFA) scores. The study reported improvements in oxygenation (as measured by the ratio of arterial partial pressure of oxygen to fraction of inspired oxygen [$PaO_2/FiO_2$]) from baseline to Day 7 in the treatment arm that were statistically greater than those observed in the placebo arm (+20.0 vs. -51.9; $P = 0.04$).[4]

### *Intravenous Vitamin C Alone in Patients Without COVID-19*

A small, three-arm pilot study compared two regimens of IV vitamin C to placebo in 24 critically ill patients with sepsis. Over the 4-day study period, patients who received vitamin C 200 mg/kg per day and those who received vitamin C 50 mg/kg per day had lower SOFA scores and lower levels of proinflammatory markers than patients who received placebo.[5]

In a randomized controlled trial in critically ill patients with sepsis-induced ARDS (n = 167), patients who received IV vitamin C 200 mg/kg per day for 4 days had SOFA scores and levels of inflammatory markers that were similar to those observed in patients who received placebo. However, 28-day mortality was lower in the treatment group (29.8% vs. 46.3%; $P = 0.03$), coinciding with more days alive and free of the hospital and the intensive care unit.[6] A post hoc analysis of the study data reported a difference in median SOFA scores between the treatment group and placebo group at 96 hours; however, this difference was not present at baseline or 48 hours.[7]

### *Intravenous Vitamin C Plus Thiamine With or Without Hydrocortisone in Critically Ill Patients Without COVID-19*

Two small studies that used historic controls reported favorable clinical outcomes (i.e., reduced mortality, reduced risk of progression to organ failure, and improved radiographic findings) in patients with sepsis or severe pneumonia who received a combination of vitamin C, thiamine, and hydrocortisone.[8,9] Subsequently, several randomized trials in which patients received vitamin C and thiamine (with or without hydrocortisone) to treat sepsis and septic shock showed that this combination conferred benefits for certain clinical parameters. However, no survival benefit was reported. Two trials observed reductions in organ dysfunction (as measured by change in SOFA score on Day 3)[10,11] or the duration of shock[12] without an effect on clinical outcomes. Three other trials, including a large trial of 501 sepsis patients, found no differences in any physiologic or outcome measures between the treatment and placebo groups.[13-15]

See *ClinicalTrials.gov* for a list of clinical trials that are evaluating the use of vitamin C in patients with COVID-19.

## Other Considerations

It is important to note that high circulating concentrations of vitamin C may affect the accuracy of point-of-care glucometers.[16,17]

## References


1. Wei XB, Wang ZH, Liao XL, et al. Efficacy of vitamin C in patients with sepsis: an updated meta-analysis. *Eur J Pharmacol*. 2020;868:172889. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31870831.
2. Fisher BJ, Seropian IM, Kraskauskas D, et al. Ascorbic acid attenuates lipopolysaccharide-induced acute lung injury. *Crit Care Med.* 2011;39(6):1454-1460. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21358394.
3. Thomas S, Patel D, Bittel B, et al. Effect of high-dose zinc and ascorbic acid supplementation vs usual care on symptom length and reduction among ambulatory patients with SARS-CoV-2 infection: the COVID A to Z randomized clinical trial. *JAMA Netw Open*. 2021;4(2):e210369. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33576820.
4. Zhang J, Rao X, Li Y, et al. Pilot trial of high-dose vitamin C in critically ill COVID-19 patients. *Ann Intensive Care*. 2021;11(1):5. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33420963.
5. Fowler AA, 3rd, Syed AA, Knowlson S, et al. Phase I safety trial of intravenous ascorbic acid in patients with severe sepsis. *J Transl Med*. 2014;12:32. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24484547.
6. Fowler AA, 3rd, Truwit JD, Hite RD, et al. Effect of vitamin C infusion on organ failure and biomarkers of inflammation and vascular injury in patients with sepsis and severe acute respiratory failure: the CITRIS-ALI randomized clinical trial. *JAMA*. 2019;322(13):1261-1270. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31573637.
7. Fowler AA, 3rd, Fisher BJ, Kashiouris MG. Vitamin C for sepsis and acute respiratory failure-reply. *JAMA*. 2020;323(8):792-793. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32096845.
8. Marik PE, Khangoora V, Rivera R, Hooper MH, Catravas J. Hydrocortisone, vitamin C, and thiamine for the treatment of severe sepsis and septic shock: a retrospective before-after study. *Chest*. 2017;151(6):1229-1238. Available at: https://www.ncbi.nlm.nih.gov/pubmed/27940189.
9. Kim WY, Jo EJ, Eom JS, et al. Combined vitamin C, hydrocortisone, and thiamine therapy for patients with severe pneumonia who were admitted to the intensive care unit: propensity score-based analysis of a before-after cohort study. *J Crit Care*. 2018;47:211-218. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30029205.
10. Fujii T, Luethi N, Young PJ, et al. Effect of vitamin C, hydrocortisone, and thiamine vs hydrocortisone alone on time alive and free of vasopressor support among patients with septic shock: the VITAMINS randomized clinical trial. *JAMA*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31950979.
11. Chang P, Liao Y, Guan J, et al. Combined treatment with hydrocortisone, vitamin C, and thiamine for sepsis and septic shock: a randomized controlled trial. *Chest*. 2020;158(1):174-182. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32243943.
12. Iglesias J, Vassallo AV, Patel VV, Sullivan JB, Cavanaugh J, Elbaga Y. Outcomes of metabolic resuscitation using ascorbic acid, thiamine, and glucocorticoids in the early treatment of sepsis: the ORANGES trial. *Chest*. 2020;158(1):164-173. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32194058.
13. Hwang SY, Ryoo SM, Park JE, et al. Combination therapy of vitamin C and thiamine for septic shock: a multi-centre, double-blinded randomized, controlled study. *Intensive Care Med*. 2020;46(11):2015-2025. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32780166.
14. Moskowitz A, Huang DT, Hou PC, et al. Effect of ascorbic acid, corticosteroids, and thiamine on organ injury in septic shock: the ACTS randomized clinical trial. *JAMA*. 2020;324(7):642-650. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32809003.
15. Sevransky JE, Rothman RE, Hager DN, et al. Effect of vitamin C, thiamine, and hydrocortisone on ventilator- and vasopressor-free days in patients with sepsis: the VICTAS randomized clinical trial. *JAMA*. 2021;325(8):742-750. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33620405.
16. Hager DN, Martin GS, Sevransky JE, Hooper MH. Glucometry when using vitamin C in sepsis: a note of caution. *Chest*. 2018;154(1):228-229. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30044741.
17. Food and Drug Administration. Blood glucose monitoring devices. 2019. Available at: https://www.fda.gov/medical-devices/in-vitro-diagnostics/blood-glucose-monitoring-devices. Accessed March 26, 2021.

# Vitamin D

*Last Updated: April 21, 2021*

## Recommendation

- There is insufficient evidence to recommend either for or against the use of vitamin D for the prevention or treatment of COVID-19.

## Rationale

Vitamin D is critical for bone and mineral metabolism. Because the vitamin D receptor is expressed on immune cells such as B cells, T cells, and antigen-presenting cells, and because these cells can synthesize the active vitamin D metabolite, vitamin D also has the potential to modulate innate and adaptive immune responses.[1]

Vitamin D deficiency (defined as a serum concentration of 25-hydroxyvitamin D ≤20 ng/mL) is common in the United States, particularly among persons of Hispanic ethnicity and Black race. These groups are also overrepresented among cases of COVID-19 in the United States.[2] Vitamin D deficiency is also more common in older patients and patients with obesity and hypertension; these factors have been associated with worse outcomes in patients with COVID-19. In observational studies, low vitamin D levels have been associated with an increased risk of community-acquired pneumonia in older adults[3] and children.[4]

Vitamin D supplements may increase the levels of T regulatory cells in healthy individuals and patients with autoimmune diseases; vitamin D supplements may also increase T regulatory cell activity.[5] In a meta-analysis of randomized clinical trials, vitamin D supplementation was shown to protect against acute respiratory tract infection.[6] However, in two double-blind, placebo-controlled, randomized clinical trials, administering high doses of vitamin D to critically ill patients with vitamin D deficiency (but not COVID-19) did not reduce the length of the hospital stay or the mortality rate when compared to placebo.[7,8] High levels of vitamin D may cause hypercalcemia and nephrocalcinosis.[9]

The rationale for using vitamin D is based largely on immunomodulatory effects that could potentially protect against COVID-19 infection or decrease the severity of illness. Ongoing observational studies are evaluating the role of vitamin D in preventing and treating COVID-19. Some investigational trials on the use of vitamin D in people with COVID-19 are being planned or are already accruing participants. These trials will administer vitamin D alone or in combination with other agents to participants with and without vitamin D deficiency. The latest information on these clinical trials can be found on *ClinicalTrials.gov*.

## Clinical Data

### *Randomized Clinical Trial of Vitamin D Versus Placebo in Patients With Moderate to Severe COVID-19*

In a double-blind, placebo-controlled randomized trial that was conducted at two sites in Brazil, 240 hospitalized patients with moderate to severe COVID-19 received either a single dose of 200,000 international units of vitamin $D_3$ or placebo.[10] Moderate to severe COVID-19 was defined as patients with a positive result on a SARS-CoV-2 polymerase chain reaction test (or compatible computed tomography scan findings) and a respiratory rate >24 breaths/min, oxygen saturation <93% on room air, or risk factors for complications. The primary outcome in this study was the length of the hospital stay.

The median length of stay was not significantly different between the vitamin $D_3$ arm (7.0 days [IQR 4.0–10.0 days]) and the placebo arm (7.0 days [IQR 5.0–13.0 days]; $P = 0.59$, log-rank test). No significant differences were observed between the arms in the percentages of patients who were admitted to the intensive care unit, who required mechanical ventilation, or who died during hospitalization.

It should be noted that this study had a small sample size and enrolled participants with a variety of comorbidities and concomitant medications. The time between symptom onset and randomization was relatively long, with patients randomized at a mean of 10.3 days after symptom onset. In this study, a single, high dose of vitamin $D_3$ did not significantly reduce the length of stay for hospitalized patients with COVID-19.

## References


1. Aranow C. Vitamin D and the immune system. *J Investig Med*. 2011;59(6):881-886. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21527855.
2. Forrest KY,Stuhldreher WL. Prevalence and correlates of vitamin D deficiency in US adults. *Nutr Res*. 2011;31(1):48-54. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21310306.
3. Lu D, Zhang J, Ma C, et al. Link between community-acquired pneumonia and vitamin D levels in older patients. *Z Gerontol Geriatr*. 2018;51(4):435-439. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28477055.
4. Science M, Maguire JL, Russell ML, Smieja M, Walter SD,Loeb M. Low serum 25-hydroxyvitamin D level and risk of upper respiratory tract infection in children and adolescents. *Clin Infect Dis*. 2013;57(3):392-397. Available at: https://www.ncbi.nlm.nih.gov/pubmed/23677871.
5. Fisher SA, Rahimzadeh M, Brierley C, et al. The role of vitamin D in increasing circulating T regulatory cell numbers and modulating T regulatory cell phenotypes in patients with inflammatory disease or in healthy volunteers: a systematic review. *PLoS One*. 2019;14(9):e0222313. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31550254.
6. Martineau AR, Jolliffe DA, Hooper RL, et al. Vitamin D supplementation to prevent acute respiratory tract infections: systematic review and meta-analysis of individual participant data. *BMJ*. 2017;356:i6583. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28202713.
7. Amrein K, Schnedl C, Holl A, et al. Effect of high-dose vitamin D3 on hospital length of stay in critically ill patients with vitamin D deficiency: the VITdAL-ICU randomized clinical trial. *JAMA*. 2014;312(15):1520-1530. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25268295.
8. National Heart L, Blood Institute PCTN, Ginde AA, et al. Early high-dose vitamin D3 for critically ill, vitamin D-deficient patients. *N Engl J Med*. 2019;381(26):2529-2540. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31826336.
9. Institue of Medicine. Dietary Reference Intakes for Calcium and Vitamin D. The National Academies Press; 2011.
10. Murai IH, Fernandes AL,Sales LP. Effect of a single high dose of vitamin D3 on hospital length of stay in patients with moderate to severe COVID-19: a randomized clinical trial. 2021; Published online ahead of print. Available at: https://pubmed.ncbi.nlm.nih.gov/33595634/.

# Zinc

*Last Updated: April 21, 2021*

## Recommendations

- There is insufficient evidence for the COVID-19 Treatment Guidelines Panel (the Panel) to recommend either for or against the use of zinc for the treatment of COVID-19.
- The Panel **recommends against** using **zinc** supplementation above the recommended dietary allowance for the prevention of COVID-19, except in a clinical trial **(BIII)**.

## Rationale

Increased intracellular zinc concentrations efficiently impair replication in a number of RNA viruses.[1] Zinc has been shown to enhance cytotoxicity and induce apoptosis when used in vitro with a zinc ionophore (e.g., chloroquine). Chloroquine has also been shown to enhance intracellular zinc uptake in vitro.[2] The relationship between zinc and COVID-19, including how zinc deficiency affects the severity of COVID-19 and whether zinc supplements can improve clinical outcomes, is currently under investigation.[3] Zinc levels are difficult to measure accurately, as zinc is distributed as a component of various proteins and nucleic acids.[4]

Several clinical trials are currently investigating the use of zinc supplementation alone or in combination with hydroxychloroquine for the prevention and treatment of COVID-19 (see *ClinicalTrials.gov* for more information about ongoing studies). The recommended dietary allowance for elemental zinc is 11 mg daily for men and 8 mg for nonpregnant women.[5] The doses used in registered clinical trials for patients with COVID-19 vary between studies, with a maximum dose of zinc sulfate 220 mg (50 mg of elemental zinc) twice daily. However, there is currently insufficient evidence to recommend either for or against the use of zinc for the treatment of COVID-19.

Long-term zinc supplementation can cause copper deficiency with subsequent reversible hematologic defects (i.e., anemia, leukopenia) and potentially irreversible neurologic manifestations (i.e., myelopathy, paresthesia, ataxia, spasticity).[6,7] The use of zinc supplementation for durations as short as 10 months has been associated with copper deficiency.[4] In addition, oral zinc can decrease the absorption of medications that bind with polyvalent cations.[5] Because zinc has not been shown to have a clinical benefit and may be harmful, the Panel **recommends against** using **zinc** supplementation above the recommended dietary allowance for the prevention of COVID-19, except in a clinical trial **(BIII)**.

## Clinical Data

### *Randomized Clinical Trial of Zinc Plus Hydroxychloroquine Versus Hydroxychloroquine Alone in Hospitalized Patients With COVID-19*

In a randomized clinical trial that was conducted at three academic medical centers in Egypt, 191 patients with laboratory-confirmed SARS-CoV-2 infection were randomized to receive either zinc 220 mg twice daily plus hydroxychloroquine or hydroxychloroquine alone for a 5-day course. The primary endpoints were recovery within 28 days, the need for mechanical ventilation, and death. The two arms were matched for age and gender.[8]

#### Results

- There were no significant differences between the two arms in the percentages of patients who recovered within 28 days (79.2% in the hydroxychloroquine plus zinc arm vs. 77.9% in the hydroxychloroquine only arm; $P = 0.969$), the need for mechanical ventilation ($P = 0.537$), or

overall mortality ($P = 0.986$).

- The only risk factors for mortality were age and the need for mechanical ventilation.

#### Limitations

- This study had a relatively small sample size.

#### Interpretation

A moderately sized randomized clinical trial failed to find a clinical benefit for the combination of zinc and hydroxychloroquine.

### *Open-Label, Randomized Trial of Zinc Versus Ascorbic Acid Versus Zinc Plus Ascorbic Acid Versus Standard of Care in Outpatients With COVID-19*

In an open-label clinical trial that was conducted at two sites in the United States, outpatients with laboratory-confirmed SARS-CoV-2 infection were randomized to receive either 10 days of zinc gluconate 50 mg, ascorbic acid 8,000 mg, both agents, or standard of care. The primary end point was the number of days required to reach a 50% reduction in the patient's symptom severity score. The study was stopped early by an operational and safety monitoring board due to futility after 40% of the planned 520 participants were enrolled (n = 214).[9]

#### Results

- Participants who received standard of care achieved a 50% reduction in their symptom severity scores at a mean of 6.7 days (SD 4.4 days) compared with 5.5 days (SD 3.7 days) for the ascorbic acid arm, 5.9 days (SD 4.9 days) for the zinc gluconate arm, and 5.5 days (SD 3.4 days) for the arm that received both agents (overall $P = 0.45$).
- Nonserious adverse effects occurred more frequently in patients who received supplements than in those who did not; 39.5% of patients in the ascorbic acid arm, 18.5% in the zinc gluconate arm, and 32.1% in the arm that received both agents experienced nonserious adverse effects compared with 0% of patients in the standard of care arm (overall $P < 0.001$). The most common nonserious adverse effects in this study were gastrointestinal events.

#### Limitations

- The study had a small sample size.
- There was no placebo control.

#### Interpretation

In outpatients with COVID-19, treatment with high-dose zinc gluconate, ascorbic acid, or a combination of the two supplements did not significantly decrease the number of days required to reach a 50% reduction in a symptom severity score compared with standard of care.

### *Observational Study of Zinc Supplementation in Hospitalized Patients*

A retrospective study enrolled 242 patients with polymerase chain reaction-confirmed SARS-CoV-2 infection who were admitted to Hoboken University Medical Center. One hundred and ninety-six patients (81.0%) received a total daily dose of zinc sulfate 440 mg (100 mg of elemental zinc); of those, 191 patients (97%) also received hydroxychloroquine. Among the 46 patients who did not receive zinc, 32 patients (70%) received hydroxychloroquine. The primary outcome was days from hospital admission to in-hospital mortality, and the primary analysis explored the causal association between zinc therapy and survival.[10]

#### Results

- There were no significant differences in baseline characteristics between the arms. In the zinc arm, 73 patients (37.2%) died compared with 21 patients (45.7%) in the control arm. In the primary analysis, which used inverse probability weighting (IPW), the effect estimate of zinc therapy was an additional 0.84 days of survival (95% CI, -1.51 days to 3.20 days; $P = 0.48$).
- In a multivariate Cox regression analysis with IPW, the use of zinc sulfate was not significantly associated with a change in the risk of in-hospital mortality (aHR 0.66; 95% CI, 0.41–1.07; $P = 0.09$).
- Older age, male sex, and severe or critical COVID-19 were significantly associated with an increased risk of in-hospital mortality.

#### Limitations

- This is a retrospective study; patients were not randomized to receive zinc supplementation or to receive no zinc.

#### Interpretation

This single-center, retrospective study failed to find a mortality benefit in patients who received zinc supplementation.

### *Multicenter, Retrospective Cohort Study That Compared Hospitalized Patients Who Received Zinc Plus Hydroxychloroquine to Those Who Did Not*

*This study has not been peer reviewed.*

This multicenter, retrospective cohort study of hospitalized adults with SARS-CoV-2 infection who were admitted to four New York City hospitals between March 10 and May 20, 2020, compared patients who received zinc plus hydroxychloroquine to those who received treatment that did not include this combination.[11]

#### Results

- The records of 3,473 patients were reviewed.
- The median patient age was 64 years; 1,947 patients (56%) were male, and 522 patients (15%) were mechanically ventilated.
- Patients who received an interleukin-6 inhibitor or remdesivir were excluded from the analysis.
- A total of 1,006 patients (29%) received zinc plus hydroxychloroquine, and 2,467 patients (71%) received hydroxychloroquine without zinc.
- During the study, 545 patients (16%) died. In univariate analyses, mortality rates were significantly lower among patients who received zinc plus hydroxychloroquine than among those who did not (12% vs. 17%; $P < 0.001$). Similarly, hospital discharge rates were significantly higher among patients who received zinc plus hydroxychloroquine than among those who did not (72% vs. 67%; $P < 0.001$).
- In a Cox regression analysis that adjusted for confounders, treatment with zinc plus hydroxychloroquine was associated with a significantly reduced risk of in-hospital death (aHR 0.76; 95% CI, 0.60–0.96; $P = 0.023$). Treatment with zinc alone (n = 1,097) did not affect mortality (aHR 1.14; 95% CI, 0.89–1.44; $P = 0.296$), and treatment with hydroxychloroquine alone (n = 2,299) appeared to be harmful (aHR 1.60; 95% CI, 1.22–2.11; $P = 0.001$).
- There were no significant interactions between zinc plus hydroxychloroquine and other COVID-19-specific medications.

### Limitations

- This is a retrospective review; patients were not randomized to receive zinc plus hydroxychloroquine or to receive other treatments.
- The authors do not have data on whether patients were taking zinc and/or hydroxychloroquine prior to study admission.
- The arms were not balanced; recipients of zinc plus hydroxychloroquine were more likely to be male, Black, or to have a higher body mass index and diabetes. Patients who received zinc plus hydroxychloroquine were also treated more often with corticosteroids and azithromycin and less often with lopinavir/ritonavir than those who did not receive this drug combination.

### Interpretation

In this preprint, the use of zinc plus hydroxychloroquine was associated with decreased rates of in-hospital mortality, but neither zinc alone nor hydroxychloroquine alone reduced mortality. Treatment with hydroxychloroquine alone appeared to be harmful.

## References


1. te Velthuis AJ, van den Worm SH, Sims AC, Baric RS, Snijder EJ,van Hemert MJ. Zn(2+) inhibits coronavirus and arterivirus RNA polymerase activity in vitro and zinc ionophores block the replication of these viruses in cell culture. *PLoS Pathog*. 2010;6(11):e1001176. Available at: https://www.ncbi.nlm.nih.gov/pubmed/21079686.
2. Xue J, Moyer A, Peng B, Wu J, Hannafon BN,Ding WQ. Chloroquine is a zinc ionophore. *PLoS One*. 2014;9(10):e109180. Available at: https://www.ncbi.nlm.nih.gov/pubmed/25271834.
3. Calder PC, Carr AC, Gombart AF,Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients*. 2020;12(4). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32340216.
4. Hambridge K. The management of lipohypertrophy in diabetes care. *Br J Nurs*. 2007;16(9):520-524. Available at: https://www.ncbi.nlm.nih.gov/pubmed/17551441.
5. National Institutes of Health. Office of Dietary Supplements. Zinc fact sheet for health professionals. 2020. Available at: https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/.
6. Myint ZW, Oo TH, Thein KZ, Tun AM,Saeed H. Copper deficiency anemia: review article. *Ann Hematol*. 2018;97(9):1527-1534. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29959467.
7. Kumar N. Copper deficiency myelopathy (human swayback). *Mayo Clin Proc*. 2006;81(10):1371-1384. Available at: https://www.ncbi.nlm.nih.gov/pubmed/17036563.
8. Abd-Elsalam S, Soliman S, Esmail ES, et al. Do zinc supplements enhance the clinical efficacy of hydroxychloroquine?: a randomized, multicenter trial. *Biol Trace Elem Res*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33247380.
9. Thomas S, Patel D,Bittel B. Effect of high-dose zinc and ascorbic acid supplementation vs usual care on symptom length and reduction among ambulatory patients with SARS-CoV-2 Infection: the COVID a to z randomized clinical trial. *JAMA Netw Open*. 2021;4(2):e210369. Available at: https://pubmed.ncbi.nlm.nih.gov/33576820/.
10. Yao JS, Paguio JA, Dee EC, et al. The minimal effect of zinc on the survival of hospitalized patients with COVID-19: an observational study. *Chest*. 2021;159(1):108-111. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32710890.
11. Frontera JA, Rahimian JO, Yaghi S, et al. Treatment with zinc is associated with reduced in-hospital mortality among COVID-19 patients: a multi-center cohort study. *Res Sq*. 2020;Preprint. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33140042.

# Considerations for Certain Concomitant Medications in Patients with COVID-19

*Last Updated: August 4, 2021*

| Summary Recommendations |
| --- |
| • Patients with COVID-19 who are receiving concomitant medications (e.g., angiotensin-converting enzyme [ACE] inhibitors, angiotensin receptor blockers [ARBs], statins, systemic or inhaled corticosteroids, nonsteroidal anti-inflammatory drugs, acid-suppressive therapy) for underlying medical conditions **should not discontinue** these medications during acute management of COVID-19 unless discontinuation is otherwise warranted by their clinical condition (**AIIa** for **ACE inhibitors and ARBs**; **AIII** for **other medications**).<br>• The COVID-19 Treatment Guidelines Panel **recommends against** using medications off-label to treat COVID-19 if they have not demonstrated safety and efficacy in patients with COVID-19, except in a clinical trial **(AIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

Individuals with underlying medical conditions, such as cardiovascular disease, pulmonary disease, diabetes, and malignancy, are at higher risk of severe illness with COVID-19. These patients are often prescribed medications to treat their underlying medical conditions. It is unclear whether these concomitant medications have a positive or negative impact on the treatment and outcomes of COVID-19.

The following section reviews the available data on the use of certain concomitant medications for comorbid conditions in patients with COVID-19 and discusses the considerations clinicians should be aware of when evaluating a patient's concomitant therapy. When prescribing medications for the treatment of COVID-19, clinicians should always assess the patient's current medications for potential drug interactions and adverse effects. The decision to continue or change a patient's medications should be individualized based on their condition.

Patients with COVID-19 who are treated with concomitant medications for an underlying medical condition **should not discontinue** these medications during acute management of COVID-19 unless discontinuation is otherwise warranted by their clinical condition **(AIII)**. Some of these medications have been evaluated as potential treatments for COVID-19; this section will discuss the available data and any additional considerations that clinicians should be aware of when using these medications.

## Angiotensin-Converting Enzyme Inhibitors and Angiotensin Receptor Blockers

### *Recommendations*

- Patients with COVID-19 who are receiving **angiotensin-converting enzyme (ACE) inhibitors** or **angiotensin receptor blockers (ARBs)** for cardiovascular disease (or other non-COVID-19 indications) **should not discontinue** these medications unless discontinuation is otherwise warranted by their clinical condition **(AIIa)**.
- The COVID-19 Treatment Guidelines Panel (the Panel) **recommends against** the use of **ACE inhibitors** or **ARBs** for the treatment of COVID-19, except in a clinical trial **(AIII)**.

These recommendations are in accord with a joint statement of the American Heart Association, the Heart Failure Society of America, and the American College of Cardiology.[1]

ACE2 is the cell surface receptor for SARS-CoV-2. It has been hypothesized that using ACE inhibitors or ARBs to modulate ACE2 could suppress or enhance SARS-CoV-2 replication.[2,3] Meta-analyses and an ongoing systematic review have not found an association between the use of ACE inhibitors or ARBs and the likelihood of a positive result on a SARS-CoV-2 test or the severity of COVID-19.[4,5]

In a multicenter, open-label randomized trial, hospitalized patients with COVID-19 (n = 659) who were receiving chronic ACE inhibitor therapy or ARB therapy were randomized to continue or discontinue their therapy for 30 days. Treatment of COVID-19 followed local standards of care, and the use of alternative therapies to replace the discontinued medications was at the discretion of the treating physician. The study did not enroll any patients who required invasive mechanical ventilation or who had hemodynamic instability or multiple organ failure.

Overall, there was no difference between the arms in the primary endpoint of days alive and out of the hospital; the mean number of days alive and out of the hospital was 21.9 days in the discontinuation arm and 22.9 days in the continuation arm (mean ratio 0.95; 95% CI, 0.90–1.01). No differences were observed in the secondary endpoints of the percentages of patients who experienced death, cardiovascular events, or COVID-19 progression. Subgroup analyses identified an interaction between the treatment effect and the subgroup of patients who had more severe COVID-19 (those with oxygen saturation <94%, pulmonary infiltrates >50%, or a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen [$PaO_2/FiO_2$] <300 mm Hg). There may be a clinical benefit to continuing ACE inhibitor therapy or ARB therapy in these patients. Because of limitations in the available data, it is difficult to interpret these findings in patients with certain comorbid conditions, severe or critical illness, and pre-existing diagnoses of heart failure.[6]

Additional investigations into the role of ACE inhibitors, ARBs, and recombinant human ACE2 in the management of COVID-19 are underway.[1] Please see *ClinicalTrials.gov* for the latest information.

## Corticosteroids

### *Recommendations*

- Patients with COVID-19 who are receiving **inhaled or systemic corticosteroids** for an underlying condition **should not discontinue** these medications unless discontinuation is otherwise warranted by their clinical condition **(AIII)**.
- There is insufficient evidence for the Panel to recommend either for or against the use of inhaled budesonide for the treatment of COVID-19.
- Systemic treatment with dexamethasone or other corticosteroids is recommended for certain populations of patients with COVID-19. See Therapeutic Management of Hospitalized Adults With COVID-19, Corticosteroids, and Special Considerations in Pregnancy for specific recommendations.

Oral corticosteroid therapy prescribed for an underlying medical condition (e.g., primary or secondary adrenal insufficiency, rheumatological diseases) should be continued in patients after the diagnosis of COVID-19.[7] Supplemental or stress-dose steroids may be indicated in individual cases.

Inhaled corticosteroids that are used daily by patients with asthma and chronic obstructive pulmonary disease to control airway inflammation should not be discontinued in patients with COVID-19. A large, retrospective study of adult patients with chronic obstructive pulmonary disease and asthma found that those who were prescribed high doses of inhaled corticosteroids had a higher risk of mortality than those who received other inhaled medications without corticosteroids; however, the study had limitations.[8] In fact, the authors suggested that this association may have been due to differences between the groups

in the severity of the underlying disease rather than a harmful effect of the inhaled corticosteroids. For patients with COVID-19 who require nebulized corticosteroids, precautions should be taken to minimize the potential for transmission of SARS-CoV-2 in the home and in health care settings.[9,10] Please see Corticosteroids for a summary of the clinical data on using inhaled corticosteroids to manage COVID-19 in outpatients.

The use of corticosteroids has been associated with delayed viral clearance and/or worse clinical outcomes in patients with other viral respiratory infections.[11-13] Some studies have suggested that systemic corticosteroids slow SARS-CoV-2 clearance, especially when they are administered earlier in the course of infection.[14-18] There is insufficient evidence to identify a relationship between inhaled corticosteroid use and the speed of viral clearance.

## HMG-CoA Reductase Inhibitors (Statins)

### *Recommendations*

- Patients with COVID-19 who are receiving **statin therapy** for an underlying condition **should not discontinue** these medications unless discontinuation is otherwise warranted by their clinical condition **(AIII)**.
- The Panel **recommends against** the use of **statins** for the treatment of COVID-19, except in a clinical trial **(AIII)**.

HMG-CoA reductase inhibitors, or statins, affect ACE2 as part of their function in reducing endothelial dysfunction. It has been proposed that these agents may have a potential role in managing patients with severe COVID-19.[19]

A large observational study in China found that hospitalized patients with COVID-19 who received statins had a lower risk of all-cause mortality than patients who did not receive statins (aHR 0.63; 95% CI, 0.48–0.84; $P = 0.001$).[20] In contrast, a retrospective, multicenter study of critically ill patients with COVID-19 in Italy found no association between the long-term use of statins and mortality (aHR 0.98; 95% CI, 0.81–1.20; $P = 0.87$).[21] Similarly, recent receipt of statin therapy was not associated with a higher mortality risk (aHR 0.96; 95% CI, 0.78–1.18) or the severity of disease (aHR 1.16; 95% CI, 0.95–1.41) in a national cohort study of 4,842 patients with COVID-19 in Denmark.[22]

More data are needed to clarify the impact of statin therapy on COVID-19. Clinical trials that are evaluating the therapeutic impact of statins as an adjunctive therapy for COVID-19 are currently underway. Please see *ClinicalTrials.gov* for the latest information.

## Nonsteroidal Anti-Inflammatory Drugs

### *Recommendations*

- Patients with COVID-19 who are receiving **nonsteroidal anti-inflammatory drugs (NSAIDs)** for an underlying medical condition **should not discontinue** therapy unless discontinuation is otherwise warranted by their clinical condition **(AIII)**.
- Strategies for using **antipyretic therapy** (e.g., acetaminophen, NSAIDs) in patients with COVID-19 should remain similar to the approaches used in other patients **(AIII)**.

In March 2020, news agencies promoted reports that anti-inflammatory drugs may worsen COVID-19. It has been proposed that NSAIDs can increase the expression of ACE2[2] and inhibit antibody production.[23] Shortly after these reports, the Food and Drug Administration stated that there is no evidence linking the use of NSAIDs with worsening of COVID-19 and advised patients to use NSAIDs as directed.[24]

In a national cohort study of patients who tested positive for SARS-CoV-2 infection in Denmark, no association was found between a history of NSAID use and the need for hospitalization, the risk of mortality, or the severity of illness.[25]

## Acid-Suppressive Therapy

### *Recommendations*

- Patients with COVID-19 who are receiving **acid-suppressive therapy** for an underlying condition **should not discontinue** these medications unless discontinuation is otherwise warranted by their clinical condition **(AIII)**.
- The Panel **recommends against** the use of **famotidine** for the treatment of COVID-19, except in a clinical trial **(AIII)**.

Acid-suppressive therapies, such as proton pump inhibitors (PPIs) and histamine-2 receptor antagonists (H2RAs), increase gastric pH. Low gastric pH is proposed to be a protective mechanism against infection with viruses that can enter the body through the gastrointestinal tract (e.g., enteric viruses, SARS-CoV).[26] Observational studies that have evaluated the relationship between the use of acid-suppressive therapy and the acquisition of SARS-CoV-2 or COVID-19 disease severity have produced mixed results.

A propensity-matched cohort study in South Korea observed that current PPI use was not associated with a higher risk of testing positive for SARS-CoV-2, but it was associated with a higher risk of severe illness.[27] An online survey conducted in the United States identified no association between the use of H2RAs and the risk of SARS-CoV-2 infection, while PPI therapy was associated with higher odds of receiving a diagnosis of SARS-CoV-2 infection, especially in those who received twice-daily doses of PPIs.[26] However, these studies had the inherent limitations of observational studies and studies that rely on surveys, and they likely had multiple confounding factors.

The impact of the H2RA famotidine on COVID-19 outcomes has been evaluated in observational studies. In a retrospective study of 878 hospitalized patients with COVID-19, the patients who received famotidine (n = 83) had lower odds of death than those who did not.[28] In another retrospective study of 84 patients who received famotidine and a matched comparator group of 420 patients who did not, the use of famotidine was associated with a reduction in the composite outcome of death or intubation.[29] Only a small proportion of the patients enrolled in these studies received famotidine, and it is unclear what the indications for famotidine therapy were or whether there were other confounding factors. These limitations make it difficult to draw conclusions about the efficacy of using famotidine to treat patients with COVID-19.

Results from ongoing clinical trials will provide more insights into the role of famotidine in the treatment of COVID-19. Please see *ClinicalTrials.gov* for the latest information.

In patients with COVID-19 who require PPI therapy, the American College of Gastroenterology suggests using the lowest effective dose of the PPI.[30]

## References


1. Bozkurt B, Kovacs R, Harrington B. Joint HFSA/ACC/AHA statement addresses concerns re: using RAAS antagonists in COVID-19. *J Card Fail*. 2020;26(5):370. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32439095.
2. Fang L, Karakiulakis G, Roth M. Are patients with hypertension and diabetes mellitus at increased risk for COVID-19 infection? *Lancet Respir Med*. 2020;8(4):e21. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/32171062.

3. Patel AB, Verma A. COVID-19 and angiotensin-converting enzyme inhibitors and angiotensin receptor blockers: what is the evidence? *JAMA*. 2020;323(18):1769-1770. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32208485.
4. Mackey K, Kansagara D, Vela K. Update alert 3: risks and impact of angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers on SARS-CoV-2 infection in adults. *Ann Intern Med*. 2020;173(7):130-131. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32845705.
5. Flacco ME, Acuti Martellucci C, Bravi F, et al. Treatment with ACE inhibitors or ARBs and risk of severe/lethal COVID-19: a meta-analysis. *Heart*. 2020;106(19):1519-1524. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32611676.
6. Lopes RD, Macedo AVS, de Barros E Silva PGM, et al. Effect of discontinuing vs continuing angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers on days alive and out of the hospital in patients admitted With COVID-19: a randomized clinical trial. *JAMA*. 2021;325(3):254-264. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33464336.
7. Kaiser UB, Mirmira RG, Stewart PM. Our response to COVID-19 as endocrinologists and diabetologists. *J Clin Endocrinol Metab*. 2020;105(5). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32232480.
8. Schultze A, Walker AJ, MacKenna B, et al. Risk of COVID-19-related death among patients with chronic obstructive pulmonary disease or asthma prescribed inhaled corticosteroids: an observational cohort study using the OpenSAFELY platform. *Lancet Respir Med*. 2020;8(11):1106-1120. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32979987.
9. Cazzola M, Ora J, Bianco A, Rogliani P, Matera MG. Guidance on nebulization during the current COVID-19 pandemic. *Respir Med*. 2021;176:106236. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33248363.
10. Sethi S, Barjaktarevic IZ, Tashkin DP. The use of nebulized pharmacotherapies during the COVID-19 pandemic. *Ther Adv Respir Dis*. 2020;14:1753466620954366. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33167796.
11. Stockman LJ, Bellamy R, Garner P. SARS: systematic review of treatment effects. *PLoS Med*. 2006;3(9):e343. Available at: https://www.ncbi.nlm.nih.gov/pubmed/16968120.
12. Rodrigo C, Leonardi-Bee J, Nguyen-Van-Tam J, Lim WS. Corticosteroids as adjunctive therapy in the treatment of influenza. *Cochrane Database Syst Rev*. 2016;3:CD010406. Available at: https://www.ncbi.nlm.nih.gov/pubmed/26950335.
13. Arabi YM, Mandourah Y, Al-Hameed F, et al. Corticosteroid therapy for critically ill patients with Middle East respiratory syndrome. *Am J Respir Crit Care Med*. 2018;197(6):757-767. Available at: https://www.ncbi.nlm.nih.gov/pubmed/29161116.
14. Chen Y, Li L. Influence of corticosteroid dose on viral shedding duration in patients with COVID-19. *Clin Infect Dis*. 2021;72(7):1298-1300. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7454365/.
15. Li S, Hu Z, Song X. High-dose but not low-dose corticosteroids potentially delay viral shedding of patients with COVID-19. *Clin Infect Dis*. 2021;72(7):1297-1298. Available at: https://pubmed.ncbi.nlm.nih.gov/32588877/.
16. Ding C, Feng X, Chen Y, et al. Effect of corticosteroid therapy on the duration of SARS-CoV-2 clearance in patients with mild COVID-19: a retrospective cohort study. *Infect Dis Ther*. 2020;9(4):943-952. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32986226.
17. Liu J, Zhang S, Dong X, et al. Corticosteroid treatment in severe COVID-19 patients with acute respiratory distress syndrome. *J Clin Invest*. 2020;130(12):6417-6428. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33141117.
18. Spagnuolo V, Guffanti M, Galli L, et al. Viral clearance after early corticosteroid treatment in patients with moderate or severe covid-19. *Sci Rep*. 2020;10(1):21291. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33277573.

19. Fedson DS, Opal SM, Rordam OM. Hiding in plain sight: an approach to treating patients with severe COVID-19 infection. *mBio*. 2020;11(2). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32198163.

20. Zhang XJ, Qin JJ, Cheng X, et al. In-hospital use of statins is associated with a reduced risk of mortality among individuals with COVID-19. *Cell Metab*. 2020;32(2):176-187 e174. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32592657.

21. Grasselli G, Greco M, Zanella A, et al. Risk factors associated with mortality among patients with COVID-19 in intensive care units in Lombardy, Italy. *JAMA Intern Med*. 2020;180(10):1345-1355. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32667669.

22. Butt JH, Gerds TA, Schou M, et al. Association between statin use and outcomes in patients with coronavirus disease 2019 (COVID-19): a nationwide cohort study. *BMJ Open*. 2020;10(12):e044421. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33277291.

23. Bancos S, Bernard MP, Topham DJ, Phipps RP. Ibuprofen and other widely used non-steroidal anti-inflammatory drugs inhibit antibody production in human cells. *Cell Immunol*. 2009;258(1):18-28. Available at: https://www.ncbi.nlm.nih.gov/pubmed/19345936.

24. Food and Drug Administration. FDA advises patients on use of non-steroidal anti-inflammatory drugs (NSAIDs) for COVID-19. 2020. Available at: https://www.fda.gov/drugs/drug-safety-and-availability/fda-advises-patients-use-non-steroidal-anti-inflammatory-drugs-nsaids-covid-19. Accessed July 28, 2021.

25. Lund LC, Kristensen KB, Reilev M, et al. Adverse outcomes and mortality in users of non-steroidal anti-inflammatory drugs who tested positive for SARS-CoV-2: a Danish nationwide cohort study. *PLoS Med*. 2020;17(9):e1003308. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32898149.

26. Almario CV, Chey WD, Spiegel BMR. Increased risk of COVID-19 among users of proton pump inhibitors. *Am J Gastroenterol*. 2020;115(10):1707-1715. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32852340.

27. Lee SW, Ha EK, Yeniova AO, et al. Severe clinical outcomes of COVID-19 associated with proton pump inhibitors: a nationwide cohort study with propensity score matching. *Gut*. 2021;70(1):76-84. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32732368.

28. Mather JF, Seip RL, McKay RG. Impact of famotidine use on clinical outcomes of hospitalized patients with COVID-19. *Am J Gastroenterol*. 2020;115(10):1617-1623. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32852338.

29. Freedberg DE, Conigliaro J, Wang TC, et al. Famotidine use is associated with improved clinical outcomes in hospitalized COVID-19 patients: a propensity score matched retrospective cohort study. *Gastroenterology*. 2020;159(3):1129-1131 e1123. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32446698.

30. American College of Gastroenterology. Information sheet and FAQs about proton pump inhibitors (PPIs) and risk of COVID-19. 2020. Available at: https://webfiles.gi.org/links/media/ACG_Almario_et_al_Info_Sheet_and_FAQs_About_PPIs_COVID19_07072020_FINAL.pdf.

# COVID-19 and Special Populations

*Last Updated: October 9, 2020*

| Key Considerations |
|---|
| There is current guidance from the Centers for Disease Control and Prevention (CDC), the American College of Obstetricians and Gynecologists (ACOG), and the Society for Maternal-Fetal Medicine (SMFM) on the management of pregnant patients with COVID-19.[1-4] This section of the COVID-19 Treatment Guidelines complements that guidance. Below are key considerations regarding the management of COVID-19 in pregnancy.<br>• Pregnant women should be counseled about the potential for severe disease from SARS-CoV-2 infection and the recommended measures to take to protect themselves and their families from infection.<br>• If hospitalization for COVID-19 is indicated in a pregnant woman, care should be provided in a facility that can conduct maternal and fetal monitoring, when appropriate.<br>• Management of COVID-19 in the pregnant patient should include:<br>  • Fetal and uterine contraction monitoring, when appropriate, based on gestational age<br>  • Individualized delivery planning<br>  • A multispecialty, team-based approach that may include consultation with obstetric, maternal-fetal medicine, infectious disease, pulmonary and critical care, and pediatric specialists, as appropriate<br>• The COVID-19 Treatment Guidelines Panel (the Panel) recommends that potentially effective treatment for COVID-19 should not be withheld from pregnant women because of theoretical concerns related to the safety of therapeutic agents in pregnancy **(AIII)**.<br>• Decisions regarding the use of drugs approved for other indications or investigational drugs for the treatment of COVID-19 in pregnant patients must be made with shared decision-making between the patient and the clinical team, considering the safety of the medication for the pregnant woman and the fetus and the severity of maternal disease. For detailed guidance on the use of COVID-19 therapeutic agents in pregnancy, please refer to the pregnancy considerations subsection of each individual section of the Guidelines. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

To date, most of the data generated about the epidemiology, clinical course, prevention, and treatment of COVID-19 have come from studies of nonpregnant adults. More information is urgently needed regarding COVID-19 in other patient populations, such as in children, pregnant individuals, and other populations as outlined in the following sections of the Guidelines.

Although children with COVID-19 may have less severe disease overall than adults with COVID-19, the recently described multisystem inflammatory syndrome in children (MIS-C) requires further study. Data are also emerging on the clinical course of COVID-19 in pregnant patients, pregnancy outcomes in the setting of COVID-19, and vertical transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). There are special considerations for transplant recipients, patients with cancer, persons with HIV, and patients with other immunocompromising conditions, as some of these patients may be at increased risk of serious complications as a result of COVID-19.

The following sections review the available data on COVID-19 in some of these populations and discuss the specific considerations that clinicians should take into account for the prevention and treatment of SARS-CoV-2 infections in these populations.

# Special Considerations in Pregnancy

*Last Updated: July 8, 2021*

| Key Considerations |
|---|
| There is current guidance from the Centers for Disease Control and Prevention, the American College of Obstetricians and Gynecologists, and the Society for Maternal-Fetal Medicine on the management of pregnant patients with COVID-19. This section of the COVID-19 Treatment Guidelines complements that guidance. The following are key considerations regarding the management of COVID-19 in pregnancy:<br>• Pregnant people should be counseled about the increased risk for severe disease from SARS-CoV-2 infection and receive recommendations on ways to protect themselves and their families from infection.<br>• If hospitalization for COVID-19 is indicated for a pregnant patient, care should be provided in a facility that can conduct maternal and fetal monitoring, when appropriate.<br>• Management of COVID-19 in pregnant patients should include:<br>  • Fetal and uterine contraction monitoring based on gestational age, when appropriate<br>  • Individualized delivery planning<br>  • A multispecialty, team-based approach that may include consultation with obstetric, maternal-fetal medicine, infectious disease, pulmonary-critical care, and pediatric specialists, as appropriate<br>  • In general, the therapeutic management of pregnant patients with COVID-19 should be the same as for nonpregnant patients. The COVID-19 Treatment Guidelines Panel **recommends against** withholding treatment for COVID-19 and SARS-CoV-2 vaccination from pregnant or lactating individuals because of theoretical safety concerns **(AIII)**. For details regarding therapeutic recommendations and pregnancy considerations, see General Management of Nonhospitalized Patients With Acute COVID-19 and the individual drug sections.<br>• Pregnant or lactating patients with COVID-19 and their clinical teams should discuss the use of investigational drugs or drugs that are approved for other indications as treatments for COVID-19. During this shared decision-making process, the patient and the clinical team should consider the safety of the medication for the pregnant or lactating individual and the fetus and the severity of maternal disease. For detailed guidance on using COVID-19 therapeutic agents during pregnancy, please refer to the pregnancy considerations subsections found in the Antiviral Therapy and Immunomodulators sections of these Guidelines.<br>• The decision to feed the infant breast milk while the patient is receiving therapeutic agents for COVID-19 should be a collaborative effort between the patient and the clinical team, including infant care providers. The patient and the clinical team should discuss the potential benefits of the therapeutic agent and evaluate the potential impact of pausing lactation on the future of breast milk delivery to the infant. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Epidemiology of COVID-19 in Pregnancy

Early in the pandemic, reports of COVID-19 disease acquired during pregnancy were limited to case series or studies that did not compare pregnant patients to age-matched, nonpregnant controls, and these reports were largely reassuring. Subsequent data have indicated that while the overall risk of severe illness is low, COVID-19 is associated with more severe disease in pregnant people than in nonpregnant people.[1] There is also an increased risk of poor obstetric outcomes among pregnant people with COVID-19, such as preterm birth.[2,3]

In November 2020, the Centers for Disease Control and Prevention (CDC) released surveillance data on outcomes in approximately 400,000 reproductive-aged women with symptomatic, laboratory-confirmed COVID-19.[1] After adjusting for age, race/ethnicity, and underlying medical conditions, pregnant women had significantly higher rates of intensive care unit (ICU) admission (10.5 vs. 3.9 cases per 1,000 cases;

adjusted risk ratio [aRR] 3.0; 95% CI, 2.6–3.4), mechanical ventilation (2.9 vs. 1.1 cases per 1,000 cases; aRR 2.9; 95% CI, 2.2–3.8), extracorporeal membrane oxygenation (0.7 vs. 0.3 cases per 1,000 cases; aRR 2.4; 95% CI, 1.5–4.0), and death (1.5 vs. 1.2 cases per 1,000 cases; aRR 1.7; 95% CI, 1.2–2.4). The increased risk for severe disease was most significant in women aged 35 to 44 years, who were almost four times as likely to be mechanically ventilated and twice as likely to die as nonpregnant women of the same age.

Notably, among Hispanic women, pregnancy was associated with a risk of death that was 2.4 times higher (95% CI, 1.3–4.3) than the risk observed in nonpregnant Hispanic women. Racial and ethnic disparities were also seen in other reports. Among 8,207 pregnant women with COVID-19 who were reported to CDC, the proportion of those who were reported to be Hispanic (46%) and Black (22%) was higher than the proportion of Hispanic and Black women who gave birth in 2019 (24% and 15%, respectively), suggesting that pregnant people who are Hispanic or Black may be disproportionately affected by SARS-CoV-2 infection.[4]

In an ongoing systematic review that includes 192 studies to date, maternal factors that were associated with severe disease included increased maternal age (OR 1.83; 95% CI, 1.27–2.63; 3,561 women from 7 studies); a high body mass index (OR 2.37; 95% CI, 1.83–3.07; 3,367 women from 5 studies); any pre-existing maternal comorbidity, including chronic hypertension and diabetes (OR 1.81; 95% CI, 1.49–2.20; 2,634 women from 3 studies); pre-eclampsia (OR 4.21; 95% CI, 1.27–14.0; 274 women from 4 studies); and pre-existing diabetes (OR 2.12; 95% CI, 1.62–2.78; 3,333 women from 3 studies).[5] Compared with pregnant women and recently pregnant women without COVID-19, pregnant women with COVID-19 were at a higher risk of any instance of preterm birth (OR 1.47; 95% CI, 1.14–1.91; 8,549 women from 18 studies) and stillbirth (OR 2.84; 95% CI, 1.25–6.45; 5,794 women from 9 studies).

An observational cohort study of all pregnant patients at 33 U.S. hospitals with a singleton gestation and a positive result on a SARS-CoV-2 virologic test evaluated maternal characteristics and outcomes across disease severity.[6] The data suggested that adverse perinatal outcomes were more common in patients with severe or critical disease than in asymptomatic patients with SARS-CoV-2 infection, including an increased incidence of cesarean delivery (59.6% vs. 34.0% of patients; aRR 1.57; 95% CI, 1.30–1.90), hypertensive disorders of pregnancy (40.4% vs. 18.8%; aRR 1.61; 95% CI, 1.18–2.20), and preterm birth (41.8% vs. 11.9%; aRR 3.53; 95% CI, 2.42–5.14). The perinatal outcomes for those with mild to moderate illness were similar to those observed among asymptomatic patients with SARS-CoV2 infection.

Although vertical transmission of SARS-CoV-2 is possible, current data suggest that it is rare.[7] A review of 101 infants born to 100 women with SARS-CoV-2 infection at a single U.S. academic medical center found that 2 infants (2%) had indeterminate SARS-CoV-2 polymerase chain reaction (PCR) results, which were presumed to be positive; however, the infants exhibited no evidence of clinical disease. It is reassuring that the majority of the infants received negative PCR results after rooming with their mothers and breastfeeding directly (the mothers in this study practiced appropriate hand and breast hygiene).

## Managing COVID-19 in Pregnancy

Pregnant people should be counseled about the increased risk for severe disease from SARS-CoV-2 and the measures they can take to protect themselves and their families from infection. These measures include practicing physical distancing, washing their hands regularly, and wearing a face covering (if indicated). If the patient is not vaccinated, they should be counseled about wearing a face covering and getting vaccinated against SARS-CoV-2 infection. CDC, the American College of Obstetricians and Gynecologists (ACOG), and the Society for Maternal-Fetal Medicine highlight the importance of accessing prenatal care. ACOG provides a list of frequently asked questions on using telehealth to deliver antenatal care, when appropriate.

ACOG has developed an algorithm to evaluate and manage pregnant outpatients with suspected or laboratory-confirmed SARS-CoV-2 infection. As in nonpregnant patients, SARS-CoV-2 infection in pregnant patients can present as asymptomatic/presymptomatic disease or with a wide range of clinical manifestations, from mild symptoms that can be managed with supportive care at home to severe disease and respiratory failure that requires ICU admission. As in other patients, the illness severity, underlying comorbidities, and clinical status of pregnant patients with symptoms that are compatible with COVID-19 should be assessed to determine whether in-person evaluation for potential hospitalization is needed.

If hospitalization is indicated, care should be provided in a facility that can conduct maternal and fetal monitoring, when appropriate. The management of COVID-19 in the pregnant patient may include:

- Fetal and uterine contraction monitoring based on gestational age, when appropriate
- Individualized delivery planning
- A multispecialty, team-based approach that may include consultation with obstetric, maternal-fetal medicine, infectious disease, pulmonary-critical care, and pediatric specialists, as appropriate.

In general, the recommendations for managing COVID-19 in nonpregnant patients also apply to pregnant patients.

## Therapeutic Management of COVID-19 in the Setting of Pregnancy

Potentially effective treatments for COVID-19 should not be withheld from pregnant people because of theoretical concerns related to the safety of using those therapeutic agents in pregnancy **(AIII)**.

Pregnant or lactating patients with COVID-19 and their clinical teams should discuss the use of investigational drugs or drugs that are approved for other indications as treatments for COVID-19. During this shared decision-making process, the patient and the clinical team should consider the safety of the medication for the pregnant or lactating individual and the fetus and the severity of maternal disease. For detailed guidance on the use of COVID-19 therapeutic agents during pregnancy, please refer to the pregnancy considerations subsections found in the Antiviral Therapy and Immunomodulators sections of these Guidelines.

The use of anti-SARS-CoV-2 monoclonal antibodies can be considered in pregnant people with COVID-19, especially in those who have additional risk factors for severe disease. There is no pregnancy-specific data on the use of monoclonal antibodies; however, other immunoglobulin G products have been safely used in pregnancy when their use is indicated. Therefore, these products should not be withheld in the setting of pregnancy.

To date, most SARS-CoV-2-related clinical trials have excluded individuals who are pregnant and lactating; in cases where lactating and pregnant individuals have been included in studies, only a small number have been enrolled. This limitation makes it difficult to make evidence-based recommendations on the use of SARS-CoV-2 therapies in these vulnerable patients and potentially limits their COVID-19 treatment options. When possible, pregnant and lactating individuals should not be excluded from clinical trials of therapeutic agents or vaccines for SARS-CoV-2 infection.

## Timing of Delivery

ACOG provides detailed guidance on the timing of delivery and the risk of vertical transmission of SARS-CoV-2.

In most cases, the timing of delivery should be dictated by obstetric indications rather than maternal diagnosis of COVID-19. For women who had suspected or confirmed COVID-19 early in pregnancy

who recover, no alteration to the usual timing of delivery is indicated.

## Post-Delivery

The majority of studies have not demonstrated the presence of SARS-CoV-2 in breast milk; therefore, breastfeeding is not contraindicated for people with laboratory-confirmed or suspected SARS-CoV-2 infection.[8] Precautions should be taken to avoid transmission to the infant, including practicing good hand hygiene, wearing face coverings, and performing proper pump cleaning before and after breast milk expression.

The decision to feed the infant breast milk while the patient is receiving therapeutic agents for COVID-19 should be a joint effort between the patient and the clinical team, including infant care providers. The patient and the clinical team should discuss the potential benefits of the therapeutic agent and evaluate the potential impact of pausing lactation on the future of breast milk delivery to the infant.

Specific guidance on the post-delivery management of infants born to mothers with known or suspected SARS-CoV-2 infection, including breastfeeding recommendations, is provided by CDC and the American Academy of Pediatrics, as well as the Special Considerations in Children section in these Guidelines.

## SARS-CoV-2 Vaccine in Pregnancy

A study that used data from three vaccine safety reporting systems in the United States reported that the frequency of adverse events among 35,691 vaccine recipients who identified as pregnant was similar to the frequency observed among nonpregnant patients. Local injection site pain, nausea, and vomiting were reported slightly more frequently in pregnant people than in nonpregnant people. Other systemic reactions were reported more frequently among nonpregnant vaccine recipients, but the overall reactogenicity profile was similar for pregnant and nonpregnant patients. Surveillance data from 3,958 pregnant patients who were enrolled in CDC's v-safe Vaccine Pregnancy Registry showed that, among 827 people who completed their pregnancies, there were no obvious safety signals among obstetric or neonatal outcomes when rates of pregnancy loss (spontaneous abortion or stillbirth), preterm birth, congenital anomalies, infants who were small for gestational age, and neonatal death were compared to historic incidences in the peer-reviewed literature.[9] ACOG has published practice guidance on using COVID-19 vaccines in pregnant and lactating people, including a guide to assist clinicians during risk and benefit conversations with pregnant patients.

## References


1. Zambrano LD, Ellington S, Strid P, et al. Update: characteristics of symptomatic women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status—United States, January 22–October 3, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(44):1641-1647. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33151921.
2. Ko JY, DeSisto CL, Simeone RM, et al. Adverse pregnancy outcomes, maternal complications, and severe illness among U.S. delivery hospitalizations with and without a COVID-19 diagnosis. *Clin Infect Dis*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33977298.
3. Woodworth KR, Olsen EO, Neelam V, et al. Birth and infant outcomes following laboratory-confirmed SARS-CoV-2 infection in pregnancy—SET-NET, 16 jurisdictions, March 29–October 14, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(44):1635-1640. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33151917.
4. Ellington S, Strid P, Tong VT, et al. Characteristics of women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status—United States, January 22–June 7, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(25):769-775. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32584795.

5. Allotey J, Stallings E, Bonet M, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. *BMJ*. 2020;370:m3320. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32873575.
6. Metz TD, Clifton RG, Hughes BL, et al. Disease severity and perinatal outcomes of pregnant patients with coronavirus disease 2019 (COVID-19). *Obstet Gynecol*. 2021;137(4):571-580. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33560778.
7. Dumitriu D, Emeruwa UN, Hanft E, et al. Outcomes of neonates born to mothers with severe acute respiratory syndrome coronavirus 2 infection at a large medical center in New York City. *JAMA Pediatr*. 2021;175(2):157-167. Available at: https://pubmed.ncbi.nlm.nih.gov/33044493/.
8. The American College of Obstetricians and Gynecologists. COVID-19 FAQs for obstetrician-gynecologists, obstetrics. 2020. Available at: https://www.acog.org/clinical-information/physician-faqs/covid-19-faqs-for-ob-gyns-obstetrics. Accessed February 8, 2021.
9. Shimabukuro TT, Kim SY, Myers TR, et al. Preliminary findings of mRNA COVID-19 vaccine safety in pregnant persons. *N Engl J Med*. 2021;384(24):2273-2282. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33882218.

# Special Considerations in Children

*Last Updated: April 21, 2021*

**Summary Recommendations**

- SARS-CoV-2 infection is generally milder in children than in adults, and a substantial proportion of children with the disease have asymptomatic infection.
- Most children with SARS-CoV-2 infection will not require any specific therapy.
- Children who have a history of medical complexity (e.g., due to neurologic impairment, developmental delays, or genetic syndromes including trisomy 21), obesity, chronic cardiopulmonary disease, or who are immunocompromised, as well as nonwhite children and older teenagers may be at increased risk for severe disease.
- There are limited data on the pathogenesis and clinical spectrum of COVID-19 disease in children. There are no pediatric data from placebo-controlled randomized clinical trials and limited data from observational studies to inform the development of pediatric-specific recommendations for the treatment of COVID-19.

**Specific Therapy for Children**

- In the absence of adequate data on the treatment of children with acute COVID-19, recommendations are based on outcome and safety data for adult patients and the child's risk of disease progression.
- Most children with mild or moderate disease can be managed with supportive care alone **(AIII)**.
- **Remdesivir** is recommended for:
  - Hospitalized children aged ≥12 years with COVID-19 who have risk factors for severe disease and have an emergent or increasing need for supplemental oxygen **(BIII)**.
  - Hospitalized children aged ≥16 years with COVID-19 who have an emergent or increasing need for supplemental oxygen regardless of whether they have risks factors for severe disease **(BIII)**.
- In consultation with a pediatric infectious disease specialist, **remdesivir** can be considered for hospitalized children of all ages with COVID-19 who have an emergent or increasing need for supplemental oxygen **(CIII)**.
- The COVID-19 Treatment Guidelines Panel (the Panel) recommends using **dexamethasone** for hospitalized children with COVID-19 who require high-flow oxygen, noninvasive ventilation, invasive mechanical ventilation, or extracorporeal membrane oxygenation **(BIII)**.
- There is insufficient evidence for the Panel to recommend either for or against the use of anti-SARS-CoV-2 monoclonal antibody products for children with COVID-19 who are not hospitalized but who have risk factors for severe disease. Based on adult studies, bamlanivimab plus etesevimab or casirivimab plus imdevimab may be considered on a case-by-case basis for nonhospitalized children who meet Emergency Use Authorization (EUA) criteria for high-risk of severe disease, especially those who meet more than one criterion or are aged ≥16 years. The Panel recommends consulting a pediatric infectious disease specialist in such cases.
- The Panel **recommends against** the use of **convalescent plasma** for hospitalized children with COVID-19 who do not require mechanical ventilation, except in a clinical trial **(AIII)**. The Panel **recommends against** the use of **convalescent plasma** for pediatric patients with COVID-19 who are mechanically ventilated **(AIII)**. In consultation with a pediatric infectious disease specialist, high-titer convalescent plasma may be considered on a case-by-case basis for hospitalized children who meet the EUA criteria for its use.
- There is insufficient evidence for the Panel to recommend either for or against the use of baricitinib in combination with remdesivir for the treatment of COVID-19 in hospitalized children in whom corticosteroids cannot be used.
- There is insufficient evidence for the Panel to recommend either for or against the use of tocilizumab in hospitalized children with COVID-19 or multisystem inflammatory syndrome in children (MIS-C). The Panel **recommends against** the use of **sarilumab** for hospitalized children with COVID-19 or MIS-C, except in a clinical trial **(AIII)**.
- MIS-C is a serious delayed complication of SARS-CoV-2 infection that may develop in a minority of children and young adults.
  - Consultation with a multidisciplinary team is recommended when considering and managing immunomodulating therapy for children with MIS-C **(AIII)**. Intravenous immunoglobulin and/or corticosteroids are generally used as first-line therapy, although interleukin-1 antagonists have been used for refractory cases. The optimal choice and combination of immunomodulating therapies have not been definitively established.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion

## Epidemiology

Data from the Centers for Disease Control and Prevention (CDC) demonstrate a lower incidence of SARS-CoV-2 infection and severe disease in children than in adults.[1] However, without more systematic testing for children, including for children with mild symptoms as part of contact tracing, or seroprevalence studies, the true burden of pediatric SARS-CoV-2 infection remains unclear. Data on the pathogenesis and disease severity of SARS-CoV-2 infection in children are increasing but are still limited compared to the data in adults. Several large epidemiologic studies suggest that severe manifestations of acute disease are substantially less common in children than in adults. Although only a small percentage of children with COVID-19 will require medical attention, intensive care unit (ICU)-admission rates for hospitalized children are comparable to those for hospitalized adults with COVID-19.[2-10]

## Clinical Manifestations

The signs and symptoms of SARS-CoV-2 infection in children may be similar to those in adults, but most children may be asymptomatic or only have a few symptoms. The most common signs and symptoms of COVID-19 in hospitalized children are fever, nausea/vomiting, cough, shortness of breath, and upper respiratory symptoms.[9,11] Of note, signs and symptoms of COVID-19 may overlap significantly with those of other viral infections, including influenza and other respiratory and enteric viral infections. Although the true incidence of asymptomatic SARS-CoV-2 infection is unknown, asymptomatic infection was reported in up to 45% of children who underwent surveillance testing at the time of hospitalization for a non-COVID-19 indication.[12]

SARS-CoV-2 has been associated with a potentially severe inflammatory syndrome in children and young adults (multisystem inflammatory syndrome in children [MIS-C]), which is discussed below.

## Risk Factors

Data to clearly establish risk factors for severe COVID-19 in children are limited. Data reported to CDC show lower hospitalization rates and ICU admission rates for children with COVID-19 than for adults with the disease.[11,13] COVID-19-related hospitalization rates for children were highest in children aged <2 years and higher in Hispanic and Black children than in White children. The majority of hospitalized children with acute COVID-19 had underlying conditions, with obesity, chronic lung disease, and prematurity (data collected only for children aged <2 years) being the most prevalent.[14] Risk factors such as obesity may be more applicable to older teenagers.

In a large study of hospitalized children from the United Kingdom, age <1 month, age 10 to 14 years, and Black race were associated with admission to critical care unit on multivariate analysis.[9] Another large multicenter study from Europe identified male sex, pre-existing medical conditions, and the presence of lower respiratory tract disease at presentation as additional risk factors for ICU admission in multivariable models.[10]

Deaths associated with COVID-19 among those aged <21 years are higher among children aged 10 to 20 years, especially young adults aged 18 to 20 years, as well as among Hispanic, Black, and American Indian/Alaska Native persons.[15] A high proportion of the fatal cases of pediatric COVID-19 are in children with underlying medical conditions, most commonly chronic lung disease, obesity, and neurologic and developmental disorders.

Based on data for adults with COVID-19 and extrapolations from data for non-COVID-19 pediatric respiratory viral infections, severely immunocompromised children and those with underlying cardiopulmonary disease may be at higher risk for severe COVID-19. Initial reports of SARS-CoV-2 infection among pediatric patients with cancer and pediatric solid organ transplant recipients have demonstrated a low frequency of infection and associated morbidity;[16-20] however, similar reports for other immunocompromised pediatric populations are limited.[21] A few reports have demonstrated a higher prevalence of asthma in pediatric COVID-19 cases, although the association of asthma with severe disease is not clearly defined.[7,8] Congenital heart disease may be associated with increased risk of severe COVID-19, but the condition has not been consistently identified as a risk factor.[22,23] Guidance on the treatment of COVID-19 in children endorsed by the Pediatric Infectious Diseases Society specifies additional risk factors to consider when making decisions about antiviral and monoclonal antibody therapy for pediatric patients.[24,25]

Persistent symptoms after acute COVID-19 have been described in adults, although the incidence of this sequelae in children remains unknown and is an active area of research (see Clinical Spectrum of SARS-CoV-2 Infection). Cardiac imaging studies have described myocardial injury in young athletes who had only mild disease;[26] additional studies are needed to determine long-term cardiac sequelae.

## Vertical Transmission and Infants Born to Mothers with SARS-CoV-2 Infection

Vertical transmission of SARS-CoV-2 is thought to be rare, but suspected or probable vertical transmission has been described.[27-29] Initial data on perinatal transmission of SARS-CoV-2 were limited to small case series with conflicting results; some studies demonstrated lack of transmission, whereas others were not able to definitively rule out this possibility.[30-33] Among 100 women with SARS-CoV-2 infection who delivered 101 infants, only two infants had equivocal reverse transcription polymerase chain reaction (RT-PCR) results that may have reflected SARS-CoV-2 infection even though most of the infants remained with their mothers, in rooms with infection prevention measures in place, and were breast fed.[34]

Infants born to individuals with SARS-CoV-2 infection may have higher risk of poor clinical outcomes than those born to individuals without SARS-CoV-2 infection, although data are conflicting. In a systematic review of case series in pregnant women with confirmed SARS-CoV-2 infection (predominantly from China), the preterm birth rate was 20.1% (57 of 284 births were preterm; 95% CI, 15.8–25.1), the cesarean delivery rate was 84.7% (33 of 392 births were by cesarean delivery; 95% CI, 80.8–87.9), there was no vertical transmission, and the neonatal death rate was 0.3% (1 of 313 neonates died; 95% CI, 0.1–1.8).[35] In a prospective cohort study of 263 infants born in the United States, the rates for preterm births, neonatal ICU admissions, and respiratory disease did not differ between infants born to mothers with and without SARS-CoV-2 infection.[36] A cohort study from Sweden demonstrated that 5-minute Apgar scores and birth weight for gestational age did not differ between infants born to mothers with and without SARS-CoV-2 infection.[37] Coronavirus Disease 2019 (COVID-19)-Associated Hospitalization Surveillance Network (COVID-NET) data from CDC that captured 598 hospitalized, pregnant women with SARS-CoV-2 infection showed a pregnancy loss rate of 2% among 458 pregnancies completed during COVID-19-related hospitalizations and a preterm birth rate of 12.9% compared to 10% for the general U.S. population.[38] A systematic review and meta-analysis of studies that included 2,567 pregnancies concluded that SARS-CoV-2-positive mothers were at increased risk of iatrogenic preterm birth. This risk was predominantly due to caesarean sections (21.8% of births) performed due to maternal illness and fear of maternal decompensation. In contrast, there was no increase in the rate of spontaneous preterm birth relative to the expected rate in pregnant individuals without SARS-CoV-2 infection.[39,40] Finally, a prospective cohort study from the United Kingdom of 66 neonates with SARS-CoV-2 infection found that 3% may have had vertically acquired

infection and 12% had suspected nosocomially acquired infection.[29] Specific guidance on the diagnosis and management of COVID-19 in neonates born to mothers with known or suspected SARS-CoV-2 infection is provided by CDC.

## Treatment Considerations

There are no results available from clinical trials evaluating treatment for COVID-19 in children, and observational data on the safety or efficacy of drug therapy in children with COVID-19 are extremely limited. More high-quality studies, including randomized trials, are urgently needed. Guidance for the treatment of COVID-19 in children has been published and is mostly extrapolated from recommendations for adults with COVID-19.[41,42] The older the child and the more severe the disease, the more reasonable it is to follow recommendations for adult patients with COVID-19 (see Therapeutic Management of Nonhospitalized Adults With COVID-19 and Therapeutic Management of Hospitalized Adults With COVID-19). To address the uncertain safety and efficacy of these treatment options, children should be enrolled in clinical trials and multicenter pragmatic trials whenever possible.

The majority of children with mild or moderate COVID-19 will not progress to more severe illness and thus should be managed with supportive care alone **(AIII)**. The risks and benefits of therapy should be assessed based on illness severity, age, and the presence of risk factors outlined above.

### *Remdesivir*

Remdesivir is the only drug approved by the Food and Drug Administration (FDA) for the treatment of COVID-19 (see Remdesivir for detailed information). It is approved for the treatment of COVID-19 in hospitalized adult and pediatric patients (aged ≥12 years and weighing ≥40 kg). It is also available through an FDA Emergency Use Authorization (EUA) for the treatment of COVID-19 in hospitalized pediatric patients weighing 3.5 kg to <40 kg or aged <12 years and weighing ≥3.5 kg.[43] Remdesivir has not been evaluated in clinical trials that include children, and there have been no results from systematic evaluations of pharmacokinetics, efficacy, or toxicity in younger children, although studies are ongoing (see *ClinicalTrials.gov*). However, based on adult data, the potential benefits of remdesivir are likely to be greater for hospitalized children with COVID-19 who are at higher risk of progression due to older age (i.e., aged ≥16 years) or medical condition than for those without these risk factors. **Remdesivir** is recommended for hospitalized children aged ≥12 years with COVID-19 who have risk factors for severe disease and have an emergent or increasing need for supplemental oxygen **(BIII)**. **Remdesivir** is also recommended for hospitalized children aged ≥16 years with COVID-19 who have an emergent or increasing need for supplemental oxygen even in the absence of risk factors **(BIII)**. **Remdesivir** can be considered for other hospitalized children of all ages with COVID-19 who have an emergent or increasing need for supplemental oxygen in consultation with a pediatric infectious disease specialist **(CIII)**.

### *Dexamethasone*

Dexamethasone is recommended for the treatment of hospitalized adults with COVID-19 who require mechanical ventilation or supplemental oxygen through a high-flow device (see Corticosteroids and Therapeutic Management of Hospitalized Adults With COVID-19 for detailed information). The safety and effectiveness of dexamethasone or other corticosteroids for COVID-19 treatment have not been sufficiently evaluated in pediatric patients and thus caution is warranted when extrapolating recommendations for adults to patients aged <18 years. The COVID-19 Treatment Guidelines Panel (the Panel) recommends using **dexamethasone** for children with COVID-19 who require high-flow oxygen, noninvasive ventilation, invasive mechanical ventilation, or extracorporeal membrane oxygenation (ECMO) **(BIII)**. It is not routinely recommended for pediatric patients who require only low levels of oxygen support (i.e., via a nasal cannula only). Use of dexamethasone for the treatment of severe COVID-19 in children who are profoundly immunocompromised has not been evaluated, may

be harmful, and therefore should be considered only on a case-by-case basis. If dexamethasone is not available, alternative glucocorticoids such as prednisone, methylprednisolone, or hydrocortisone can be considered. The dexamethasone dosing regimen for pediatric patients is dexamethasone 0.15 mg/kg/dose (maximum dose 6 mg) once daily for up to 10 days.

### *Anti-SARS-CoV-2 Monoclonal Antibodies*

Although EUAs have been issued for bamlanivimab plus etesevimab and casirivimab plus imdevimab for the treatment of nonhospitalized, high-risk patients aged ≥12 years and weighing ≥40 kg with mild to moderate COVID-19, there are currently no data available to determine which high-risk pediatric patients defined in the EUAs will likely benefit from these therapies. Consequently, there is insufficient evidence for the Panel to recommend either for or against the use of these monoclonal antibodies in children with COVID-19 who are not hospitalized but are at high risk of severe disease and/or hospitalization. In consultation with a pediatric infectious disease specialist, bamlanivimab plus etesevimab or casirivimab plus imdevimab can be considered on a case-by-case basis for children who meet the EUA criteria, but should not be considered routine care. This recommendation is primarily based on the absence of data assessing efficacy or safety in children or adolescents, limited data with which to identify children at the highest risk of severe COVID-19, as well as the low overall risk of progression to serious disease in children, and the potential risk associated with infusion reactions.

Additional guidance is provided in a recent publication endorsed by the Pediatric Infectious Diseases Society.[25] There are currently no data to support the use of anti-SARS-CoV-2 monoclonal antibodies in hospitalized children for COVID-19. Emerging data regarding the prevalence and clinical significance of SARS-CoV-2 variants, and the efficacy of monoclonal antibodies against variants, may inform the choice of specific anti-SARS-CoV-2 monoclonal antibody therapy in the future.

### *Convalescent Plasma*

FDA has also issued an EUA for the use of high-titer convalescent plasma for the treatment of hospitalized patients with COVID-19 (see Convalescent Plasma for detailed information).[44] The safety and efficacy of convalescent plasma have not been evaluated in pediatric patients with COVID-19. There is insufficient evidence for the Panel to recommend either for or against the use of convalescent plasma for the treatment of COVID-19 in either pediatric outpatients or in hospitalized children who do not require mechanical ventilation. The Panel **recommends against** the use of **convalescent plasma** for pediatric patients with COVID-19 who are mechanically ventilated **(AIII)**. In consultation with a pediatric infectious disease specialist, convalescent plasma may be considered on a case-by-case basis for children who meet the EUA criteria for its use.

### *Baricitinib*

FDA has also issued an EUA for the use of baricitinib in combination with remdesivir in hospitalized adults and children aged ≥2 years with COVID-19 who require supplemental oxygen, invasive mechanical ventilation, or ECMO.[45] The safety and efficacy of baricitinib have not been evaluated in pediatric patients with COVID-19, and pediatric data regarding its use for other conditions are extremely limited. Thus, there is insufficient evidence for the Panel to recommend either for or against the use of baricitinib in combination with remdesivir for the treatment of COVID-19 in hospitalized children in whom corticosteroids cannot be used (see Kinase Inhibitors for detailed information).

### *Tocilizumab*

Data on tocilizumab use for the treatment of non-COVID-19 conditions in children are limited to very specific clinical scenarios (e.g., chimeric antigen receptor T cell-related cytokine release syndrome).[46]

The use of tocilizumab for severe cases of acute COVID-19 has been described in pediatric case series.[14,47] Data on tocilizumab efficacy from trials in adults with COVID-19 are conflicting, and benefit has only been demonstrated in a subset of hospitalized patients (see Interleukin-6 Inhibitors). There is insufficient evidence for the Panel to recommend either for or against the use of tocilizumab for hospitalized children with COVID-19 or MIS-C. If used, tocilizumab should be used in combination with dexamethasone. The Panel **recommends against** the use of **sarilumab** for hospitalized children with COVID-19 or MIS-C, except in a clinical trial **(AIII)**.

As for other agents outlined in these Guidelines, there is insufficient evidence for the Panel to recommend either for or against the use of specific antivirals or immunomodulatory agents for the treatment of COVID-19 in pediatric patients. Considerations, such as underlying conditions, disease severity, and potential for drug toxicity or drug interactions, may inform decisions on the use of these agents in pediatric patients with COVID-19 on a case-by-case basis. Children should be enrolled in clinical trials evaluating COVID-19 therapies whenever possible. A number of additional drugs are being investigated for the treatment of COVID-19 in adults; refer to the Antiviral Therapy and Immunomodulators sections to review special considerations for use of these drugs in children and refer to Table 2e and Table 4e for recommendations on pediatric dosing regimens.

## Multisystem Inflammatory Syndrome in Children

A small subset of children and young adults with SARS-CoV-2 infection develop MIS-C. This immune manifestation is also referred to as pediatric multisystem inflammatory syndrome–temporally associated with SARS-CoV-2 (PMIS-TS), although the case definitions for the syndromes differ slightly. This syndrome was first described in Europe, where previously healthy children with severe inflammation and Kawasaki disease-like features were identified to have current or recent infection with SARS-CoV-2. The clinical spectrum of MIS-C has been described in the United States and is similar to that described for PIMS-TS. MIS-C is consistent with a post-infectious inflammatory syndrome related to SARS-CoV-2.[48,49] Most MIS-C patients have serologic evidence of previous SARS-CoV-2 infection, but only a minority are RT-PCR positive for SARS-CoV-2 at presentation.[50,51] The peak incidence of MIS-C lags about 4 weeks behind the peak of acute pediatric COVID-19 hospitalizations. Emerging data suggests that adults may also develop a similar syndrome, multisystem inflammatory syndrome in adults (MIS-A), although it is not clear if this is a postinfectious complication similar to MIS-C.[50-52] Although risk factors for MIS-C have not been established, in an analysis of MIS-C cases in the United States, most of the children were nonwhite, and obesity was the most common comorbidity.[53] Unlike in children with acute COVID-19, the majority of children who present with MIS-C do not seem to have underlying comorbid conditions other than obesity.

### *Clinical Manifestations*

The current CDC case definition for MIS-C includes:

- An individual aged <21 years presenting with fever,[a] laboratory evidence of inflammation,[b] and evidence of clinically severe illness requiring hospitalization with multisystem (i.e., more than two) organ involvement (cardiac, renal, respiratory, hematologic, gastrointestinal, dermatologic, or neurological); *and*
- No alternative plausible diagnoses; *and*
- Positive for current or recent SARS-CoV-2 infection by RT-PCR, antigen test, or serology; or COVID-19 exposure within the 4 weeks prior to the onset of symptoms.[54]

[a] Fever >38.0°C for ≥24 hours or report of subjective fever lasting ≥24 hours

[b] Including, but not limited to one or more of the following: an elevated C-reactive protein, erythrocyte sedimentation

rate, fibrinogen, procalcitonin, d-dimer, ferritin, lactic acid dehydrogenase, interleukin (IL)-6, or neutrophils, or reduced lymphocytes or albumin levels

Distinguishing MIS-C from other febrile illnesses in the community setting remains challenging, but presence of persistent fever, multisystem manifestations, and laboratory abnormalities could help early recognition.[55] The clinical spectrum of hospitalized cases has included younger children with mucocutaneous manifestations that overlap those with Kawasaki disease, older children with more multiorgan involvement and shock, and patients with respiratory manifestations that overlap with acute COVID-19. Patients with MIS-C are often critically ill and up to 80% of children require ICU admission.[53] Most patients with MIS-C have markers of cardiac injury or dysfunction, including elevated levels of troponin and brain natriuretic protein.[50,51] Echocardiographic findings in these cases include impaired left ventricular function, as well as coronary artery dilations, and rarely, coronary artery aneurysms. Reported mortality rate in the United States for hospitalized children with MIS-C is 1% to 2%. Longitudinal studies are currently ongoing to examine the long-term sequelae of MIS-C.

The pathogenesis of MIS-C is still being elucidated. Differences have been demonstrated between MIS-C and typical Kawasaki disease in terms of epidemiology, cytopenias, cytokine expression, and elevation of inflammatory markers. Immunologic profiling has also shown differences in cytokine expression (tumor necrosis factor alpha and IL-10) between MIS-C and acute COVID-19 in children.[56-58]

### *Management*

Currently, there are only observational data available to guide treatment for MIS-C. Supportive care remains the mainstay of therapy. There is currently insufficient evidence for the Panel to recommend either for or against any specific therapeutic strategy for the management of MIS-C. MIS-C management decisions should involve a multidisciplinary team of pediatric specialists including experts in intensive care, infectious diseases, cardiology, hematology, and rheumatology. Although no clinical trial data are available, many centers have described the use of immunomodulatory therapy (e.g., intravenous immune globulin [IVIG], corticosteroids, IL-1 and IL-6 inhibitors). The American College of Rheumatology has outlined initial diagnostic and treatment considerations for MIS-C, recommending IVIG and/or corticosteroids as first-tier therapies and other biologic agents as second-line options.[48,49,59] An observational study from Europe used propensity matching to compare short-term outcomes in children with MIS-C who were treated initially with IVIG alone or IVIG and methylprednisolone. They observed a lower risk of treatment failure (defined as persistence of fever), more rapid improvement in hemodynamic support, less severe left ventricular dysfunction, and shorter ICU stays among children initially treated with the combination therapy.[60] These findings must be confirmed with additional prospective studies. The role of antiviral therapy in MIS-C is not clear, therefore the use of remdesivir should be reserved for patients who have features of acute COVID-19.

## References


1. Centers for Disease Control and Prevention. COVID-19: information for pediatric healthcare providers. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/pediatric-hcp.html. Accessed March 26, 2021.
2. Dong Y, Mo X, Hu Y, et al. Epidemiology of COVID-19 among children in China. *Pediatrics.* 2020;145(6). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32179660.
3. Centers for Disease Control and Prevention. Coronavirus disease 2019 in children—United States, February 12–April 2, 2020. 2020. Available at: https://www.cdc.gov/mmwr/volumes/69/wr/mm6914e4.htm. Accessed: January 5, 2021.
4. Cui X, Zhang T, Zheng J, et al. Children with coronavirus disease 2019 (COVID-19): a review of demographic, clinical, laboratory and imaging features in 2,597 pediatric patients. *J Med Virol*. 2020;92(9):1501-1510. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32418216.

5. Livingston E, Bucher K. Coronavirus Disease 2019 (COVID-19) in Italy. *JAMA*. 2020;323(14):1335. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32181795.
6. Tagarro A, Epalza C, Santos M, et al. Screening and severity of coronavirus disease 2019 (COVID-19) in children in Madrid, Spain. *JAMA Pediatr*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32267485.
7. DeBiasi RL, Song X, Delaney M, et al. Severe COVID-19 in children and young adults in the Washington, DC metropolitan region. *J Pediatr*. 2020;223:199-203.e1. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32405091.
8. Chao JY, Derespina KR, Herold BC, et al. Clinical characteristics and outcomes of hospitalized and critically ill children and adolescents with coronavirus disease 2019 (COVID-19) at a tertiary care medical center in New York City. *J Pediatr*. 2020;223:14-19.e2. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32407719.
9. Swann OV, Holden KA, Turtle L, et al. Clinical characteristics of children and young people admitted to hospital with COVID-19 in United Kingdom: prospective multicentre observational cohort study. *BMJ*. 2020;370:m3249. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32960186.
10. Gotzinger F, Santiago-Garcia B, Noguera-Julian A, et al. COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study. *Lancet Child Adolesc Health*. 2020;4(9):653-661. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32593339.
11. Kim L, Whitaker M, O'Halloran A, et al. Hospitalization rates and characteristics of children aged <18 years hospitalized with laboratory-confirmed COVID-19—COVID-NET, 14 States, March 1–July 25, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(32):1081-1088. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32790664.
12. Poline J, Gaschignard J, Leblanc C, et al. Systematic SARS-CoV-2 screening at hospital admission in children: a French prospective multicenter study. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32710743.
13. Leidman E, Duca LM, Omura JD, Proia K, Stephens JW, Sauber-Schatz EK. COVID-19 trends among persons aged 0–24 years—United States, March 1–December 12, 2020. *MMWR Morb Mortal Wkly Rep*. 2021;70(3):88-94. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33476314.
14. Shekerdemian LS, Mahmood NR, Wolfe KK, et al. Characteristics and outcomes of children with coronavirus disease 2019 (COVID-19) infection admitted to US and Canadian pediatric intensive care units. *JAMA Pediatr*. 2020;174(9):868-873. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32392288.
15. Bixler D, Miller AD, Mattison CP, et al. SARS-CoV-2-associated deaths among persons aged <21 years—United States, February 12–July 31, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(37):1324-1329. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32941417.
16. Goss MB, Galvan NTN, Ruan W, et al. The pediatric solid organ transplant experience with COVID-19: an initial multi-center, multi-organ case series. *Pediatr Transplant*. 2020:e13868. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32949098.
17. Bisogno G, Provenzi M, Zama D, et al. Clinical characteristics and outcome of severe acute respiratory syndrome coronavirus 2 infection in Italian pediatric oncology patients: a study from the Infectious Diseases Working Group of the Associazione Italiana di Oncologia e Ematologia Pediatrica. *J Pediatric Infect Dis Soc*. 2020;9(5):530-534. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32652521.
18. Boulad F, Kamboj M, Bouvier N, Mauguen A, Kung AL. COVID-19 in children with cancer in New York City. *JAMA Oncol*. 2020;6(9):1459-1460. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32401276.
19. de Rojas T, Perez-Martinez A, Cela E, et al. COVID-19 infection in children and adolescents with cancer in Madrid. *Pediatr Blood Cancer*. 2020;67(7):e28397. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32383819.
20. Hrusak O, Kalina T, Wolf J, et al. Flash survey on severe acute respiratory syndrome coronavirus-2 infections in paediatric patients on anticancer treatment. *Eur J Cancer*. 2020;132:11-16. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/32305831.

21. Freeman MC, Rapsinski GJ, Zilla ML, Wheeler SE. Immunocompromised seroprevalence and course of illness of SARS-CoV-2 in one pediatric quaternary care center. *J Pediatric Infect Dis Soc*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33049042.
22. Madhusoodhan PP, Pierro J, Musante J, et al. Characterization of COVID-19 disease in pediatric oncology patients: the New York-New Jersey regional experience. *Pediatr Blood Cancer*. 2021;68(3):e28843. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33338306.
23. Lewis MJ, Anderson BR, Fremed M, et al. Impact of coronavirus disease 2019 (COVID-19) on patients with congenital heart disease across the lifespan: the experience of an academic congenital heart disease center in New York City. *J Am Heart Assoc*. 2020;9(23):e017580. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33196343.
24. Chiotos K, Hayes M, Kimberlin DW, et al. Multicenter interim guidance on use of antivirals for children with coronavirus disease 2019/severe acute respiratory syndrome coronavirus 2. *J Pediatric Infect Dis Soc*. 2021;10(1):34-48. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32918548.
25. Wolf J, Abzug MJ, Wattier RL, et al. Initial guidance on use of monoclonal antibody therapy for treatment of COVID-19 in children and adolescents. *J Pediatric Infect Dis Soc*. 2021;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33388760.
26. Rajpal S, Tong MS, Borchers J, et al. Cardiovascular magnetic resonance findings in competitive athletes recovering from COVID-19 infection. *JAMA Cardiol*. 2021;6(1):116-118. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32915194.
27. Demirjian A, Singh C, Tebruegge M, et al. Probable vertical transmission of SARS-CoV-2 infection. *Pediatr Infect Dis J*. 2020;39(9):e257-e260. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32658096.
28. Dong L, Tian J, He S, et al. Possible vertical transmission of SARS-CoV-2 From an infected mother to her newborn. *JAMA*. 2020;323(18):1846-1848. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32215581.
29. Gale C, Quigley MA, Placzek A, et al. Characteristics and outcomes of neonatal SARS-CoV-2 infection in the UK: a prospective national cohort study using active surveillance. *Lancet Child Adolesc Health*. 2021;5(2):113-121. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33181124.
30. Chen H, Guo J, Wang C, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *Lancet*. 2020;395(10226):809-815. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32151335.
31. Fan C, Lei D, Fang C, et al. Perinatal transmission of COVID-19 associated SARS-CoV-2: should we worry? *Clin Infect Dis*. 2021;72(5):862-864. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32182347.
32. Zeng L, Xia S, Yuan W, et al. Neonatal early-onset infection with SARS-CoV-2 in 33 neonates born to mothers with COVID-19 in Wuhan, China. *JAMA Pediatr.* 2020;174(7):722-725. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32215598.
33. Von Kohorn I, Stein SR, Shikani BT, et al. In utero severe acute respiratory syndrome voronavirus 2 infection. *J Pediatric Infect Dis Soc*. 2020;9(6):769-771. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33089311.
34. Dumitriu D, Emeruwa UN, Hanft E, et al. Outcomes of neonates born to mothers with severe acute respiratory syndrome coronavirus 2 infection at a large medical center in New York City. *JAMA Pediatr*. 2021;175(2):157-167. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33044493.
35. Huntley BJF, Huntley ES, Di Mascio D, Chen T, Berghella V, Chauhan SP. Rates of maternal and perinatal mortality and vertical transmission in pregnancies complicated by severe acute respiratory syndrome coronavirus 2 (SARS-Co-V-2) infection: a systematic review. *Obstet Gynecol*. 2020;136(2):303-312. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32516273.
36. Flaherman VJ, Afshar Y, Boscardin J, et al. Infant outcomes following maternal infection with SARS-CoV-2: first report from the PRIORITY study. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32947612.

37. Ahlberg M, Neovius M, Saltvedt S, et al. Association of SARS-CoV-2 test status and pregnancy outcomes. *JAMA*. 2020;324(17):1782-1785. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32965467.

38. Delahoy MJ, Whitaker M, O'Halloran A, et al. Characteristics and maternal and birth outcomes of hospitalized pregnant women with laboratory-confirmed COVID-19 - COVID-NET, 13 states, March 1–August 22, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(38):1347-1354. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32970655.

39. Khalil A, Kalafat E, Benlioglu C, et al. SARS-CoV-2 infection in pregnancy: a systematic review and meta-analysis of clinical features and pregnancy outcomes. *EClinicalMedicine*. 2020;25:100446. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32838230.

40. Khoury R, Bernstein PS, Debolt C, et al. Characteristics and outcomes of 241 births to women with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection at five New York City medical centers. *Obstet Gynecol*. 2020;136(2):273-282. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32555034.

41. Chiotos K, Hayes M, Kimberlin DW, et al. Multicenter initial guidance on use of antivirals for children with COVID-19/SARS-CoV-2. *J Pediatric Infect Dis Soc*. 2020;9(6):701-715. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32318706.

42. Dulek DE, Fuhlbrigge RC, Tribble AC, et al. Multidisciplinary guidance regarding the use of immunomodulatory therapies for acute coronavirus disease 2019 in pediatric patients. *J Pediatric Infect Dis Soc*. 2020;9(6):716-737. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32808988.

43. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of veklury (remdesivir) for hospitalized pediatric patients weighing 3.5 kg to less than 40 kg or hospitalized pediatric patients less than 12 years of age weighing at least 3.5 kg. 2020. Available at: https://www.fda.gov/media/137566/download.

44. Food and Drug Administration. EUA 26382: Emergency Use Authorization (EUA) Decision Memo. 2020. Available at: https://www.fda.gov/media/141480/download.

45. Food and Drug Administration. Letter of authorization: EUA for baricitinib (Olumiant), in combination with remdesivir (Veklury), for the treatment of suspected or laboratory confirmed coronavirus disease 2019 (COVID-19). 2020. Available at: https://www.fda.gov/media/143822/download.

46. Kotch C, Barrett D, Teachey DT. Tocilizumab for the treatment of chimeric antigen receptor T cell-induced cytokine release syndrome. *Expert Rev Clin Immunol.* 2019;15(8):813-822. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31219357.

47. Derespina KR, Kaushik S, Plichta A, et al. Clinical manifestations and outcomes of critically ill children and adolescents with coronavirus disease 2019 in New York City. *J Pediatr*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32681989.

48. Riphagen S, Gomez X, Gonzalez-Martinez C, Wilkinson N, Theocharis P. Hyperinflammatory shock in children during COVID-19 pandemic. *Lancet*. 2020;395(10237):1607-1608. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32386565.

49. Whittaker E, Bamford A, Kenny J, et al. Clinical characteristics of 58 children with a pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. *JAMA*. 2020;324(3):259-269. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32511692.

50. Dufort EM, Koumans EH, Chow EJ, et al. Multisystem inflammatory syndrome in children in New York State. *N Engl J Med*. 2020;383(4):347-358. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32598830.

51. Feldstein LR, Rose EB, Horwitz SM, et al. Multisystem inflammatory syndrome in U.S. children and adolescents. *N Engl J Med*. 2020;383(4):334-346. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32598831.

52. Morris SB, Schwartz NG, Patel P, et al. Case series of multisystem inflammatory syndrome in adults associated with SARS-CoV-2 infection—United Kingdom and United States, March–August 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(40):1450-1456. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/33031361.

53. Godfred-Cato S, Bryant B, Leung J, et al. COVID-19-associated multisystem inflammatory syndrome in children—United States, March–-July 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(32):1074-1080. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32790663.
54. Centers for Disease Control and Prevention. Information for healthcare providers about multisystem inflammatory syndrome in children (MIS-C). 2021. Available at: https://www.cdc.gov/mis-c/hcp/. Accessed March 26, 2021.
55. Carlin RF, Fischer AM, Pitkowsky Z, et al. Discriminating multisystem inflammatory syndrome in children requiring treatment from common febrile conditions in outpatient settings. *J Pediatr*. 2021;229:26-32 e22. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33065115.
56. Lee PY, Day-Lewis M, Henderson LA, et al. Distinct clinical and immunological features of SARS-CoV-2-induced multisystem inflammatory syndrome in children. *J Clin Invest*. 2020;130(11):5942-5950. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32701511.
57. Rowley AH, Shulman ST, Arditi M. Immune pathogenesis of COVID-19-related multisystem inflammatory syndrome in children. *J Clin Invest*. 2020;130(11):5619-5621. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32870815.
58. Diorio C, Henrickson SE, Vella LA, et al. Multisystem inflammatory syndrome in children and COVID-19 are distinct presentations of SARS-CoV-2. *J Clin Invest*. 2020;130(11):5967-5975. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32730233.
59. Henderson LA, Canna SW, Friedman KG, et al. American College of Rheumatology clinical guidance for multisystem inflammatory syndrome in children associated with SARS-CoV-2 and hyperinflammation in pediatric COVID-19: version 2. *Arthritis Rheumatol*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33277976.
60. Ouldali N, Toubiana J, Antona D, et al. Association of intravenous immunoglobulins plus methylprednisolone vs immunoglobulins alone with course of fever in multisystem inflammatory syndrome in children. *JAMA*. 2021;325(9):855-864. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33523115.

# Special Considerations in Adults and Children With Cancer

*Last Updated: April 21, 2020*

| Summary Recommendations |
|---|
| • Given the effectiveness of the SARS-CoV-2 vaccines in the general population and the increased risk of severe COVID-19 and mortality in patients with cancer, the COVID-19 Treatment Guidelines Panel (the Panel) recommends SARS-CoV-2 vaccination for patients with active cancer or patients who are receiving treatment for cancer **(AIII)**. See the text below for information on the appropriate timing for SARS-CoV-2 vaccination in these patients.<br>• The Panel recommends performing molecular diagnostic testing for SARS-CoV-2 in patients with cancer who develop signs and symptoms that suggest COVID-19 **(AIII)** and in asymptomatic patients prior to procedures that require anesthesia and before initiating cytotoxic chemotherapy and long-acting biologic therapy **(BIII)**.<br>• The recommendations for treating COVID-19 in patients with cancer are the same as those for the general population **(AIII)**. See Antiviral Drugs That Are Approved or Under Evaluation for the Treatment of COVID-19 and Immunomodulators Under Evaluation for the Treatment of COVID-19 for more information.<br>• Clinicians should pay careful attention to potential drug-drug interactions and overlapping toxicities between drugs that are used to treat COVID-19 and cancer-directed therapies, prophylactic antimicrobials, corticosteroids, and other medications **(AIII)**.<br>• Clinicians who are treating COVID-19 in patients with cancer should consult a hematologist or oncologist before adjusting cancer-directed medications **(AIII)**.<br>• Decisions about administering cancer-directed therapy during SARS-CoV-2 infection should be made on a case-by-case basis; clinicians should consider the indication for chemotherapy, the goals of care, and the patient's history of tolerance to the treatment **(BIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

People who are being treated for cancer may be at increased risk of severe COVID-19, and clinical outcomes of COVID-19 are generally worse in people with cancer than in people without cancer.[1-4] A meta-analysis of 46,499 patients with COVID-19 showed that all-cause mortality (risk ratio 1.66; 95% CI, 1.33–2.07) was higher in patients with cancer, and that patients with cancer were more likely to be admitted to intensive care units (risk ratio 1.56; 95% CI, 1.31–1.87).[5] The risk for immunosuppression and susceptibility to SARS-CoV-2 infection varies between cancer types, treatments administered, and stages of therapy (e.g., patients who are actively being treated compared to those in remission). In a study that used data from the COVID-19 and Cancer Consortium Registry, cancer patients who were in remission or who had no evidence of disease were at a lower risk of death from COVID-19 than those who were receiving active treatment.[6] It is unclear whether cancer survivors are at increased risk for severe COVID-19 and its complications compared to people without a history of cancer.

Many organizations have outlined recommendations for treating patients with cancer during the COVID-19 pandemic, such as:

- National Comprehensive Cancer Network (NCCN)
- American Society of Hematology
- American Society of Clinical Oncology
- Society of Surgical Oncology
- American Society for Radiation Oncology
- International Lymphoma Radiation Oncology Group

This section of the COVID-19 Treatment Guidelines complements these sources and focuses on

considerations regarding testing for SARS-CoV-2, managing COVID-19 in patients with cancer, and managing cancer-directed therapies during the COVID-19 pandemic. The optimal management and therapeutic approach to COVID-19 in this population has not yet been defined.

## Vaccination for SARS-CoV-2 in Patients With Cancer

The clinical trials that evaluated the SARS-CoV-2 vaccines that have received Emergency Use Authorizations from the Food and Drug Administration excluded severely immunocompromised patients. The Advisory Committee on Immunization Practices notes that the authorized SARS-CoV-2 vaccines are not live vaccines; therefore, they can be safely administered to immunocompromised people.[7] Given the effectiveness of the SARS-CoV-2 vaccines in the general population and the increased risk of severe COVID-19 and mortality in patients with cancer, the COVID-19 Treatment Guidelines Panel (the Panel) recommends SARS-CoV-2 vaccination for patients with active cancer or patients who are receiving treatment for cancer **(AIII)**.

The mRNA vaccines contain polyethylene glycol (PEG), and the Johnson & Johnson (J&J)/Janssen vaccine contains polysorbate. In patients who experience a severe anaphylactic reaction to PEG-asparaginase, consider performing allergy testing for PEG prior to vaccination with either of the mRNA vaccines or consider using the J&J/Janssen vaccine with precautions.[8-10]

When determining the timing of SARS-CoV-2 vaccination in patients with cancer, clinicians should consider the following factors:

- If possible, patients who are planning to receive chemotherapy should complete vaccination for SARS-CoV-2 at least 2 weeks before starting chemotherapy.[11,12]
- In patients with hematologic malignancy who are undergoing intensive chemotherapy (e.g., induction chemotherapy for acute myelogenous leukemia), vaccination should be delayed until neutrophil recovery.[13]
- Hematopoietic stem cell and chimeric antigen receptor T cell recipients can be offered SARS-CoV-2 vaccination starting at least 3 months after therapy.[12]

It is unknown whether the immune response to SARS-CoV-2 vaccination can increase the risk of graft-versus-host disease or other immune-related complications. Studies of responses to influenza vaccination have shown that the immune response in cancer patients varies based on the type of cancer, whether the patient has received chemotherapy recently, and the type of chemotherapy.[14,15] Additional research is needed to understand the vaccine response in patients with cancer. Outside of a clinical study, antibody testing **is not recommended** to assess immunity to SARS-CoV-2 following vaccination in patients with cancer. For people who received COVID-19 vaccines during chemotherapy or treatment with other immunosuppressive drugs, revaccination after they regain immune competence is currently **not recommended**.[7]

Vaccination of household members, close contacts, and health care providers who provide care for immunocompromised patients is imperative to protect immunocompromised patients from infection. All close contacts are strongly encouraged to get vaccinated as soon as possible.

## Testing for COVID-19 in Patients With Cancer

The Panel recommends molecular diagnostic testing for SARS-CoV-2 in patients with cancer who develop signs and symptoms of COVID-19 **(AIII)**.

Patients with cancer who are receiving chemotherapy are at risk of developing neutropenia. The NCCN *Guidelines for Hematopoietic Growth Factors* categorizes cancer treatment regimens based on the risk

of developing neutropenia. A retrospective study suggests that cancer patients with neutropenia have a higher mortality rate if they develop COVID-19.[16] Due to the potential risk of poor clinical outcomes in the setting of neutropenia and/or during the perioperative period, the Panel recommends performing molecular diagnostic testing for SARS-CoV-2 prior to procedures that require anesthesia and before initiating cytotoxic chemotherapy and long-acting biologic therapy **(BIII)**.[17,18]

## General Guidance on Medical Care for Patients With Cancer During the COVID-19 Pandemic

Patients with cancer frequently engage with the health care system to receive treatment and supportive care for cancer and/or treatment-related complications. Telemedicine can minimize the need for in-person services and reduce the risk of SARS-CoV-2 exposure. The Centers for Disease Control and Prevention published a framework to help clinicians decide whether a patient should receive in-person or virtual care during the COVID-19 pandemic; this framework accounts for factors such as the potential harm of delayed care and the degree of SARS-CoV-2 transmission in a patient's community.[19] Telemedicine may improve access to providers for medically or socially vulnerable populations but could worsen disparities if these populations have limited access to technology. Nosocomial transmission of SARS-CoV-2 to patients and health care workers has been reported.[20-22] Principles of physical distancing and prevention strategies, including masking patients and health care workers and practicing hand hygiene, apply to all in-person interactions.[23]

Decisions about treatment regimens, surgery, and radiation therapy for the underlying malignancy should be made on an individual basis depending on the biology of the cancer, the need for hospitalization, the number of clinic visits required, and the anticipated degree of immunosuppression. Several key points should be considered:

- If possible, treatment delays should be avoided for curable cancers that have been shown to have worse outcomes when treatment is delayed (e.g., pediatric acute lymphoblastic leukemia).
- When deciding between equally effective treatment regimens, regimens that can be administered orally or those that require fewer infusions are preferred.[24,25]
- The potential risks of drug-related lung toxicity (e.g., from using bleomycin or PD-1 inhibitors) must be balanced with the clinical efficacy of alternative regimens or the risk of delaying care.[26]
- Preventing neutropenia can decrease the risk of neutropenic fever and the need for emergency department evaluation and hospitalization during the COVID-19 pandemic. Granulocyte colony-stimulating factor (G-CSF) should be given with chemotherapy regimens that have intermediate (10% to 20%) or high (>20%) risk of febrile neutropenia.[27]
- Cancer treatment regimens that do not affect outcomes of COVID-19 in cancer patients may not need to be altered. In a prospective observational study, receipt of immunotherapy, hormonal therapy, or radiotherapy in the month prior to SARS-CoV-2 infection was not associated with an increased risk of mortality among cancer patients with COVID-19.[28] A retrospective study from Italy evaluated the incidence of SARS-CoV-2 infection in patients with prostate cancer and found that 114 of 37,161 patients (0.3%) who were treated with therapies other than androgen deprivation therapy became infected, compared to 4 of 5,273 patients (0.08%) who were treated with androgen deprivation therapy (OR 4.05; 95% CI, 1.55–10.59).[29] A small cohort study of patients with prostate cancer from Finland did not find an association between androgen deprivation and incidence of SARS-CoV-2 infection.[30] The viral spike proteins that SARS-CoV-2 uses to enter cells are primed by TMPRSS2, an androgen-regulated gene. Whether androgen deprivation therapy protects against SARS-CoV-2 infection requires further investigation in larger cohorts or clinical trials.[29]

- Radiation therapy guidelines suggest increasing the dose per fraction and reducing the number of daily treatments in order to minimize the number of hospital visits during the COVID-19 pandemic.[24,25]

Blood supply shortages will likely continue during the COVID-19 pandemic due to social distancing, cancellation of blood drives, and infection among donors. Revised donor criteria have been proposed by the Food and Drug Administration to increase the number of eligible donors.[31] In patients with cancer, lowering the transfusion thresholds for blood products (e.g., red blood cells, platelets) in asymptomatic patients should be considered.[32,33] At this time, there is no evidence that COVID-19 can be transmitted through blood products.[34,35]

## Febrile Neutropenia

Cancer patients with febrile neutropenia should undergo molecular diagnostic testing for SARS-CoV-2 and evaluation for other infectious agents; they should also be given empiric antibiotics, as outlined in the NCCN Guidelines.[36] Low-risk febrile neutropenia patients should be treated at home with oral antibiotics or intravenous infusions of antibiotics to limit nosocomial exposure to SARS-CoV-2. Patients with high-risk febrile neutropenia should be hospitalized per standard of care.[36] Empiric antibiotics should be continued per standard of care in patients who test positive for SARS-CoV-2. Clinicians should also continuously evaluate neutropenic patients for emergent infections.

## Treating COVID-19 and Managing Chemotherapy in Patients With Cancer and COVID-19

Retrospective studies suggest that patients with cancer who were admitted to the hospital with SARS-CoV-2 infection have a high case-fatality rate, with higher rates observed in patients with hematologic malignancies than in those with solid tumors.[37,38]

Recommendations for the treatment of COVID-19 are the same for cancer patients as for the general population **(AIII)**. See Antiviral Drugs That Are Approved or Under Evaluation for the Treatment of COVID-19 and Immunomodulators Under Evaluation for the Treatment of COVID-19 for more information. Dexamethasone treatment has been associated with a lower mortality rate in patients with COVID-19 who require supplemental oxygen or invasive mechanical ventilation.[39] In cancer patients, dexamethasone is commonly used to prevent chemotherapy-induced nausea, as a part of tumor-directed therapy, and to treat inflammation associated with brain metastasis. The side effects of dexamethasone are expected to be the same in patients with cancer as in those without cancer. If possible, treatments that are not currently recommended for SARS-CoV-2 infection should be administered as part of a clinical trial, since the safety and efficacy of these agents have not been well-defined in patients with cancer.

The NCCN recommends discontinuing G-CSF and granulocyte-macrophage colony-stimulating factor in patients with cancer and acute SARS-CoV-2 infection who do not have bacterial or fungal infections to avoid the hypothetical risk of increasing inflammatory cytokine levels and pulmonary inflammation.[27,40] Secondary infections (e.g., invasive pulmonary aspergillosis) have been reported in critically ill patients with COVID-19.[41,42]

Decisions about administering cancer-directed therapy to patients with acute COVID-19 and those who are recovering from COVID-19 should be made on a case-by-case basis; clinicians should consider the indication for chemotherapy, the goals of care, and the patient's history of tolerance to the treatment **(BIII)**. The optimal duration of time between resolution of infection and initiating or restarting cancer-directed therapy is unclear. Withholding treatment until COVID-19 symptoms have resolved is recommended, if possible. Prolonged viral shedding (detection of SARS-CoV-2 by molecular testing) may occur in cancer patients,[2] although it is unknown how this relates to infectious virus and how it

impacts outcomes. Therefore, there is no role for repeat testing in those recovering from COVID-19, and the decision to restart cancer treatments in this setting should be made on a case-by-case basis. The Panel recommends that clinicians who are treating COVID-19 in patients with cancer consult a hematologist or oncologist before adjusting cancer-directed medications **(AIII)**.

## Medication Interactions

The use of antiviral or immune-based therapies to treat COVID-19 can present additional challenges in cancer patients. Clinicians should pay careful attention to potential drug-drug interactions and overlapping toxicities between drugs that are used to treat COVID-19 and cancer-directed therapies, prophylactic antimicrobials, corticosteroids, and other medications **(AIII)**.

Several antineoplastic medications have known interactions with therapies that are being investigated for COVID-19.[32] For example, tocilizumab can interact with vincristine and doxorubicin. Any COVID-19 therapy that may cause QT prolongation must be used with caution in patients who are being treated with venetoclax, gilteritinib, or tyrosine kinase inhibitor therapy (e.g., nilotinib). Dexamethasone is commonly used as an antiemetic for cancer patients and is recommended for the treatment of certain patients with COVID-19 (see Therapeutic Management of Hospitalized Adults With COVID-19). Dexamethasone is a weak to moderate cytochrome P450 (CYP) 3A4 inducer; therefore, interactions with any CYP3A4 substrates need to be considered. Lopinavir/ritonavir is a CYP3A4 inhibitor, and it can increase methotrexate, vincristine, or ruxolitinib concentrations. Lopinavir/ritonavir **is not recommended** for the treatment of COVID-19; however, patients may receive it in a clinical trial. In general, concomitant use of lopinavir/ritonavir and CYP3A4 substrates should be avoided. If lopinavir/ritonavir is used in combination with a cytotoxic drug that is also a CYP3A4 substrate, clinicians should monitor for toxicities of the cytotoxic drug and adjust the dose if necessary.

## Special Considerations in Children

Preliminary published reports suggest that pediatric patients with cancer may have milder manifestations of COVID-19 than adult patients with cancer, although larger studies are needed.[43-45] Guidance on managing children with cancer during the COVID-19 pandemic is available from an international group with input from the International Society of Paediatric Oncology, the Children's Oncology Group, St. Jude Global, and Childhood Cancer International.[46] Two publications include guidance for managing specific malignancies, guidance for supportive care, and a summary of web links from expert groups that are relevant to the care of pediatric oncology patients during the COVID-19 pandemic.[46,47] Special considerations for using antivirals in immunocompromised children, including those with malignancy, are available in a multicenter guidance statement.[48]

## References


1. Dai M, Liu D, Liu M, et al. Patients with cancer appear more vulnerable to SARS-CoV-2: a multicenter study during the COVID-19 outbreak. *Cancer Discov*. 2020;10(6):783-791. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32345594.
2. Shah V, Ko Ko T, Zuckerman M, et al. Poor outcome and prolonged persistence of SARS-CoV-2 RNA in COVID-19 patients with haematological malignancies; King's College Hospital experience. *Br J Haematol*. 2020;190(5):e279-282. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32526039.
3. Yang K, Sheng Y, Huang C, et al. Clinical characteristics, outcomes, and risk factors for mortality in patients with cancer and COVID-19 in Hubei, China: a multicentre, retrospective, cohort study. *Lancet Oncol*. 2020;21(7):904-913. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32479787.
4. Robilotti EV, Babady NE, Mead PA, et al. Determinants of COVID-19 disease severity in patients with cancer. *Nat Med*. 2020;26(8):1218-1223. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32581323.

5. Giannakoulis VG, Papoutsi E, Siempos II. Effect of cancer on clinical outcomes of patients with COVID-19: a meta-analysis of patient data. *JCO Glob Oncol*. 2020;6:799-808. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32511066.
6. Kuderer NM, Choueiri TK, Shah DP, et al. Clinical impact of COVID-19 on patients with cancer (CCC19): a cohort study. *Lancet*. 2020;395(10241):1907-1918. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32473681.
7. Centers for Disease Control and Prevention. COVID-19 ACIP vaccine recommendations. Available at: https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html. Accessed January 6, 2021.
8. Loh M, Baruchel A, Biondi A, et al. COVID-19 and pediatric ALL: frequently asked questions. 2021. Available at: https://www.hematology.org/covid-19/covid-19-and-pediatric-all. Accessed April 15, 2021.
9. Centers for Disease Control and Prevention. Information about COVID-19 vaccines for people with allergies. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/specific-groups/allergies.html. Accessed April 15, 2021.
10. Centers for Disease Control and Prevention. Interim clinical considerations for use of COVID-19 vaccines currently authorized in the United States. Available at: https://www.cdc.gov/vaccines/covid-19/info-by-product/clinical-considerations.html#Contraindications. Accessed April 15, 2021.
11. Auletta J, Chemaly R, Khawaja F, et al. General principles of COVID-19 vaccines for immunocompromised patients. 2021. Available at: https://www.hematology.org/covid-19/ash-astct-covid-19-and-vaccines. Accessed April 15, 2021.
12. Khawaja F, Chemaly R, Dadwal S, et al. ASH-ASTCT COVID-19 vaccination for HCT and CAR T cell recipients: frequently asked questions. 2021. Available at: https://www.hematology.org/covid-19/ash-astct-covid-19-vaccination-for-hct-and-car-t-cell-recipients. Accessed April 15, 2021.
13. National Comprehensive Cancer Network. COVID-19 vaccination guide V2.0. 2021. Available at: https://www.nccn.org/covid-19.
14. Lo W, Whimbey E, Elting L, Couch R, Cabanillas F, Bodey G. Antibody response to a two-dose influenza vaccine regimen in adult lymphoma patients on chemotherapy. *Eur J Clin Microbiol Infect Dis*. 1993;12(10):778-782. Available at: https://www.ncbi.nlm.nih.gov/pubmed/8307050.
15. Wumkes ML, van der Velden AM, Los M, et al. Serum antibody response to influenza virus vaccination during chemotherapy treatment in adult patients with solid tumours. *Vaccine*. 2013;31(52):6177-6184. Available at: https://www.ncbi.nlm.nih.gov/pubmed/24176495.
16. Yarza R, Bover M, Paredes D, et al. SARS-CoV-2 infection in cancer patients undergoing active treatment: analysis of clinical features and predictive factors for severe respiratory failure and death. *Eur J Cancer*. 2020;135:242-250. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32586724.
17. American Society of Clinical Oncology. ASCO pecial report: a guide to cancer care delivery during the COVID-19 pandemic. 2020. Available at: https://www.asco.org/sites/new-www.asco.org/files/content-files/2020-ASCO-Guide-Cancer-COVID19.pdf.
18. American Society of Anesthesiologists. The ASA and APSF joint statement on perioperative testing for the COVID-19 virus. 2020. Available at: https://www.asahq.org/about-asa/newsroom/news-releases/2020/06/asa-and-apsf-joint-statement-on-perioperative-testing-for-the-covid-19-virus. Accessed April 15, 2021.
19. Centers for Disease Control and Prevention. Framework for healthcare systems providing non-COVID-19 clinical care during the COVID-19 pandemic. 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/framework-non-COVID-care.html. Accessed April 15, 2021.
20. Wang X, Zhou Q, He Y, et al. Nosocomial outbreak of COVID-19 pneumonia in Wuhan, China. *Eur Respir J*. 2020;55(6). Available at: https://www.ncbi.nlm.nih.gov/pubmed/32366488.
21. Luong-Nguyen M, Hermand H, Abdalla S, et al. Nosocomial infection with SARS-CoV-2 within departments of digestive surgery. *J Visc Surg*. 2020;157(3S1):S13-S18. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32381426.

22. Rivett L, Sridhar S, Sparkes D, et al. Screening of healthcare workers for SARS-CoV-2 highlights the role of asymptomatic carriage in COVID-19 transmission. *Elife*. 2020;9. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32392129.

23. Centers for Disease Control and Prevention. How to protect yourself and others. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html. Accessed April 15, 2021.

24. American Society for Radiation Oncology. COVID-19 clinical guidance. 2020. Available at: https://www.astro.org/Daily-Practice/COVID-19-Recommendations-and-Information/Clinical-Guidance. Accessed April 15, 2021.

25. 25. Yahalom J, Dabaja BS, Ricardi U, et al. ILROG emergency guidelines for radiation therapy of hematological malignancies during the COVID-19 pandemic. *Blood*. 2020;135(21):1829-1832. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32275740.

26. Advani R, Bartlett N, LaCasce A, et al. COVID-19 and hodgkin lymphoma: frequently asked questions. 2020. Available at: https://www.hematology.org/covid-19/covid-19-and-hodgkin-lymphoma. Accessed April 15, 2021.

27. National Comprehensive Cancer Network. NCCN hematopoietic growth factors: short-term recommendations specific to issues with COVID-19 (SARS-CoV-2). 2020. Available at: https://jnccn.org/view/journals/jnccn/18/1/article-p12.xml. Accessed April 15, 2021.

28. Lee LYW, Cazier JB, Starkey T, et al. COVID-19 mortality in patients with cancer on chemotherapy or other anticancer treatments: a prospective cohort study. *Lancet*. 2020;395(10241):1919-1926. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32473682.

29. Montopoli M, Zumerle S, Vettor R, et al. Androgen-deprivation therapies for prostate cancer and risk of infection by SARS-CoV-2: a population-based study (N = 4532). *Ann Oncol*. 2020;31(8):1040-1045. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32387456.

30. Koskinen M, Carpen O, Honkanen V, et al. Androgen deprivation and SARS-CoV-2 in men with prostate cancer. *Ann Oncol*. 2020;31(10):1417-1418. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32615154.

31. Food and Drug Administration. Coronavirus (COVID-19) update: FDA provides updated guidance to address the urgent need for blood during the pandemic. 2020. Available at: https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-provides-updated-guidance-address-urgent-need-blood-during-pandemic. Accessed April 15, 2020.

32. American Society of Hematology. COVID-19 resources. Available at: https://www.hematology.org/covid-19. Accessed April 15, 2020.

33. American Society of Clinical Oncology. Cancer treatment and supportive care. 2021. Available at: https://www.asco.org/asco-coronavirus-resources/care-individuals-cancer-during-covid-19/cancer-treatment-supportive-care. Accessed April 15, 2021.

34. Food and Drug Administration. COVID-19 frequently asked questions. 2020. Available at: https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-frequently-asked-questions. Accessed April 15, 2021.

35. Centers for Disease Control and Prevention. Clinical questions about COVID-19: questions and answers. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/faq.html#Transmission. Accessed April 15, 2021.

36. National Comprehensive Cancer Network. Infectious disease management and considerations in cancer patients with documented or suspected COVID-19. 2020. Available at: https://www.nccn.org/docs/default-source/covid-19/2021-covid-infectious-disease-management.pdf?sfvrsn=63f70c30_7. Accessed August 3, 2020.

37. Mehta V, Goel S, Kabarriti R, et al. Case fatality rate of cancer patients with COVID-19 in a New York hospital system. *Cancer Discov*. 2020;10(7):935-941. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32357994.

38. Meng Y, Lu W, Guo E, et al. Cancer history is an independent risk factor for mortality in hospitalized COVID-19 patients: a propensity score-matched analysis. *J Hematol Oncol*. 2020;13(1):75. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32522278.

39. RECOVERY Collaborative Group, Horby P, Lim WS, et al. Dexamethasone in hospitalized patients with COVID-19. *N Engl J Med*. 2021;384(8):693-704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32678530.

40. Nawar T, Morjaria S, Kaltsas A, et al. Granulocyte-colony stimulating factor in COVID-19: is it stimulating more than just the bone marrow? *Am J Hematol*. 2020;95(8):E210-E213. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32419212.

41. van Arkel ALE, Rijpstra TA, Belderbos HNA, van Wijngaarden P, Verweij PE, Bentvelsen RG. COVID-19-associated pulmonary aspergillosis. *Am J Respir Crit Care Med*. 2020;202(1):132-135. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32396381.

42. Alanio A, Delliere S, Fodil S, Bretagne S, Megarbane B. Prevalence of putative invasive pulmonary aspergillosis in critically ill patients with COVID-19. *Lancet Respir Med*. 2020;8(6):e48-e49. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32445626.

43. Hrusak O, Kalina T, Wolf J, et al. Flash survey on severe acute respiratory syndrome coronavirus-2 infections in paediatric patients on anticancer treatment. *Eur J Cancer*. 2020;132:11-16. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32305831.

44. Andre N, Rouger-Gaudichon J, Brethon B, et al. COVID-19 in pediatric oncology from French pediatric oncology and hematology centers: high risk of severe forms? *Pediatr Blood Cancer*. 2020;67(7):e28392. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32383827.

45. de Rojas T, Perez-Martinez A, Cela E, et al. COVID-19 infection in children and adolescents with cancer in Madrid. *Pediatr Blood Cancer*. 2020;67(7):e28397. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32383819.

46. Sullivan M, Bouffet E, Rodriguez-Galindo C, et al. The COVID-19 pandemic: a rapid global response for children with cancer from SIOP, COG, SIOP-E, SIOP-PODC, IPSO, PROS, CCI, and St. Jude Global. *Pediatr Blood Cancer*. 2020;67(7):e28409. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32400924.

47. Bouffet E, Challinor J, Sullivan M, Biondi A, Rodriguez-Galindo C, Pritchard-Jones K. Early advice on managing children with cancer during the COVID-19 pandemic and a call for sharing experiences. *Pediatr Blood Cancer*. 2020;67(7):e28327. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32239747.

48. Chiotos K, Hayes M, Kimberlin DW, et al. Multicenter initial guidance on use of antivirals for children with coronavirus disease 2019/Severe Acute Respiratory Syndrome Coronavirus 2. *J Pediatric Infect Dis Soc*. 2020;9(6):701-715. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32318706.

# Special Considerations in Solid Organ Transplant, Hematopoietic Stem Cell Transplant, and Cellular Therapy Candidates, Donors, and Recipients

*Last Updated: April 21, 2021*

| Summary Recommendations |
|---|
| **Vaccination for SARS-CoV-2**<br>• Given the effectiveness of SARS-CoV-2 vaccines in the general population and the increased risk of worse clinical outcomes of COVID-19 in transplant and cellular therapy recipients, the COVID-19 Treatment Guidelines Panel (the Panel) recommends SARS-CoV-2 vaccination for potential transplant and cellular therapy candidates, potential donors, and recipients **(AIII)**. See the text below for information on the appropriate timing for SARS-CoV-2 vaccination in these patients.<br>**Potential Transplant and Cellular Therapy Candidates**<br>• The Panel recommends diagnostic molecular testing for SARS-CoV-2 for all potential solid organ transplant (SOT), hematopoietic cell transplant (HCT), and cell therapy candidates with signs and symptoms that suggest acute COVID-19 infection **(AIII)**.<br>• The Panel recommends following the guidance from medical professional organizations that specialize in providing care for SOT, HCT, or cell therapy recipients when performing diagnostic molecular testing for SARS-CoV-2 in these patients **(AIII)**.<br>• If SARS-CoV-2 is detected or if infection is strongly suspected, transplantation should be deferred, if possible **(BIII)**.<br>**Potential Transplant Donors**<br>• The Panel recommends assessing all potential SOT and HCT donors for signs and symptoms that are associated with COVID-19 according to guidance from medical professional organizations **(AIII)**.<br>  • The Panel recommends performing diagnostic molecular testing for SARS-CoV-2 if symptoms are present **(AIII)**.<br>  • If SARS-CoV-2 is detected or if infection is strongly suspected, donation should be deferred **(BIII)**.<br>**Transplant and Cellular Therapy Recipients With COVID-19**<br>• Clinicians should follow the guidelines for evaluating and managing COVID-19 in nontransplant patients when treating transplant and cellular therapy recipients **(AIII)**. See Therapeutic Management of Nonhospitalized Adults With COVID-19 and Therapeutic Management of Hospitalized Adults With COVID-19 for more information.<br>• The Panel recommends that clinicians who are treating COVID-19 in transplant and cellular therapy patients consult with a transplant specialist before adjusting immunosuppressive medications **(AIII)**.<br>• When treating COVID-19, clinicians should pay careful attention to potential drug-drug interactions and overlapping toxicities with immunosuppressants, prophylactic antimicrobials, and other medications **(AIII)**. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Introduction

Treating COVID-19 in solid organ transplant (SOT), hematopoietic cell transplant (HCT), and cellular immunotherapy recipients can be challenging due to the presence of coexisting medical conditions, transplant-related cytopenias, and the need for chronic immunosuppressive therapy to prevent graft rejection and graft-versus-host disease. Transplant recipients may also potentially have increased exposure to SARS-CoV-2 given their frequent contact with the health care system. Since immunosuppressive agents modulate several aspects of the host's immune response, the severity of COVID-19 could potentially be affected by the type and the intensity of the immunosuppressive

effect of the agent, as well as by specific combinations of immunosuppressive agents. Some transplant recipients have medical comorbidities that have been associated with more severe cases of COVID-19 and a greater risk of mortality, which makes the attributable impact of transplantation on disease severity difficult to assess.

The American Association for the Study of Liver Diseases (AASLD),[1] the International Society for Heart and Lung Transplantation, the American Society of Transplantation, the American Society for Transplantation and Cellular Therapy (ASTCT), the European Society for Blood and Marrow Transplantation (EBMT), and the Association of Organ Procurement Organizations provide guidance for clinicians who are caring for transplant recipients with COVID-19, as well as guidance for screening potential donors and transplant or cell therapy candidates. This section of the COVID-19 Treatment Guidelines complements these sources and focuses on considerations for managing COVID-19 in SOT, HCT, and cellular therapy recipients. The optimal management and therapeutic approach to COVID-19 in these populations is unknown. At this time, the procedures for evaluating and managing COVID-19 in transplant recipients are the same as those for nontransplant patients **(AIII)**. See Therapeutic Management of Nonhospitalized Adults With COVID-19 and Therapeutic Management of Hospitalized Adults With COVID-19 for more information. The medications that are used to treat COVID-19 may present different risks and benefits to transplant patients and nontransplant patients.

## Vaccination for SARS-CoV-2 in Solid Organ Transplant, Hematopoietic Stem Cell Transplant, and Cellular Therapy Candidates, Donors, and Recipients

The clinical trials that have evaluated the SARS-CoV-2 vaccines that have received Emergency Use Authorizations from the Food and Drug Administration have excluded severely immunocompromised patients.[2-4] The Advisory Committee on Immunization Practices notes that the currently authorized COVID-19 vaccines are not live vaccines; therefore, they can be safely administered to immunocompromised people.[5] The efficacy rates for the available vaccines may be lower in immunocompromised patients than in the general population, and the relative efficacy of the different vaccines for transplant candidates or recipients is currently unknown. Given the effectiveness of SARS-CoV-2 vaccines in the general population and the increased risk of worse clinical outcomes of COVID-19 in transplant and cellular therapy recipients, the COVID-19 Treatment Guidelines Panel (the Panel) recommends SARS-CoV-2 vaccination for potential transplant and cellular therapy candidates, potential donors, and recipients **(AIII)**.

When determining the timing of SARS-CoV-2 vaccination in SOT, HCT, and cell therapy recipients, clinicians should consider the following factors:

- Ideally, SOT candidates should receive SARS-CoV-2 vaccines while they are awaiting transplant.
- In general, vaccination should be completed at least 2 weeks prior to SOT or started 1 month after SOT.
- In certain situations, it may be appropriate to delay vaccination until 3 months after SOT, such as when T cell or B cell ablative therapy (with antithymocyte globulin or rituximab) is used at the time of transplant.[6]
- At this time, reducing the dose of immunosuppressants and holding immunosuppressants prior to SARS-CoV-2 vaccination **are not recommended**.
- SARS-CoV-2 vaccines can be offered as early as 3 months after a patient receives HCT or chimeric antigen receptor T cell (CAR-T) therapy, although the efficacy of the vaccines may be reduced compared to the efficacy observed in the general population.[7,8] Patients who are scheduled to receive cytotoxic or B cell–depleting therapies should complete their SARS-CoV-2 vaccination

prior to initiation or between cycles of cytotoxic or B cell–depleting therapies if possible.

- After completing SARS-CoV-2 vaccination, immunocompromised persons should be advised to continue to exercise precautions to reduce their risk of SARS-CoV-2 exposure and infection (e.g., they should continue wearing a mask, maintain a distance of 6 feet from others, and avoid crowds and poorly ventilated spaces).[9]

It is unknown whether the immune responses to SARS-CoV-2 vaccination can increase the risk of graft-versus-host disease or other immune-related complications. Outside of a clinical study, antibody testing **is not recommended** to assess immunity to SARS-CoV-2 following COVID-19 vaccination in transplant patients. For people who received COVID-19 vaccines during treatment with immunosuppressive drugs, revaccination after they regain immune competence is currently not recommended.

Vaccination of household members, close contacts, and health care providers who provide care for immunocompromised patients is imperative to protect immunocompromised patients from infection. All close contacts are strongly encouraged to get vaccinated as soon as possible.

## Assessment of SARS-CoV-2 Infection in Transplant and Cellular Therapy Candidates and Donors

The risk of transmission of SARS-CoV-2 from donors to candidates is unknown. The probability that a donor or candidate may have SARS-CoV-2 infection can be estimated by considering the epidemiologic risk, obtaining a clinical history, and testing with molecular techniques. No current testing strategy is sensitive enough or specific enough to totally exclude active infection. Living solid organ donors should be counseled on strategies to prevent infection and monitored for exposures and symptoms in the 14 days prior to a scheduled transplant.[10] HCT donors should practice good hygiene and avoid crowded places and large group gatherings during the 28 days prior to donation.[11]

### *Assessment of Transplant and Cellular Therapy Candidates*

Diagnostic molecular testing for SARS-CoV-2 is recommended for all potential SOT candidates with signs and symptoms that suggest acute COVID-19 infection **(AIII)**. All potential SOT candidates should be assessed for exposure to COVID-19 and clinical symptoms that are compatible with COVID-19 before they are called in for transplantation and should undergo diagnostic molecular testing for SARS-CoV-2 shortly before SOT in accordance with guidance from medical professional organizations **(AIII)**.

Clinicians should consider performing diagnostic testing for SARS-CoV-2 in all HCT and cellular therapy candidates who exhibit symptoms. All candidates should also undergo diagnostic molecular testing for SARS-CoV-2 shortly before HCT or cell therapy **(AIII)**.

### *Assessment of Donors*

The Panel recommends following the guidance from medical professional organizations and assessing all potential HCT donors for exposure to COVID-19 and clinical symptoms that are compatible with COVID-19 before donation **(AIII)**. Deceased donors should undergo screening for known symptoms and exposure to others with COVID-19 before transplantation, and decisions about using such organs should be made on a case-by-case basis **(BIII)**. Recommendations for screening are outlined in the ASTCT and EBMT guidelines.

### *If SARS-CoV-2 Infection Is Detected or Is Strongly Suspected*

If SARS-CoV-2 is detected or if infection is strongly suspected in a potential SOT donor or candidate, transplant should be deferred, if possible **(BIII)**. The optimal disease-free interval before transplantation

is not known. The risks of viral transmission should be balanced against the risks to the candidate, such as progression of the underlying disease and risk of mortality if the candidate does not receive the transplant. This decision should be continually reassessed as conditions evolve. For HCT and cellular therapy candidates, current guidelines recommend deferring transplants or immunotherapy procedures, including peripheral blood stem cell mobilization, bone marrow harvest, T cell collection, and conditioning/lymphodepletion in recipients who test positive for SARS-CoV-2 or who have clinical symptoms that are consistent with infection. Final decisions should be made on a case-by-case basis while weighing the risks of delaying or altering therapy for the underlying disease.

## Transplant Recipients With COVID-19

SOT recipients who are receiving immunosuppressive therapy should be considered to be at increased risk for severe COVID-19.[1,12] A national survey of 88 U.S. transplant centers conducted between March 24 and 31, 2020, reported that 148 SOT recipients received a diagnosis of COVID-19 infection (69.6% were kidney recipients, 15.5% were liver recipients, 8.8% were heart recipients, and 6.1% were lung recipients).[13] COVID-19 was mild in 54% of recipients and moderate in 21% of recipients, and 25% of recipients were critically ill. Modification of immunosuppressive therapy during COVID-19 and the use of investigational therapies for treatment of COVID-19 varied widely among recipients. Initial reports of transplant recipients who were hospitalized with COVID-19 suggest mortality rates of up to 28%.[14-18]

### *Risk of Graft Rejection*

There have been no published reports of graft rejection in SOT recipients who received a diagnosis of COVID-19, although this may be due to a limited ability to perform biopsies. Acute cellular rejection should not be presumed in SOT recipients without biopsy confirmation, regardless of whether the individual has COVID-19. Similarly, immunosuppressive therapy should be initiated in recipients with or without COVID-19 who have rejection confirmed by a biopsy.[1]

There are limited data on the incidence and clinical characteristics of SARS-CoV-2 infection in HCT and cellular therapy recipients. Recent data from the Center for International Blood and Marrow Transplant Research demonstrated a mortality rate of approximately 30% within a month of COVID-19 diagnosis among a cohort of 318 HCT recipients.[19] This mortality rate was observed in both allogeneic and autologous recipients. Older age (≥50 years), male sex, and receipt of a COVID-19 diagnosis within 12 months of transplantation were associated with a higher risk of mortality among allogeneic recipients. In autologous recipients, patients with lymphoma had a higher risk of mortality than patients who had plasma cell disorder or myeloma.

A smaller study demonstrated a slightly lower mortality rate among HCT and cellular therapy recipients than earlier reports. This study found that the number of comorbidities, the presence of infiltrates on initial chest imaging, and neutropenia were predictors for increased disease severity.[20] Additional factors that have been used to determine the clinical severity of other respiratory viral infections include the degree of cytopenia, the intensity of the conditioning regimen, the graft source, the degree of mismatch, and the need for further immunosuppression to manage graft-versus-host disease. Prolonged viral shedding has been described in SOT and HCT recipients; this can have implications for infection prevention and for the timing of potential therapeutic interventions.[21]

## Treatment of COVID-19 in Transplant Recipients

Currently, the antiviral agent remdesivir is the only drug that is approved by the Food and Drug Administration (FDA) for the treatment of COVID-19. Outpatient transplant recipients who are immunosuppressed or who have certain underlying comorbidities are candidates for the anti-SARS-CoV-2 monoclonal antibodies that are available through Emergency Use Authorizations (see

Anti-SARS-CoV-2 Monoclonal Antibodies). Transplant recipients who are hospitalized with mild to moderate COVID-19 may be considered for anti-SARS-CoV-2 monoclonal antibodies that are available through expanded access programs.

Data from a large randomized controlled trial found that a short course of dexamethasone (6 mg once daily for up to 10 days) improved survival in hospitalized patients with COVID-19 who were mechanically ventilated or who required supplemental oxygen.[22] Tocilizumab used in combination with dexamethasone is recommended for some patients with severe or critical COVID-19 who exhibit rapid respiratory decompensation (see Interleukin-6 Inhibitors).[23,24] The risks and benefits of using both dexamethasone and tocilizumab in transplant recipients with COVID-19 who are receiving immunosuppressive therapy are unknown. Because both dexamethasone and tocilizumab are immunosuppressive agents, patients who receive this combination should be closely monitored for secondary infections.

The Panel's recommendations for the use of remdesivir, dexamethasone, and tocilizumab in patients with COVID-19 can be found in Therapeutic Management of Hospitalized Adults With COVID-19.

A number of other investigational agents and drugs that are approved by the FDA for other indications are being evaluated for the treatment of COVID-19 (e.g., antiviral therapies, COVID-19 convalescent plasma) and its associated complications (e.g., immunomodulators, antithrombotic agents). In general, the considerations for treating COVID-19 are the same for transplant recipients as for the general population. When possible, treatment should be given as part of a clinical trial. The safety and efficacy of investigational agents and drugs that have been approved by the FDA for other indications are not well-defined in transplant recipients. Moreover, it is unknown whether concomitant use of immunosuppressive agents to prevent allograft rejection in the setting of COVID-19 affects treatment outcome.

Clinicians should pay special attention to the potential for drug-drug interactions and overlapping toxicities with concomitant medications, such as immunosuppressants that are used to prevent allograft rejection (e.g., corticosteroids, mycophenolate, and calcineurin inhibitors such as tacrolimus and cyclosporine), antimicrobials that are used to prevent opportunistic infections, and other medications. Dose modifications may be necessary for drugs that are used to treat COVID-19 in transplant recipients with pre-existing organ dysfunction. Adjustments to the immunosuppressive regimen should be individualized based on disease severity, the specific immunosuppressants used, the type of transplant, the time since transplantation, the drug concentration, and the risk of graft rejection.[15] Clinicians who are treating COVID-19 in transplant patients should consult a transplant specialist before adjusting immunosuppressive medication **(AIII)**.

Certain therapeutics (e.g., remdesivir, tocilizumab) are associated with elevated levels of transaminases. For liver transplant recipients, the AASLD does not consider abnormal liver biochemistries a contraindication to using remdesivir.[25] Close monitoring of liver biochemistries is warranted in patients with COVID-19, especially when they are receiving agents with a known risk of hepatotoxicity.

Calcineurin inhibitors, which are commonly used to prevent allograft rejection, have a narrow therapeutic index. Medications that inhibit or induce cytochrome P450 (CYP) enzymes or P-glycoprotein may put patients who receive calcineurin inhibitors at risk of clinically significant drug-drug interactions, increasing the need for therapeutic drug monitoring and the need to assess for signs of toxicity or rejection.[26] Among the drugs that are commonly used to treat COVID-19, dexamethasone is a moderate inducer of CYP3A4, and interleukin-6 inhibitors may lead to increased metabolism of CYP substrates. Close monitoring of serum concentration of calcineurin inhibitors should be considered when these drugs are used.

Additional details about the adverse effects and drug interactions of antiviral medications and immune-based therapy for COVID-19 are noted in Tables 2e, 3c, and 4e.

## References


1. Fix OK, Hameed B, Fontana RJ, et al. Clinical best practice advice for hepatology and liver transplant providers during the COVID-19 pandemic: AASLD expert panel consensus statement. *Hepatology*. 2020;72(1):287-304. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32298473.
2. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. *N Engl J Med*. 2020;384(5):403-416. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33378609.
3. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA COVID-19 vaccine. *N Engl J Med*. 2020;383(27):2603-2615. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33301246.
4. Food and Drug Administration. Vaccines and related biological products advisory committee meeting. 2021. Available at: https://www.fda.gov/media/146217/download. Accessed March 26, 2021.
5. Centers for Disease Control and Prevention. COVID-19 ACIP vaccine recommendations. 2020. Available at: https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html. Accessed January 6, 2021.
6. American Society of Transplantation. COVID-19 vaccine FAQ sheet. 2021. Available at: https://www.myast.org/sites/default/files/2021%2003%2018%20COVID19%20VACCINE%20FAQS_update.pdf. Accessed April 8, 2021.
7. Khawaja F, Chemaly R, Dadwal S, et al. ASH-ASTCT COVID-19 vaccination for HCT and CAR T cell recipients: frequently asked questions. 2021. Available at: https://www.hematology.org/covid-19/ash-astct-covid-19-vaccination-for-hct-and-car-t-cell-recipients. Accessed April 8, 2021.
8. Ljungman P, Avetisyan G. Influenza vaccination in hematopoietic SCT recipients. *Bone Marrow Transplant*. 2008;42(10):637-641. Available at: https://www.ncbi.nlm.nih.gov/pubmed/18724396.
9. Centers for Disease Control and Prevention. When you've been fully vaccinated: how to protect yourself and others. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/fully-vaccinated.html. Accessed April 8, 2021.
10. American Society of Transplantation. COVID-19 resources for transplant community. 2020. Available at: https://www.myast.org/covid-19-information. Accessed June 26, 2020.
11. American Society for Transplantation and Cellular Therapy. ASTCT interim patient guidelines April 20, 2020. 2020. Available at: https://www.astct.org/viewdocument/astct-interim-patient-guidelines-ap?CommunityKey=d3949d84-3440-45f4-8142-90ea05adb0e5&tab=librarydocuments. Accessed July 2, 2020.
12. Centers for Disease Control and Prevention. People with certain medical conditions. 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/groups-at-higher-risk.html. Accessed April 20, 2021.
13. Boyarsky BJ, Po-Yu Chiang T, Werbel WA, et al. Early impact of COVID-19 on transplant center practices and policies in the United States. *Am J Transplant*. 2020;20(7):1809-1818. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32282982.
14. Akalin E, Azzi Y, Bartash R, et al. COVID-19 and kidney transplantation. *N Engl J Med*. 2020;382(25):2475-2477. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32329975.
15. Pereira MR, Mohan S, Cohen DJ, et al. COVID-19 in solid organ transplant recipients: initial report from the US epicenter. *Am J Transplant*. 2020;20(7):1800-1808. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32330343.
16. Alberici F, Delbarba E, Manenti C, et al. A single center observational study of the clinical characteristics and short-term outcome of 20 kidney transplant patients admitted for SARS-CoV2 pneumonia. *Kidney Int*. 2020;97(6):1083-1088. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32354634.

17. Montagud-Marrahi E, Cofan F, Torregrosa JV, et al. Preliminary data on outcomes of SARS-CoV-2 infection in a Spanish single center cohort of kidney recipients. *Am J Transplant*. 2020;20(10):2958-2959. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32368838.

18. Kates OS, Haydel BM, Florman SS, et al. COVID-19 in solid organ transplant: a multi-center cohort study. *Clin Infect Dis*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32766815.

19. Sharma A, Bhatt NS, St. Martin A, et al. Clinical characteristics and outcomes of COVID-19 in haematopoietic stem-cell transplantation recipients: an observational cohort study. *Lancet Haematol*. 2021;8(3):e185-e193. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33482113.

20. Shah GL, DeWolf S, Lee YJ, et al. Favorable outcomes of COVID-19 in recipients of hematopoietic cell transplantation. *J Clin Invest*. 2020;130(12):6656-6667. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32897885.

21. Aydillo T, Gonzalez-Reiche AS, Aslam S, et al. Shedding of viable SARS-CoV-2 after immunosuppressive therapy for cancer. *N Engl J Med*. 2020;383(26):2586-2588. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33259154.

22. Horby P, Lim WS, Emberson JR, et al. Dexamethasone in hospitalized patients with COVID-19. *N Engl J Med*. 2021;384(8):693-704. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32678530.

23. Horby PW, Pessoa-Amorim G, Peto L, et al. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): preliminary results of a randomised, controlled, open-label, platform trial. *medRxiv*. 2021;preprint. Available at: https://www.medrxiv.org/content/10.1101/2021.02.11.21249258v1.

24. Gordon AC, Mouncey PR, Al-Beidh F, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19. *N Engl J Med*. 2021. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33631065.

25. American Association for the Study of Liver Diseases. Clinical best practice advice for hepatology and liver transplant providers during the COVID-19 pandemic: AASLD expert panel consensus statement. 2021. Available at: https://www.aasld.org/sites/default/files/2021-03/AASLD-COVID19-ExpertPanelConsensusStatement-March92021.pdf. Accessed April 12, 2021.

26. Elens L, Langman LJ, Hesselink DA, et al. Pharmacologic treatment of transplant recipients infected with SARS-CoV-2: considerations regarding therapeutic drug monitoring and drug-drug interactions. *Ther Drug Monit*. 2020;42(3):360-368. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32304488.

# Special Considerations in People With HIV

*Last Updated: April 21, 2021*

| Summary Recommendations |
|---|
| **Prevention of COVID-19**<br>• The COVID-19 Treatment Guidelines Panel (the Panel) recommends that people with HIV receive SARS-CoV-2 vaccines regardless of their CD4 T lymphocyte cell count or HIV viral load, because the potential benefits outweigh the potential risks **(AIII)**.<br>**Diagnosis of COVID-19**<br>• The Panel recommends using the same approach for diagnosing SARS-CoV-2 infection in people with HIV as in people without HIV **(AIII)**.<br>**Management of COVID-19**<br>• Recommendations for the triage, management, and treatment of COVID-19 in people with HIV are the same as those for the general population **(AIII)**.<br>• In people with advanced HIV and suspected or documented COVID-19, HIV-associated opportunistic infections (OIs) should also be considered in the differential diagnosis of febrile illness **(AIII)**.<br>• When starting treatment for COVID-19 in patients with HIV, clinicians should pay careful attention to potential drug-drug interactions and overlapping toxicities among COVID-19 treatments, antiretroviral (ARV) medications, antimicrobial therapies, and other medications **(AIII)**.<br>• People with HIV should be offered the opportunity to participate in clinical trials of vaccines and potential treatments for SARS-CoV-2 infection.<br>**Management of HIV**<br>• People with HIV who develop COVID-19, including those who require hospitalization, should continue their antiretroviral therapy (ART) and OI prophylaxis whenever possible **(AIII)**.<br>• Clinicians who are treating COVID-19 in people with HIV should consult an HIV specialist before adjusting or switching ARV medications **(AIII)**.<br>• An ARV regimen should not be switched or adjusted (i.e., by adding ARV drugs to the regimen) for the purpose of preventing or treating SARS-CoV-2 infection **(AIII)**.<br>• For people who present with COVID-19 and a new diagnosis of HIV, clinicians should consult an HIV specialist to determine the optimal time to initiate ART. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Introduction

Approximately 1.2 million persons in the United States are living with HIV. Most of these individuals are in care, and many are on antiretroviral therapy (ART) and have well-controlled disease.[1] Similar to COVID-19, HIV disproportionately affects racial and ethnic minorities and persons of lower socioeconomic status in the United States;[2] these demographic groups also appear to have a higher risk for severe outcomes with COVID-19. Information on SARS-CoV-2/HIV coinfection is evolving rapidly. The sections below outline the current state of knowledge regarding the prevention and diagnosis of SARS-CoV-2 infection in people with HIV, treatment and clinical outcomes in people with HIV who develop COVID-19, and management of HIV during the COVID-19 pandemic. In addition to these Guidelines, the Department of Health and Human Services (HHS) Panel on Antiretroviral Guidelines for Adults and Adolescents has developed the Interim Guidance for COVID-19 and Persons with HIV.

## Clinical Outcomes of COVID-19 in People With HIV

Data are emerging on the clinical outcomes of COVID-19 in people with HIV. In a case series of people with COVID-19 in Europe and the United States, no significant differences were observed in the clinical outcomes for COVID-19 between people with HIV and people who did not have HIV.[3-10] For example, the Veterans Aging Cohort Study compared the clinical outcomes for 253 veterans with HIV and COVID-19 and the outcomes for a matched comparator arm of 504 veterans without HIV who developed COVID-19. More than 95% of the participants in this study were male. In this comparison, no differences were found between the outcomes for patients with HIV and those who did not have HIV.[11]

In contrast, worse outcomes for patients with HIV and COVID-19, including increased COVID-19 mortality rates, have been reported by subsequent cohort studies in the United States, the United Kingdom, and South Africa.[12-17] In a multicenter cohort study of 286 patients with HIV and COVID-19 in the United States, lower CD4 T lymphocyte (CD4) cell counts (i.e., <200 cells/mm$^3$) were associated with a higher risk for the composite endpoint of intensive care unit admission, mechanical ventilation, or death. This increased risk was observed even in patients who had achieved virologic suppression of HIV.[15] In another study of 175 patients with HIV and COVID-19, a low CD4 count or a low CD4 nadir was associated with poor outcomes.[16] In a cohort study conducted in New York, people with HIV and COVID-19 had higher rates of hospitalization and mortality than people with COVID-19 who did not have HIV.[17]

## Prevention of COVID-19 in People With HIV

The COVID-19 Treatment Guidelines Panel (the Panel) recommends using the same approach for advising persons with HIV on the strategies to prevent acquisition of SARS-CoV-2 infection that is used for people without HIV **(AIII)**. There is currently no clear evidence that any antiretroviral (ARV) medications can prevent the acquisition of SARS-CoV-2 infection.

People with HIV should receive SARS-CoV-2 vaccines, regardless of their CD4 count or HIV viral load, because the potential benefits outweigh the potential risks **(AIII)**. People with HIV were included in the clinical trials of the two mRNA vaccines and the adenovirus vector vaccine that are currently available through Emergency Use Authorizations (EUAs) from the Food and Drug Administration;[18-20] however, the safety and efficacy of these vaccines in people with HIV have not been reported. Typically, people with HIV who are on antiretroviral therapy (ART) and who have achieved virologic suppression respond well to licensed vaccines. Guidance for using these vaccines, including guidance for people with HIV, is available through the Advisory Committee on Immunization Practices (ACIP). A patient's HIV status should be kept confidential when administering a vaccine.

## Diagnostic and Laboratory Testing for COVID-19 in People With HIV

### *Diagnosis of COVID-19 in People With HIV*

The Panel recommends using the same approach for diagnosing SARS-CoV-2 infection in people with HIV as in those without HIV (see Testing for SARS-CoV-2 Infection) **(AIII)**. There is currently no evidence that the performance characteristics of nucleic acid amplification testing differ in people with and without HIV when diagnosing acute SARS-CoV-2 infection. The Panel **recommends against** the use of serologic testing as the sole basis for diagnosis of acute SARS-CoV-2 infection **(AIII)**. However, if diagnostic serologic testing is performed in a patient with HIV, the results should be interpreted with caution because cross-reactivity between antibodies to SARS-CoV-2 and HIV has been reported.[21]

### *Correlation of CD4 Count in People With HIV and COVID-19*

The normal range for CD4 counts in healthy adults is about 500 to 1,600 cells/mm$^3$. Persons with

HIV who have a CD4 count of ≥500 cells/mm$^3$ have similar cellular immune function to persons without HIV. In people with HIV, a CD4 count <200 cells/mm$^3$ meets the definition for AIDS. For patients on ART, the hallmark of treatment success is plasma HIV RNA below the level of detection by a polymerase chain reaction assay. Lymphopenia is a common laboratory finding in patients with COVID-19; in patients with HIV, clinicians should note that CD4 counts obtained during acute COVID-19 may not accurately reflect the patient's HIV disease stage.

There have been some reports of persons with advanced HIV who have presented with COVID-19 and another coinfection, including *Pneumocystis jirovecii* pneumonia.[22,23] In patients with advanced HIV who have suspected or laboratory-confirmed SARS-CoV-2 infection, clinicians should consider a broader differential diagnosis for clinical symptoms and consider consulting an HIV specialist **(AIII)**.

## Clinical Presentation of COVID-19 in People With HIV

It is currently unknown whether people with HIV have a higher incidence of SARS-CoV-2 infection or a higher rate of progression to symptomatic disease than the general population. Approximately 50% of persons with HIV in the United States are aged >50 years, and many have comorbidities that are associated with more severe illness with COVID-19, including hypertension, diabetes mellitus, cardiovascular disease, tobacco use disorder, chronic lung disease, chronic liver disease, and cancer.[24]

There are a number of case reports and case series that describe the clinical presentation of COVID-19 in persons with HIV.[3-10,25,26] These studies indicate that the clinical presentation of COVID-19 is similar in persons with and without HIV. Most of the published reports describe populations in which most of the individuals with HIV are on ART and have achieved virologic suppression. Consequently, the current understanding of the impact of COVID-19 in persons with advanced HIV who have low CD4 counts or persistent HIV viremia is limited.

## Management of COVID-19 in People With HIV

Recommendations for the triage and management of COVID-19 in people with HIV are the same as those for the general population **(AIII)**.

The treatment of COVID-19 in persons with HIV is the same as that for persons without HIV **(AIII)**. In outpatients, people with HIV who are immunosuppressed or who have certain underlying comorbidities are candidates for the monoclonal antibodies that are available through EUAs.[27-29] In hospitalized patients, the appropriate treatment strategy depends on disease severity (see Therapeutic Management of Hospitalized Adults With COVID-19).

When starting treatment for COVID-19 in patients with HIV, clinicians should pay careful attention to potential drug-drug interactions and overlapping toxicities among COVID-19 treatments, ARV medications, antimicrobial therapies, and other medications **(AIII)**. Both tocilizumab and dexamethasone, which are recommended for some patients with severe or critical COVID-19, are immunosuppressive agents. The safety of using these drugs in immunocompromised patients, including those with advanced HIV, has not been studied. Therefore, patients with advanced HIV who are receiving these drugs should be closely monitored for secondary infections. Dexamethasone is a dose-dependent inducer of cytochrome P450 3A4 and could potentially lower the levels of certain coadministered ARV drugs. More than a single dose of dexamethasone **is not recommended** for patients who are receiving rilpivirine as part of their ARV regimen. Clinicians should consult an HIV specialist before administering dexamethasone to these patients. Whether administering up to 10 days of dexamethasone impacts the clinical efficacy of other ARV drugs is unknown. Patients with HIV who are receiving dexamethasone for COVID-19 should follow up with their HIV providers to assess virologic response.

Although some ARV drugs are being studied for the prevention and treatment of COVID-19, no agents have been shown to be effective.

People with HIV should be offered the opportunity to participate in clinical trials of vaccines and potential treatments for COVID-19. A variety of immunomodulatory therapies are prescribed empirically or administered as part of a clinical trial to treat severe COVID-19. Data about whether these medications are safe to use in patients with HIV are lacking. If a medication has been shown to reduce the mortality of patients with COVID-19 in the general population, it should also be used to treat COVID-19 in patients with HIV, unless data indicate that the medication is not safe or effective in this population.

## Management of HIV in People With SARS-CoV-2/HIV Coinfection

Below are some general considerations regarding the management of HIV in people with SARS-CoV-2/HIV coinfection.

- Whenever possible, ART and opportunistic infection prophylaxis should be continued in a patient with HIV who develops COVID-19, including in those who require hospitalization **(AIII)**. ARV treatment interruption may lead to rebound viremia, and, in some cases, the emergence of drug resistance. If the appropriate ARV drugs are not on the hospital's formulary, administer medications from the patient's home supplies (if available).
- Clinicians who are treating COVID-19 in people with HIV should consult an HIV specialist before adjusting or switching a patient's ARV medications. An ARV regimen should not be switched or adjusted (i.e., by adding ARV drugs to the regimen) for the purpose of preventing or treating SARS-CoV-2 infection **(AIII)**. Many drugs, including some ARV agents (e.g., lopinavir/ritonavir, boosted darunavir, tenofovir disoproxil fumarate/emtricitabine), have been or are being evaluated in clinical trials or are prescribed for off-label use for the treatment or prevention of SARS-CoV-2 infection. To date, lopinavir/ritonavir and darunavir/ritonavir have not been found to be effective (see Lopinavir/Ritonavir and Other HIV Protease Inhibitors).[30,31] Two retrospective studies have suggested that tenofovir disoproxil fumarate/emtricitabine may play a role in preventing SARS-CoV-2 acquisition or hospitalization or death associated with COVID-19; however, the significance of these findings is unclear, as neither study adequately controlled for confounding variables such as age and comorbidities.[12,26]
- For patients who are taking an investigational ARV medication as part of their ARV regimen, arrangements should be made with the investigational study team to continue the medication, if possible.
- For critically ill patients who require tube feeding, some ARV medications are available in liquid formulations, and some ARV pills may be crushed. Clinicians should consult an HIV specialist and/or pharmacist to assess the best way for a patient with a feeding tube to continue an effective ARV regimen. Information may be available in the drug product label or in this document.
- For people who present with COVID-19 and have either a new diagnosis of HIV or a history of HIV but are not taking ART, the optimal time to start or restart ART is currently unknown. For people with HIV who have not initiated ART or who have been off therapy for >2 weeks before presenting with COVID-19, the Panel recommends consulting an HIV specialist regarding initiation or re-initiation of ART as soon as clinically feasible. If ART is started, maintaining treatment and linking patients to HIV care upon hospital discharge is critical. If an HIV specialist is not available, clinical consultation is available by phone through the National Clinical Consultation Center, Monday through Friday, 9 am to 8 pm EST.

## Special Considerations in Children and Pregnant Women With HIV Who Develop COVID-19

Currently, there is limited information about pregnancy and maternal outcomes in women with HIV who have COVID-19 and in children with HIV and COVID-19. Please see the sections in these Guidelines that discuss the management of COVID-19 during pregnancy and in children, and the HHS Interim Guidance for COVID-19 and Persons With HIV.

## References


1. Harris NS, Johnson AS, Huang YA, et al. Vital signs: status of human immunodeficiency virus testing, viral suppression, and HIV preexposure prophylaxis–United States, 2013–2018. *MMWR Morb Mortal Wkly Rep*. 2019;68(48):1117-1123. Available at: https://www.ncbi.nlm.nih.gov/pubmed/31805031.
2. Meyerowitz EA, Kim AY, Ard KL, et al. Disproportionate burden of coronavirus disease 2019 among racial minorities and those in congregate settings among a large cohort of people with HIV. *AIDS.* 2020;34(12):1781-1787. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32604138.
3. Gervasoni C, Meraviglia P, Riva A, et al. Clinical features and outcomes of patients with human immunodeficiency virus with COVID-19. *Clin Infect Dis*. 2020;71(16):2276-2278. Available at: https://pubmed.ncbi.nlm.nih.gov/32407467/.
4. Härter G, Spinner CD, Roider J, et al. COVID-19 in people living with human immunodeficiency virus: a case series of 33 patients. *Infection*. 2020;48(5):681-686. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32394344.
5. Karmen-Tuohy S, Carlucci PM, Zervou FN, et al. Outcomes among HIV-positive patients hospitalized with COVID-19. *J Acquir Immune Defic Syndr*. 2020;85(1):6-10. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32568770.
6. Patel VV, Felsen UR, Fisher M, et al. Clinical outcomes and inflammatory markers by HIV serostatus and viral suppression in a large cohort of patients hospitalized with COVID-19. *J Acquir Immune Defic Syndr*. 2021;86(2):224-230. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33433966.
7. Shalev N, Scherer M, LaSota ED, et al. Clinical characteristics and outcomes in people living with human immunodeficiency virus hospitalized for coronavirus disease 2019. *Clin Infect Dis*. 2020;71(16):2294-2297. Available at: https://pubmed.ncbi.nlm.nih.gov/32472138/.
8. Sigel K, Swartz T, Golden E, et al. Coronavirus 2019 and people living with human immunodeficiency virus: outcomes for hospitalized patients in New York City. *Clin Infect Dis*. 2020;71(11):2933-2938. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32594164.
9. Stoeckle K, Johnston CD, Jannat-Khah DP, et al. COVID-19 in hospitalized adults with HIV. *Open Forum Infect Dis*. 2020;7(8):ofaa327. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32864388.
10. Vizcarra P, Perez-Elias MJ, Quereda C, et al. Description of COVID-19 in HIV-infected individuals: a single-centre, prospective cohort. *Lancet HIV*. 2020;7(8):e554-e564. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32473657.
11. Park LS, Rentsch CT, Sigel K, et al. COVID-19 in the largest U.S. HIV cohort. Presented at: AIDS 2020 23rd International AIDS Conference. 2020. Virtual. Available at: https://www.natap.org/2020/IAC/IAC_115.htm#:~:text=Over%20a%2078%2Dday%20period,CI%3A%200.85%2D1.26.
12. Boulle A, Davies MA, Hussey H, et al. Risk factors for COVID-19 death in a population cohort study from the Western Cape Province, South Africa. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32860699.
13. Bhaskaran K, Rentsch CT, MacKenna B, et al. HIV infection and COVID-19 death: a population-based cohort analysis of UK primary care data and linked national death registrations within the OpenSAFELY platform. *The Lancet*. 2020. Available at: https://www.thelancet.com/journals/lanhiv/article/PIIS2352-3018(20)30305-2/fulltext.

14. Geretti AM, Stockdale AJ, Kelly SH, et al. Outcomes of COVID-19 related hospitalization among people with HIV in the ISARIC WHO Clinical Characterization Protocol (UK): a prospective observational study. *Clin Infect Dis*. 2020;Published online ahead of print. Available at: https://pubmed.ncbi.nlm.nih.gov/33095853/.

15. Dandachi D, Geiger G, Montgomery MW, et al. Characteristics, comorbidities, and outcomes in a multicenter registry of patients with HIV and coronavirus disease-19. *Clin Infect Dis*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32905581.

16. Hoffmann C, Casado JL, Härter G, et al. Immune deficiency is a risk factor for severe COVID-19 in people living with HIV. *HIV Med*. 2020;Published online ahead of print. Available at: https://pubmed.ncbi.nlm.nih.gov/33368966/.

17. Tesoriero JM, Swain CE, Pierce JL, et al. COVID-19 outcomes among persons living with or without diagnosed HIV infection in New York State. *JAMA Netw Open*. 2021;4(2):e2037069. Available at: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2775827.

18. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. *N Engl J Med*. 2021;384(5):403-416. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa2035389.

19. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA covid-19 vaccine. *N Engl J Med*. 2020;383(27):2603-2615. Available at: https://www.nejm.org/doi/full/10.1056/NEJMoa2034577.

20. Food and Drug Administration. Fact sheet for healthcare providers administering vaccine (vaccination providers): emergency use authorization (EUA) of the Janssen COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). 2021; Available at: https://www.fda.gov/media/146304/download.

21. Tan SS, Chew KL, Saw S, Jureen R,Sethi S. Cross-reactivity of SARS-CoV-2 with HIV chemiluminescent assay leading to false-positive results. *J Clin Pathol*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32907911.

22. Blanco JL, Ambrosioni J, Garcia F, et al. COVID-19 in patients with HIV: clinical case series. *Lancet HIV*. 2020;7(5):e314-e316. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32304642.

23. Coleman H, Snell LB, Simons R, Douthwaite ST,Lee MJ. Coronavirus disease 2019 and Pneumocystis jirovecii pneumonia: a diagnostic dilemma in HIV. *AIDS*. 2020;34(8):1258-1260. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32501852.

24. Centers for Disease Control and Prevention. HIV surveillance report: estimated HIV incidence and prevalence in the United States 2014-2018. 2020. Available at: https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-supplemental-report-vol-25-1.pdf.

25. Byrd KM, Beckwith CG, Garland JM, et al. SARS-CoV-2 and HIV coinfection: clinical experience from Rhode Island, United States. *J Int AIDS Soc*. 2020;23(7):e25573. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32657527.

26. Del Amo J, Polo R, Moreno S, et al. Incidence and severity of COVID-19 in HIV-positive persons receiving antiretroviral therapy: a cohort study. *Ann Intern Med*. 2020;173(7):536-541. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32589451.

27. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of casirivimab and imdevimab. 2020; Available at: https://www.fda.gov/media/143892/download.

28. Food and Drug Administration. Fact sheet for health care providers emergency use authorization (EUA) of bamlanivimab and etesevimab. 2021; Available at: https://www.fda.gov/media/145802/download.

29. Food and Drug Administration. Fact sheet for healthcare providers: emergency use authorization (EUA) of bamlanivimab. 2020; Available at: https://www.fda.gov/media/143603/download.

30. Group RC. Lopinavir-ritonavir in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *Lancet*. 2020;Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/33031764.

31. Chen J, Xia L, Liu L, et al. Antiviral activity and safety of darunavir/cobicistat for the treatment of COVID-19. *Open Forum Infect Dis*. 2020;7(7):ofaa241. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32671131.

# Influenza and COVID-19

*Last Updated: October 22, 2020*

| Summary Recommendations |
| --- |
| **Influenza Vaccination**<br>• Although data are lacking on influenza vaccination for persons with COVID-19, on the basis of practice for other acute respiratory infections, the Panel recommends that persons with COVID-19 should receive an inactivated influenza vaccine **(BIII)**. The Centers for Disease Control and Prevention (CDC) has provided guidance on the timing of influenza vaccination for inpatients and outpatients with COVID-19 (see Interim Guidance for Routine and Influenza Immunization Services During the COVID-19 Pandemic).<br>**Diagnosis of Influenza and COVID-19 When Influenza Viruses and SARS-CoV-2 Are Cocirculating**<br>• Only testing can distinguish between severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and influenza virus infections and identify SARS-CoV-2 and influenza virus coinfection.<br>• When SARS-CoV-2 and influenza viruses are cocirculating, the Panel recommends testing for both viruses in all hospitalized patients with acute respiratory illness **(AIII)**.<br>• When SARS-CoV-2 and influenza viruses are cocirculating, the Panel recommends influenza testing in outpatients with acute respiratory illness if the results will change clinical management of the patient **(BIII)**.<br>• Testing for other pathogens should be considered depending on clinical circumstances, especially in patients with influenza in whom bacterial superinfection is a well-recognized complication.<br>• See the CDC Information for Clinicians on Influenza Virus Testing and the Infectious Diseases Society of America (IDSA) Clinical Practice Guidelines for more information.<br>**Antiviral Treatment of Influenza When Influenza Viruses and SARS-CoV-2 Are Cocirculating**<br>• The treatment of influenza is the same in all patients regardless of SARS-CoV-2 coinfection **(AIII)**.<br>• The Panel recommends that hospitalized patients be started on empiric treatment for influenza with oseltamivir as soon as possible without waiting for influenza testing results **(AIIb)**.<br>  • Antiviral treatment of influenza can be stopped when influenza has been ruled out by nucleic acid detection assay in upper respiratory tract specimens for nonintubated patients and in both upper and lower respiratory tract specimens for intubated patients.<br>• For influenza treatment in hospitalized and non-hospitalized patients, see the CDC and IDSA recommendations on antiviral treatment of influenza. |
| **Rating of Recommendations:** A = Strong; B = Moderate; C = Optional<br>**Rating of Evidence:** I = One or more randomized trials without major limitations; IIa = Other randomized trials or subgroup analyses of randomized trials; IIb = Nonrandomized trials or observational cohort studies; III = Expert opinion |

## Introduction

Influenza activity in the United States during the 2020–2021 influenza season is difficult to predict and could vary geographically and by the extent of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) community mitigation measures. During early 2020, sharp declines in influenza activity coincided with implementation of SARS-CoV-2 control measures in the United States and several Asian countries.[1-4] Very low influenza virus circulation was observed in Australia, Chile, and South Africa during the typical Southern Hemisphere influenza season in 2020.[5] Clinicians should monitor local influenza and SARS-CoV-2 activity (e.g., by tracking local and state public health surveillance data and testing performed at health care facilities) to inform evaluation and management of patients with acute respiratory illness.

## Influenza Vaccination

There are no data on the safety, immunogenicity, or effectiveness of influenza vaccines in patients

with mild COVID-19 or those who are recovering from COVID-19. Therefore, the optimal timing for influenza vaccination in these patients is unknown. The safety and efficacy of vaccinating persons who have mild illnesses from other etiologies have been documented.[6] On the basis of practice following other acute respiratory infections, the Panel recommends that persons with COVID-19 should receive an inactivated influenza vaccine **(BIII)**. The Centers for Disease Control and Prevention (CDC) has provided guidance on the timing of influenza vaccination for inpatients and outpatients with COVID-19 (see Interim Guidance for Routine and Influenza Immunization Services During the COVID-19 Pandemic). It is not known whether dexamethasone or other immunomodulatory therapies for COVID-19 will affect the immune response to influenza vaccine. However, despite this uncertainty, as long as influenza viruses are circulating, an unvaccinated person with COVID-19 should receive the influenza vaccine once they have substantially improved or recovered from COVID-19. See influenza vaccine recommendations from CDC and the Advisory Committee on Immunization Practices.

## Clinical Presentation of Influenza Versus COVID-19

The signs and symptoms of uncomplicated, clinically mild influenza overlap with those of mild COVID-19. Ageusia and anosmia can occur with both diseases, but these symptoms are more common with COVID-19 than with influenza. Fever is not always present in patients with either disease, particularly in patients who are immunosuppressed or elderly. Complications of influenza and COVID-19 can be similar, but the onset of influenza complications and severe disease typically occurs within a week of illness onset whereas the onset of severe COVID-19 usually occurs in the second week of illness. Because of the overlap in signs and symptoms, when SARS-CoV-2 and influenza viruses are cocirculating, diagnostic testing for both viruses in people with an acute respiratory illness is needed to distinguish between SARS-CoV-2 and influenza virus, and to identify SARS-CoV-2 and influenza virus coinfection. Coinfection with influenza A or B viruses and SARS-CoV-2 has been described in case reports and case series,[7-11] but the frequency, severity, and risk factors for coinfection with these viruses versus for infection with either virus alone are unknown.

## Which Patients Should be Tested for SARS-CoV-2 and influenza?

When influenza viruses and SARS-CoV-2 are cocirculating in the community, SARS-CoV-2 testing and influenza testing should be performed in all patients hospitalized with suspected COVID-19 or influenza (see Testing for SARS-CoV-2 Infection) **(AIII)**. When influenza viruses and SARS-CoV-2 are cocirculating in the community, SARS-CoV-2 testing should be performed in outpatients with suspected COVID-19, and influenza testing can be considered in outpatients with suspected influenza if the results will change clinical management of the illness **(BIII)**. Several multiplex assays that detect SARS-CoV-2 and influenza A and B viruses have received Food and Drug Administration Emergency Use Authorization and can provide results in 15 minutes to 8 hours on a single respiratory specimen.[12,13] For information on available influenza tests, including clinical algorithms for testing of patients when SARS-CoV-2 and influenza viruses are cocirculating, see the CDC Information for Clinicians on Influenza Virus Testing and recommendations of the Infectious Diseases Society of America (IDSA) on the use of influenza tests and interpretation of testing results.[14]

## Which Patients Should Receive Antiviral Treatment of Influenza?

When SARS-CoV-2 and influenza viruses are cocirculating in the community, patients who require hospitalization and are suspected of having either or both viral infections should receive influenza antiviral treatment with oseltamivir as soon as possible without waiting for influenza testing results **(AIIb)**.[14] Treatment for influenza is the same for all patients regardless of SARS-CoV-2 coinfection **(AIII)**. See the CDC Influenza Antiviral Medications: Summary for Clinicians, including clinical algorithms for antiviral treatment of patients with suspected or confirmed influenza when SARS-CoV-2

and influenza viruses are cocirculating, and the IDSA Clinical Practice Guidelines recommendations on antiviral treatment of influenza.

If a diagnosis of COVID-19 or another etiology is confirmed and if the result of an influenza nucleic acid detection assay from an upper respiratory tract specimen is negative:

- *In a Patient Who is Not Intubated:* Antiviral treatment for influenza can be stopped.
- *In a Patient Who is Intubated:* Antiviral treatment for influenza should be continued and if a lower respiratory tract specimen (e.g., endotracheal aspirate) can be safely obtained, it should be tested by influenza nucleic acid detection. If the lower respiratory tract specimen is also negative, influenza antiviral treatment can be stopped.

## Treatment Considerations for Hospitalized Patients With Suspected or Confirmed SARS-CoV-2 and Influenza Virus Coinfection

- Corticosteroids, which may be used for the treatment of COVID-19, may prolong influenza viral replication and viral RNA detection and may be associated with poor outcomes.[14,15]
- Oseltamivir has no activity against SARS-CoV-2.[16] Oseltamivir does not have any known interactions with remdesivir.
- Standard-dose oseltamivir is well absorbed even in critically ill patients. For patients who cannot tolerate oral or enterically administered oseltamivir (e.g., because of gastric stasis, malabsorption, or gastrointestinal bleeding), intravenous peramivir is an option.[14] There are no data on peramivir activity against SARS-CoV-2.
- CDC does not recommend inhaled zanamivir and oral baloxavir for the treatment of influenza in hospitalized patients because of insufficient safety and efficacy data (see the CDC Influenza Antiviral Medications: Summary for Clinicians). There are no data on zanamivir activity against SARS-CoV-2. Baloxavir has no activity against SARS-CoV-2.[16]
- Based upon limited data, the co-occurrence of community-acquired secondary bacterial pneumonia with COVID-19 appears to be infrequent and may be more common with influenza.[17,18] Typical bacterial causes of community-acquired pneumonia with severe influenza are *Staphylococcus aureus* (methicillin-resistant *S. aureus* [MRSA] and methicillin-susceptible *S. aureus* [MSSA]), *Streptococcus pneumoniae*, and group A *Streptococcus*.[14]
- Patients with COVID-19 who develop new respiratory symptoms with or without fever or respiratory distress, and without a clear diagnosis, should be evaluated for the possibility of nosocomial influenza.

## References


1. Kuo SC, Shih SM, Chien LH, Hsiung CA. Collateral benefit of COVID-19 control measures on influenza activity, Taiwan. *Emerg Infect Dis*. 2020;26(8):1928-1930. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32339091.
2. Soo RJJ, Chiew CJ, Ma S, Pung R, Lee V. Decreased influenza incidence under COVID-19 control measures, Singapore. *Emerg Infect Dis*. 2020;26(8):1933-1935. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32339092.
3. Suntronwong N, Thongpan I, Chuchaona W, et al. Impact of COVID-19 public health interventions on influenza incidence in Thailand. *Pathog Glob Health*. 2020;114(5):225-227. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32521210.
4. Lei H, Xu M, Wang X, et al. Non-pharmaceutical interventions used to control COVID-19 reduced seasonal influenza transmission in China. *J Infect Dis*. 2020; Published online ahead of print. Available at:

https://www.ncbi.nlm.nih.gov/pubmed/32898256.

5. Olsen SJ, Azziz-Baumgartner E, Budd AP, et al. Decreased influenza activity during the COVID-19 pandemic—United States, Australia, Chile, and South Africa, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(37):1305-1309. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32941415.
6. Centers for Disease Control and Prevention. Contraindications and precautions. General best practice guidelines for immunization: best practices guidance of the advisory committee on immunization practices (ACIP). 2020. Available at: https://www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html. Accessed October 16, 2020.
7. Hashemi SA, Safamanesh S, Ghasemzadeh-Moghaddam H, Ghafouri M, Azimian A. High prevalence of SARS-CoV-2 and influenza A virus (H1N1) coinfection in dead patients in Northeastern Iran. *J Med Virol*. 2020; Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32720703.
8. Huang BR, Lin YL, Wan CK, et al. Co-infection of influenza B virus and SARS-CoV-2: A case report from Taiwan. *J Microbiol Immunol Infect*. 2020; Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32646801.
9. Yue H, Zhang M, Xing L, et al. The epidemiology and clinical characteristics of co-infection of SARS-CoV-2 and influenza viruses in patients during COVID-19 outbreak. *J Med Virol*. 2020; Published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32530499.
10. Cuadrado-Payan E, Montagud-Marrahi E, Torres-Elorza M, et al. SARS-CoV-2 and influenza virus co-infection. *Lancet*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32423586.
11. Wu X, Cai Y, Huang X, et al. Co-infection with SARS-CoV-2 and influenza A virus in patient with pneumonia, China. *Emerg Infect Dis*. 2020;26(6):1324-1326. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32160148.
12. Food and Drug Administration. Coronavirus disease 2019 (COVID-19) emergency use authorizations for medical devices. Individual EUAs for molecular diagnostic tests for SARS-CoV-2. 2020. Available at: https://www.fda.gov/medical-devices/coronavirus-disease-2019-covid-19-emergency-use-authorizations-medical-devices/vitro-diagnostics-euas#individual-molecular. Accessed October 16, 2020.
13. Centers for Disease Control and Prevention. Table 4. Multiplex assays authorized for simultaneous detection of influenza viruses and SARS-CoV-2 by FDA. 2020. Available at: https://www.cdc.gov/flu/professionals/diagnosis/table-flu-covid19-detection.html. Accessed October 16, 2020.
14. Uyeki TM, Bernstein HH, Bradley JS, et al. Clinical practice guidelines by the Infectious Diseases Society of America: 2018 update on diagnosis, treatment, chemoprophylaxis, and institutional outbreak management of seasonal influenza. *Clin Infect Dis*. 2019;68(6):e1-e47. Available at: https://www.ncbi.nlm.nih.gov/pubmed/30566567.
15. Zhou Y, Fu X, Liu X, et al. Use of corticosteroids in influenza-associated acute respiratory distress syndrome and severe pneumonia: a systemic review and meta-analysis. *Sci Rep*. 2020;10(1):3044. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32080223.
16. Choy KT, Wong AY, Kaewpreedee P, et al. Remdesivir, lopinavir, emetine, and homoharringtonine inhibit SARS-CoV-2 replication in vitro. *Antiviral Res*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32251767.
17. Vaughn VM, Gandhi T, Petty LA, et al. Empiric antibacterial therapy and community-onset bacterial co-infection in patients hospitalized with COVID-19: a multi-hospital cohort study. *Clin Infect Dis*. 2020; published online ahead of print. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32820807.
18. Adler H, Ball R, Fisher M, Mortimer K, Vardhan MS. Low rate of bacterial co-infection in patients with COVID-19. *Lancet Microbe*. 2020. Available at: https://www.ncbi.nlm.nih.gov/pubmed/32835331.

# Appendix A, Table 1. COVID-19 Treatment Guidelines Panel Members

*Last Updated: August 4, 2021*

| Name | Affiliation |
|---|---|
| **Co-Chairs** | |
| Roy M. Gulick, MD, MPH | Weill Cornell Medicine, New York, NY |
| H. Clifford Lane, MD | National Institutes of Health, Bethesda, MD |
| Henry Masur, MD | National Institutes of Health, Bethesda, MD |
| **Executive Secretary** | |
| Alice K. Pau, PharmD | National Institutes of Health, Bethesda, MD |
| **Members** | |
| Judith Aberg, MD | Icahn School of Medicine at Mount Sinai, New York, NY |
| Adaora Adimora, MD, MPH | University of North Carolina School of Medicine, Chapel Hill, NC |
| Jason Baker, MD, MS | Hennepin Healthcare/University of Minnesota, Minneapolis, MN |
| Lisa Baumann Kreuziger, MD, MS | Versiti/Medical College of Wisconsin, Milwaukee, WI |
| Roger Bedimo, MD, MS | University of Texas Southwestern/Veterans Affairs North Texas Health Care System, Dallas, TX |
| Pamela S. Belperio, PharmD | Department of Veterans Affairs, Los Angeles, CA |
| Stephen V. Cantrill, MD | Denver Health, Denver, CO |
| Craig Coopersmith, MD | Emory University School of Medicine, Atlanta, GA |
| Eric Daar, MD | Harbor-UCLA Medical Center, Torrance, CA |
| Susan L. Davis, PharmD | Wayne State University School of Pharmacy, Detroit, MI |
| Amy L. Dzierba, PharmD | New York-Presbyterian Hospital, New York, NY |
| Gregory Eschenauer, PharmD | University of Michigan, Ann Arbor, MI |
| Laura Evans, MD, MSc | University of Washington, Seattle, WA |
| John J. Gallagher, DNP, RN | University of Pittsburgh Medical Center, Pittsburgh, PA |
| Rajesh Gandhi, MD | Massachusetts General Hospital/Harvard Medical School, Boston, MA |
| David V. Glidden, PhD | University of California San Francisco, San Francisco, CA |
| Birgit Grund, PhD | University of Minnesota, Minneapolis, MN |
| Erica J. Hardy, MD, MMSc | Warren Alpert Medical School of Brown University, Providence, RI |
| Carl Hinkson, MSRC | Providence Health & Services, Everett, WA |
| Brenna L. Hughes, MD, MSc | Duke University School of Medicine, Durham, NC |
| Steven Johnson, MD | University of Colorado School of Medicine, Aurora, CO |
| Marla J. Keller, MD | Albert Einstein College of Medicine/Montefiore Medical Center, Bronx, NY |
| Arthur Kim, MD | Massachusetts General Hospital/Harvard Medical School, Boston, MA |
| Jeffrey L. Lennox, MD | Emory University School of Medicine, Atlanta, GA |
| Mitchell M. Levy, MD | Warren Alpert Medical School of Brown University, Providence, RI |
| Jonathan Li, MD, MMSc | Brigham and Women's Hospital/Harvard Medical School, Boston, MA |
| Gregory Martin, MD, MSc | Emory University School of Medicine, Atlanta, GA |
| Susanna Naggie, MD, MHS | Duke University School of Medicine, Durham, NC |
| Andrew T. Pavia, MD | University of Utah School of Medicine, Salt Lake City, UT |

| Name | Affiliation |
|---|---|
| Nitin Seam, MD | National Institutes of Health, Bethesda, MD |
| Steven Q. Simpson, MD | University of Kansas Medical Center, Kansas City, KS |
| Susan Swindells, MBBS | University of Nebraska Medical Center, Omaha, NE |
| Pablo Tebas, MD | University of Pennsylvania, Philadelphia, PA |
| Phyllis Tien, MD, MSc | University of California, San Francisco/San Francisco VA Healthcare System, San Francisco, CA |
| Alpana A. Waghmare, MD | Seattle Children's Hospital, Seattle, WA |
| Kevin C. Wilson, MD | Boston University School of Medicine, Boston, MA |
| Jinoos Yazdany, MD, MPH | University of California, San Francisco, San Francisco, CA |
| Philip Zachariah, MD, MSc | Columbia University Irving Medical Center, New York, NY |
| **Community Members** | |
| Danielle M. Campbell, MPH | University of California, Los Angeles, Los Angeles, CA |
| Carly Harrison | LupusChat, New York, NY |
| **Consultants** | |
| Christopher Carpenter, MD, MSC | Washington University, St. Louis, MO |
| Eric Freedman, MD | Department of Veteran Affairs, Cape Coral, FL |
| **Ex Officio Members, U.S. Government Representatives** | |
| Timothy Burgess, MD | Department of Defense, Bethesda, MD |
| Derek Eisnor, MD | Biomedical Advanced Research and Development Authority, Washington, DC |
| Joseph Francis, MD, MPH | Department of Veterans Affairs, Washington, DC |
| Virginia Sheikh, MD, MHS | Food and Drug Administration, Silver Spring, MD |
| Timothy M. Uyeki, MD, MPH | Centers for Disease Control and Prevention, Atlanta, GA |
| **U.S. Government Support Team** | |
| Laura Bosque Ortiz, BS | National Institutes of Health, Bethesda, MD |
| John T. Brooks, MD | Centers for Disease Control and Prevention, Atlanta, GA |
| Richard T. Davey, Jr., MD | National Institutes of Health, Bethesda, MD |
| Laurie K. Doepel, BA | National Institutes of Health, Bethesda, MD |
| Robert W. Eisinger, PhD | National Institutes of Health, Bethesda, MD |
| Alison Han, MD (Co-Team Coordinator) | National Institutes of Health, Bethesda, MD |
| Elizabeth S. Higgs, MD, DTM&H, MIA | National Institutes of Health, Bethesda, MD |
| Martha C. Nason, PhD (Biostatistics Support) | National Institutes of Health, Bethesda, MD |
| Renee Ridzon, MD | National Institutes of Health, Bethesda, MD |
| Kanal Singh, MD, MPH (Co-Team Coordinator) | National Institutes of Health, Bethesda, MD |
| **Project Manager** | |
| Amanda Crinks, MA , MBA | Frederick National Laboratory for Cancer Research, in support of NIAID, Frederick, MD |
| **Assistant Executive Secretaries** | |
| Page Crew, PharmD, MPH | National Institutes of Health, Bethesda, MD |
| Safia Kuriakose, PharmD | Frederick National Laboratory for Cancer Research, in support of NIAID, Frederick, MD |
| Andrea M. Lerner, MD, MS | National Institutes of Health, Bethesda, MD |

# Appendix A, Table 2. COVID-19 Treatment Guidelines Panel Financial Disclosure for Companies Related to COVID-19 Treatment or Diagnostics

*Last Updated: August 4, 2021*

Reporting Period: April 1, 2020, to March 31, 2021

| Panel Member | Financial Disclosure | |
|---|---|---|
| | **Company** | **Relationship** |
| Judith Aberg, MD | Atea Pharmaceuticals | Research Support |
| | Emergent BioSolutions | Research Support |
| | Frontier Technologies | Research Support |
| | Gilead Sciences | Research Support |
| | GlaxoSmithKline | Advisory Board, Research Support |
| | Janssen | Research Support |
| | Merck & Co. | Advisory Board, Research Support |
| | Pfizer | Research Support |
| | Regeneron | Research Support |
| | ViiV Healthcare | Advisory Board, Research Support |
| Adaora Adimora, MD, MPH | Merck & Co. | Advisory Board, Consultant, Research Support |
| Jason Baker, MD, MS | Gilead Sciences | Research Support |
| | Humanigen | Research Support |
| Lisa Baumann Kreuziger, MD, MS | 3M | Stockholder, Spouse Is Employee |
| | Versiti | Employee |
| Roger Bedimo, MD, MS | Merck & Co. | Advisory Board |
| | ViiV Healthcare | Advisory Board |
| Pamela S. Belperio, PharmD | None | N/A |
| Laura Bosque Ortiz, BS | None | N/A |
| John T. Brooks, MD | None | N/A |
| Timothy Burgess, MD | None | N/A |
| Danielle M. Campbell, MPH | Gilead Sciences | Advisory Board |
| Stephen V. Cantrill, MD | None | N/A |
| Craig Coopersmith, MD | None | N/A |
| Page Crew, PharmD, MPH | None | N/A |
| Eric Daar, MD | Gilead Sciences | Consultant, Research Support |
| | Merck & Co. | Consultant, Research Support |
| | ViiV Healthcare | Research Support |
| Richard T. Davey, Jr., MD | None | N/A |
| Susan L. Davis, PharmD | None | N/A |
| Laurie K. Doepel, BA | None | N/A |
| Amy L. Dzierba, PharmD | None | N/A |
| Derek Eisnor, MD | None | N/A |

| Panel Member | Financial Disclosure | |
|---|---|---|
| | Company | Relationship |
| Gregory Eschenauer, PharmD | None | N/A |
| Laura Evans, MD, MSc | None | N/A |
| Joseph Francis, MD, MPH | None | N/A |
| John J. Gallagher, DNP, RN | None | N/A |
| Rajesh Gandhi, MD | None | N/A |
| David V. Glidden, PhD | Gilead Sciences | Consultant |
| | Merck & Co. | Advisory Board |
| Birgit Grund, PhD | None | N/A |
| Roy M. Gulick, MD, MPH | None | N/A |
| Alison Han, MD | None | N/A |
| Erica J. Hardy, MD, MMSc | None | N/A |
| Carly Harrison | AstraZeneca | Advisory Board, Consultant |
| | Aurinia Pharmaceuticals | Advisory Board, Stockholder |
| | UCB | Advisory Board |
| Elizabeth S. Higgs, MD, DTM&H, MIA | None | N/A |
| Carl Hinkson, MSRC | None | N/A |
| Brenna L. Hughes, MD, MSc | Merck & Co. | Advisory Board |
| Steven Johnson, MD | ViiV Healthcare | Advisory Board |
| Marla J. Keller, MD | None | N/A |
| Arthur Kim, MD | None | N/A |
| Safia Kuriakose, PharmD | None | N/A |
| H. Clifford Lane, MD | None | N/A |
| Jeffrey L. Lennox, MD | ViiV Healthcare | Research Support |
| Andrea M. Lerner, MD, MS | None | N/A |
| Mitchell M. Levy, MD | Citius Pharmaceuticals | Consultant |
| | Regeneron Pharmaceuticals | Consultant |
| | Sanofi | Consultant |
| Jonathan Li, MD, MMSc | Abbvie | Consultant |
| Gregory Martin, MD, MSc | Apellis | Data and Safety Monitoring Board Chair/ Member |
| | Beckman Coulter | Consultant |
| | Genentech | Data and Safety Monitoring Board Chair/ Member |
| | Grifols | Research Grants Review Panel |
| | Regeneron | Consultant |
| Henry Masur, MD | None | N/A |
| Susanna Naggie, MD, MHS | AbbVie | Research Support |
| | Bristol Myers Squibb Company | Event Adjudication |
| | Gilead Sciences | Research Support |
| | Vir Biotechnology | Advisory Board, Stockholder |

| Panel Member | Financial Disclosure | |
|---|---|---|
| | Company | Relationship |
| Martha C. Nason, PhD | None | N/A |
| Alice K. Pau, PharmD | None | N/A |
| Andrew T. Pavia, MD | GlaxoSmithKline | Consultant |
| Renee Ridzon, MD | None | N/A |
| Nitin Seam, MD | None | N/A |
| Virginia Sheikh, MD, MHS | None | N/A |
| Steven Q. Simpson, MD | None | N/A |
| Kanal Singh, MD, MPH | None | N/A |
| Susan Swindells, MBBS | ViiV Healthcare | Research Support |
| Pablo Tebas, MD | Inovio Pharmaceuticals | Research Support |
| Phyllis Tien, MD, MSc | Eli Lilly and Company | Research Support |
| | Merck & Co. | Research Support |
| Timothy M. Uyeki, MD, MPH | None | N/A |
| Alpana A. Waghmare, MD | AlloVir | Research Support |
| | Ansun BioPharma | Research Support |
| | Kyorin Pharmaceutical Co. | Advisory Board |
| Kevin C. Wilson, MD | None | N/A |
| Jinoos Yazdany, MD, MPH | AstraZeneca | Consultant, Research Support |
| | Aurinia | Consultant |
| | Bristol Myers Squibb | Research Support |
| | Eli Lilly and Company | Consultant |
| | Gilead Sciences | Research Support |
| | Pfizer | Consultant |
| Philip Zachariah, MD, MSc | Merck & Co. | Research Support |