Ritonavir-Boosted Nirmatrelvir (Paxlovid)

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Nirmatrelvir is an oral protease inhibitor that is active against M\(^{\text{PRO}}\), a viral protease that plays an essential role in viral replication by cleaving the 2 viral polyproteins.\(^1\) It has demonstrated antiviral activity against all coronaviruses that are known to infect humans.\(^2\) Nirmatrelvir is packaged with ritonavir (as Paxlovid), a strong cytochrome P450 (CYP) 3A4 inhibitor and pharmacokinetic boosting agent that has been used to boost HIV protease inhibitors. Coadministration of ritonavir is required to increase nirmatrelvir concentrations to the target therapeutic range. The Food and Drug Administration (FDA) issued an Emergency Use Authorization (EUA) for ritonavir-boosted nirmatrelvir on December 22, 2021, for the treatment of COVID-19.\(^3\)

There are currently no clinical trial data on the use of ritonavir-boosted nirmatrelvir in people with COVID-19 caused by the Omicron variant; however, ritonavir-boosted nirmatrelvir is expected to be active against this variant and its subvariants.\(^4\)\(^-\)\(^7\)

Recommendations

- The COVID-19 Treatment Guidelines Panel (the Panel) recommends using nirmatrelvir 300 mg with ritonavir 100 mg (Paxlovid) orally (PO) twice daily for 5 days in nonhospitalized adults (AIIa) and pediatric patients aged ≥12 years and weighing ≥40 kg (BIII) with mild to moderate COVID-19 who are at high risk of disease progression. Treatment should be initiated as soon as possible and within 5 days of symptom onset. For information on medical conditions that confer high risk, see the Centers for Disease Control and Prevention webpage People With Certain Medical Conditions.

- For recommendations on using ritonavir-boosted nirmatrelvir in nonhospitalized children with COVID-19, see Therapeutic Management of Nonhospitalized Children With COVID-19.

- Ritonavir-boosted nirmatrelvir may be used in patients who are hospitalized for a diagnosis other than COVID-19, provided they have mild to moderate COVID-19 (i.e., those who do not require supplemental oxygen), are at high risk of progressing to severe disease, and are within 5 days of symptom onset.

- Ritonavir-boosted nirmatrelvir has not been studied in patients who were hospitalized for mild to moderate COVID-19. The FDA EUA allows ritonavir-boosted nirmatrelvir to be used in these patients if they are at high risk of progressing to severe COVID-19 and are within 5 days of symptom onset.

- For more information on ritonavir-boosted nirmatrelvir, see Table 4e.

Drug-Drug Interactions

Ritonavir-boosted nirmatrelvir has significant drug-drug interactions, primarily due to the ritonavir component of the combination. Before prescribing ritonavir-boosted nirmatrelvir, clinicians should carefully review the patient’s concomitant medications, including over-the-counter medications, herbal supplements, and recreational drugs, to evaluate potential drug-drug interactions. Many drug-drug interactions between ritonavir-boosted nirmatrelvir and concomitant medications can be safely managed (e.g., with certain statins, calcium channel blockers, or direct oral anticoagulants).
The following resources provide information on identifying and managing drug-drug interactions.

- Quick reference lists:
  - Drug-Drug Interactions Between Ritonavir-Boosted Nirmatrelvir (Paxlovid) and Concomitant Medications. Box 1 lists select outpatient medications that are not expected to have clinically relevant interactions with ritonavir-boosted nirmatrelvir. Box 2 lists select outpatient medications that have clinically relevant drug-drug interactions with ritonavir-boosted nirmatrelvir.

- Web-based drug-drug interaction checker:
  - The Liverpool COVID-19 Drug Interactions website

- Tables with guidance on managing specific drug-drug interactions:
  - The University of Waterloo/University of Toronto drug interaction guide
  - The FDA EUA fact sheet and checklist for ritonavir-boosted nirmatrelvir

For the Panel’s recommendations on preferred and alternative antiviral therapies for outpatients with COVID-19, see Therapeutic Management of Nonhospitalized Adults With COVID-19.

**Rationale**

The EPIC-HR trial enrolled nonhospitalized adults with mild to moderate COVID-19 who were not vaccinated and who were at high risk of progressing to severe disease. The trial demonstrated that starting ritonavir-boosted nirmatrelvir within 5 days of symptom onset in these patients reduced the risk of hospitalization or death through Day 28 by 89% compared to placebo. This efficacy is comparable to remdesivir (87% relative reduction) and greater than the efficacy reported for molnupiravir (31% relative reduction). However, these agents have not been directly compared in clinical trials.

Although ritonavir-boosted nirmatrelvir demonstrated a clinical benefit during the EPIC-HR trial, the benefits in unvaccinated people who are at low risk of progression to severe disease or in vaccinated people who are at high risk of progression to severe disease are unclear. The EPIC-SR trial, which included both of these populations, found that ritonavir-boosted nirmatrelvir did not reduce the duration of symptoms and did not have a statistically significant effect on the risk of hospitalization or death compared to placebo, although the event rates were low. Some observational studies have shown a benefit of ritonavir-boosted nirmatrelvir in vaccinated individuals who were at high risk of progressing to severe COVID-19. However, observational studies have inherent limitations. In particular, the results of these studies may be affected by residual confounding. For information on treatment considerations for vaccinated individuals, see Therapeutic Management of Nonhospitalized Adults With COVID-19.

Because of the potential for significant drug-drug interactions with concomitant medications, this regimen may not be the optimal choice for all patients. See Drug-Drug Interactions Between Ritonavir-Boosted Nirmatrelvir (Paxlovid) and Concomitant Medications for more information.

**Viral Rebound and Symptom Recurrence**

Observational studies and the EPIC-HR trial have described SARS-CoV-2 viral rebound and the recurrence of COVID-19 symptoms in some patients who have completed treatment with ritonavir-boosted nirmatrelvir. The frequency, mechanism, and clinical implications of these events are unclear. Viral rebound and the recurrence of COVID-19 symptoms can also occur in the absence of treatment with ritonavir-boosted nirmatrelvir.

The EPIC-HR trial demonstrated a clinical benefit of ritonavir-boosted nirmatrelvir in patients who were
not vaccinated and who were at high risk of progressing to severe COVID-19. To date, the recurrence of COVID-19 symptoms following the use of ritonavir-boosted nirmatrelvir has not been associated with progression to severe COVID-19. Therefore, concerns about the recurrence of symptoms should not be a reason to avoid using ritonavir-boosted nirmatrelvir.\textsuperscript{20,22,23}

Longer treatment courses of ritonavir-boosted nirmatrelvir are not authorized by the current EUA, and there are insufficient data on the efficacy of administering a second course.

**SARS-CoV-2 Resistance**

Viral mutations that lead to substantial resistance to nirmatrelvir have been selected for in in vitro studies; the fitness of these mutations is unclear. Surveillance for the emergence of significant resistance to nirmatrelvir is critical.

Severely immunocompromised patients can experience prolonged periods of SARS-CoV-2 replication, which may lead to rapid viral evolution. There are theoretical concerns that using a single antiviral agent in these patients may produce antiviral-resistant viruses. Additional studies are needed to assess this risk. The role of combination antiviral therapy or a longer treatment duration in treating patients who are severely immunocompromised is not yet known.

**Additional Considerations**

- Nirmatrelvir must be administered with ritonavir to achieve sufficient therapeutic plasma concentrations.
- Patients should complete the 5-day treatment course of ritonavir-boosted nirmatrelvir, because there are concerns that a shorter treatment course may be less effective or lead to resistance.
- If a patient requires hospitalization after starting treatment, the full 5-day treatment course of ritonavir-boosted nirmatrelvir should be completed unless there are drug-drug interactions that preclude its use.
- There are no data on combining ritonavir-boosted nirmatrelvir with other antiviral therapies to treat nonhospitalized patients with COVID-19. Clinical trials are needed to determine whether combination therapy has a role in the treatment of COVID-19.
- The EUA advises against crushing nirmatrelvir and ritonavir tablets. However, some data indicate that the tablets can be split or crushed if necessary.\textsuperscript{24}

**Monitoring and Adverse Effects**

The most common adverse effects of ritonavir-boosted nirmatrelvir are dysgeusia, diarrhea, hypertension, and myalgia. Anaphylaxis and other hypersensitivity reactions have also been reported.

Renal impairment reduces the clearance of nirmatrelvir. In patients with suspected renal impairment, clinicians may consider checking the patient’s renal function to inform the dosing of ritonavir-boosted nirmatrelvir. The dose should be reduced to nirmatrelvir 150 mg with ritonavir 100 mg twice daily in patients with moderate renal impairment (i.e., those with an estimated glomerular filtration rate [eGFR] of ≥30 to <60 mL/min).

The EUA states that ritonavir-boosted nirmatrelvir is not recommended for patients with an eGFR of <30 mL/min until more data are available to establish appropriate dosing.\textsuperscript{3} Additional information is available in the initial FDA Center for Drug Evaluation and Research review for the EUA of ritonavir-boosted nirmatrelvir.\textsuperscript{16} Clinical experience on the use of ritonavir-boosted nirmatrelvir in patients who require hemodialysis is limited.\textsuperscript{25} Based on limited data, some groups have proposed dosing adjustments...
for ritonavir-boosted nirmatrelvir in patients with an eGFR of <30 mL/min and in those who require hemodialysis. A clinical trial (ClinicalTrials.gov Identifier NCT05487040) that will evaluate the use of ritonavir-boosted nirmatrelvir in patients with COVID-19 and severe renal impairment is currently underway.

Ritonavir-boosted nirmatrelvir is not recommended for patients with known or suspected severe hepatic impairment (i.e., Child-Pugh Class C), and it should be used with caution in patients with pre-existing liver diseases, liver enzyme abnormalities, or hepatitis. No pharmacokinetic or safety data are available for this patient population.

Considerations in Pregnant and Lactating People

See Pregnancy, Lactation, and COVID-19 Therapeutics for the Panel’s guidance regarding the use of ritonavir-boosted nirmatrelvir during pregnancy and lactation.

Considerations in Children

For information on using ritonavir-boosted nirmatrelvir in pediatric patients, see Special Considerations in Children, Therapeutic Management of Nonhospitalized Children With COVID-19, and Therapeutic Management of Hospitalized Children With COVID-19.

Clinical Data

The EPIC-HR study was a multinational randomized trial that compared the use of ritonavir-boosted nirmatrelvir PO twice daily for 5 days to placebo in nonhospitalized patients aged ≥18 years with mild to moderate COVID-19 who were at high risk of clinical progression. Eligible patients were randomized within 5 days of symptom onset, were not vaccinated against COVID-19, and had at least 1 risk factor for progression to severe disease. Patients were excluded if they used medications that were either highly dependent upon CYP3A4 for clearance or strong inducers of CYP3A4.

A total of 2,246 patients enrolled in the trial. The mean age was 46 years, 51% of the patients were men, and 72% were White. Forty-seven percent of the patients tested negative for SARS-CoV-2 antibodies, and 66% started study treatment within 3 days of symptom onset.

Patients who were randomized within 3 days of symptom onset (n = 1,379) were included in the modified intention-to-treat (mITT) analysis. COVID-19-related hospitalizations or all-cause deaths occurred by Day 28 in 5 of 697 patients (0.72%) in the ritonavir-boosted nirmatrelvir arm and in 44 of 682 patients (6.5%) in the placebo arm. Among the 2,085 patients who were randomized within 5 days of symptom onset (mITT1 analysis), COVID-19-related hospitalizations and all-cause deaths occurred in 8 of 1,039 patients (0.77%) in the ritonavir-boosted nirmatrelvir arm and in 66 of 1,046 patients (6.3%) in the placebo arm (89% relative risk reduction; 5.6% estimated absolute reduction; 95% CI, 7.2% to 4.0%; P < 0.001). There were no deaths in the ritonavir-boosted nirmatrelvir arm and 13 deaths in the placebo arm.

A total of 2,224 patients who received at least 1 dose of either ritonavir-boosted nirmatrelvir or placebo were included in the EPIC-HR safety analysis set. Among these patients, dysgeusia and diarrhea occurred more frequently in ritonavir-boosted nirmatrelvir recipients than in placebo recipients (6% vs. 0.3% and 3% vs. 2%, respectively). Fewer ritonavir-boosted nirmatrelvir recipients discontinued the study drug due to an adverse event than placebo recipients (2% vs. 4%).

References
1. Pillaiyar T, Manickam M, Namasivayam V, Hayashi Y, Jung SH. An overview of severe acute respiratory


