

Infectious Diseases Society of America Guidelines on the Treatment and Management of Patients with COVID-19

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Abstract

Background: There are many pharmacologic therapies that are being used or considered for treatment of coronavirus disease 2019 (COVID-19). There is a need for frequently updated practice guidelines on their use, based on critical evaluation of rapidly emerging literature.

Objective: There are many pharmacologic therapies that are being used or considered for treatment of COVID-19. There is a need for frequently updated practice guidelines on their use, based on critical evaluation of rapidly emerging literature.

Methods: In March 2020, the Infectious Diseases Society of America (IDSA) formed a multidisciplinary guideline panel of infectious disease clinicians, pharmacists, and methodologists with varied areas of expertise. The process followed a rapid recommendation checklist. The panel prioritized questions and outcomes. Then a systematic review of the peer-reviewed and grey literature was conducted. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the certainty of evidence and make recommendations.

Results: On April 11, 2020, [IDSA released online](#) initial treatment recommendations and narrative summaries of other treatments under evaluation. Since that time, the guideline panel and methodologists have continued to monitor the literature and issue updates and addendums to these guidelines in response to evolving research.

Conclusions: Since the inception of its work, the panel has expressed the overarching goal that patients be recruited into ongoing trials, which would provide much needed evidence on the efficacy and safety of various therapies for COVID-19, given that we could not make a determination whether the benefits outweigh harms for most treatments.

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Executive Summary

Coronavirus disease 2019 (COVID-19) is a pandemic with a rapidly increasing incidence of infections and deaths. Many pharmacologic therapies are being used or considered for treatment. Given the rapidity of emerging literature, the Infectious Diseases Society of America (IDSA) identified the need to develop living, frequently updated evidence-based guidelines to support patients, clinicians and other health-care professionals in their decisions about treatment and management of patients with COVID-19.

Summarized below are the recommendations with comments related to the clinical practice guideline for the treatment and management of COVID-19. A detailed description of background, methods, evidence summary and rationale that support each recommendation, and research needs can be found online in the full text. In brief, per Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology, recommendations are labeled as “strong” or “conditional”. The word “recommend” indicates strong recommendations and “suggest” indicates conditional recommendations. In situations where promising interventions were judged to have insufficient evidence of benefit to support their use and with potential appreciable harms or costs, the expert panel recommended their use in the context of a clinical trial. These recommendations acknowledge the current “knowledge gap” and aim at avoiding premature favorable recommendations for potentially ineffective or harmful interventions.

Recommendation 1: Among patients with COVID-19, the IDSA guideline panel recommends against hydroxychloroquine. (Strong recommendation, Moderate certainty of evidence)

- **Remark:** Chloroquine is considered to be class equivalent to hydroxychloroquine.

Recommendation 2: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends against hydroxychloroquine plus azithromycin. (Strong recommendation, Low certainty of evidence)

- **Remark:** Chloroquine is considered to be class equivalent to hydroxychloroquine.

Recommendation 3: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends against the use of the combination lopinavir/ritonavir. (Strong recommendation, Moderate certainty of evidence)

Recommendation 4: Among hospitalized critically ill patients* with COVID-19, the IDSA guideline panel recommends dexamethasone rather than no dexamethasone. (Strong recommendation, Moderate certainty of evidence)

- **Remark:** If dexamethasone is unavailable, equivalent total daily doses of alternative glucocorticoids may be used. Dexamethasone 6 mg IV or PO for 10 days (or until discharge) or equivalent glucocorticoid dose may be substituted if dexamethasone unavailable. Equivalent total daily doses of alternative glucocorticoids to dexamethasone 6 mg daily are methylprednisolone 32 mg and prednisone 40 mg.

*Critical illness is defined as patients on mechanical ventilation and extracorporeal mechanical oxygenation (ECMO). Critical illness includes end organ dysfunction as is seen in sepsis/septic shock. In COVID-19, the most commonly reported form of end organ dysfunction is ARDS

Recommendation 5: Among hospitalized patients with severe**, but non-critical, COVID-19, the IDSA guideline panel suggests dexamethasone rather than no dexamethasone. (Conditional recommendation, Moderate certainty of evidence)

- **Remark:** Dexamethasone 6 mg IV or PO for 10 days (or until discharge) or equivalent glucocorticoid dose may be substituted if dexamethasone unavailable. Equivalent total daily doses of alternative glucocorticoids to dexamethasone 6 mg daily are methylprednisolone 32 mg and prednisone 40 mg.

**Severe illness is defined as patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen.

Recommendation 6: Among hospitalized patients with non-severe*** COVID-19 without hypoxemia requiring supplemental oxygen, the IDSA guideline panel suggests against the use of glucocorticoids. (Conditional recommendation, Low certainty of evidence)

***Non-severe illness is defined as patient with a SpO₂ > 94% not requiring supplemental oxygen.

Recommendation 7: Among hospitalized adults with progressive severe* or critical** COVID-19 who have elevated markers of systemic inflammation, the IDSA guideline panel suggests tocilizumab in addition to standard of care (i.e., steroids) rather than standard of care alone. (Conditional recommendation, Low certainty of evidence)

- **Remarks:**
 - Patients, particularly those who respond to steroids alone, who put a high value on avoiding possible adverse events of tocilizumab and a low value on the uncertain mortality reduction, would reasonably decline tocilizumab.
 - In the largest trial on the treatment of tocilizumab, criterion for systemic inflammation was defined as CRP ≥75 mg/L.

Severity definitions:

*Severe illness is defined as patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen.

**Critical illness is defined as patients on mechanical ventilation and ECMO. Critical illness includes end organ dysfunction as is seen in sepsis/septic shock. In COVID-19, the most commonly reported form of end organ dysfunction is ARDS.

Recommendation 8: Among patients who have been admitted to the hospital with COVID-19, the IDSA guideline panel recommends COVID-19 convalescent plasma only in the context of a clinical trial. (Knowledge gap)

Recommendation 9: In hospitalized patients with severe* COVID-19, the IDSA panel suggests remdesivir over no antiviral treatment. (Conditional recommendation, Moderate certainty of evidence)

- **Remark:** For consideration in contingency or crisis capacity settings (i.e., limited remdesivir supply): Remdesivir appears to demonstrate the most benefit in those with severe COVID-19 on supplemental oxygen rather than in patients on mechanical ventilation or ECMO.

*Severe illness is defined as patients with SpO₂ ≤94% on room air, and those who require supplemental oxygen, mechanical ventilation, or ECMO.

Recommendation 10: In patients on supplemental oxygen but not on mechanical ventilation or ECMO, the IDSA panel suggests treatment with five days of remdesivir rather than 10 days of remdesivir. (Conditional recommendation, Low certainty of evidence)

- **Remark:** In patients on mechanical ventilation or ECMO, the duration of treatment is 10 days.

Recommendation 11: In patients with COVID-19 admitted to the hospital without the need for supplemental oxygen and oxygen saturation >94% on room air, the IDSA panel suggests against the routine use of remdesivir. (Conditional recommendation, Very low certainty of evidence)

Recommendation 12: Among hospitalized patients with severe COVID-19, the IDSA panel suggests against famotidine use for the sole purpose of treating COVID-19 outside of the context of a clinical trial. (Conditional recommendation, Very low certainty of evidence)

Recommendation 13: Among hospitalized patients with severe COVID-19, the IDSA guideline panel recommends against bamlanivimab. (Strong recommendation, Moderate certainty of evidence)

Recommendation 14: Among ambulatory patients with COVID-19, the IDSA guideline panel suggests against the routine use of bamlanivimab. (Conditional recommendation, Very low certainty of evidence)

- **Remark:** In ambulatory patients with COVID-19 or in patients with mild-to-moderate COVID-19 admitted to the hospital for management of conditions other than COVID-19 who are at increased risk (defined by the [FDA EUA](#)), bamlanivimab is a reasonable treatment option if, after informed decision-making, the patient puts a high value on the uncertain benefits and a low value on uncertain adverse events. For EUA criteria, see [Figure 2](#).

Recommendation 15: Among ambulatory patients with COVID-19, the IDSA guideline panel suggests against the routine use of casirivimab/imdevimab. (Conditional recommendation, Very low certainty of evidence)

- **Remark:** In ambulatory patients with COVID-19 or in patients with mild-to-moderate COVID-19 admitted to the hospital for management of conditions other than COVID-19 who are at increased risk (as defined by the [FDA EUA](#)), casirivimab/imdevimab is a reasonable treatment option if, after informed decision-making, the patient puts a high

value on the uncertain benefits and a low value on uncertain adverse events. For EUA criteria, see [Figure 2](#).

Recommendation 16: Among hospitalized patients with severe* COVID-19 who cannot receive corticosteroids because of a contraindication, the IDSA guideline panel suggests use of baricitinib with remdesivir rather than remdesivir alone. (Conditional recommendation, Low certainty of evidence)

- **Remark:** Baricitinib 4 mg daily dose for 14 days (or until hospital discharge). The benefits of baricitinib plus remdesivir for persons on mechanical ventilation are uncertain. See the [remdesivir](#) section for dose and duration. section for dose and duration. section for dose and duration.

*Severe illness is defined as patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen, oxygen through a high-flow device, or non-invasive ventilation.

Recommendation 17: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends treatment with baricitinib plus remdesivir plus corticosteroids only in the context of a clinical trial. (Knowledge gap)

Recommendation 18: In hospitalized patients with severe COVID-19, the IDSA panel suggests against ivermectin use outside of the context of a clinical trial. (Conditional recommendation, very low certainty of evidence)

Recommendation 19: In outpatients with COVID-19, the IDSA panel suggests against ivermectin use outside of the context of a clinical trial. (Conditional recommendation, very low certainty of evidence)

Since the inception of its work, the panel has expressed the overarching goal that patients be recruited into ongoing trials, which would provide much needed evidence on the efficacy and safety of various therapies for COVID-19. The panel has determined that when an explicit trade-off between highly uncertain benefits and known putative harms of these therapeutic agents were considered, a net positive benefit was not reached and could possibly be negative (risk of excess harm). The panel acknowledges that enrolling patients in randomized controlled trials (RCTs) might not be feasible for many frontline providers due to limited access and infrastructure. Should lack of access to clinical trials exist, we encourage setting up local or collaborative registries to systematically evaluate the efficacy and safety of drugs to contribute to the knowledge base. Each clinician can play a role in advancing our understanding of this disease through a local registry or other data collection efforts.

Background

The first cases of COVID-19 were reported from Wuhan, China in early December 2019 [1], now known to be caused by a novel beta-coronavirus, named as Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Within a span of months, COVID-19 has become pandemic due to its transmissibility, spreading across continents with the number of cases and deaths rising daily [2]. Although most infected individuals exhibit a mild illness (80%+), 14% have serious and 5% have critical illness. Approximately 10% will require hospital admission due to COVID-19 pneumonia, of which approximately 10% will require ICU care, including invasive ventilation due to acute respiratory distress syndrome (ARDS) [3]. While mortality appears to be more common in older individuals and those with comorbidities, such as chronic lung disease, cardiovascular disease, hypertension and diabetes, young people with no comorbidities also appear to be at risk for critical illness including multi-organ failure and death.

There has been an expanding number of studies rapidly published online and in academic journals; however, some of these may be of limited quality and are pre-published without sufficient peer-review. Critical appraisal of the existing studies is needed to determine if the existing evidence is sufficient to support currently proposed management strategies.

Given the rapid global spread of SARS-CoV-2 and the difficulty for the overburdened front-line providers and policymakers to stay up to date on emerging literature, IDSA has recognized the necessity of developing a rapid guideline for the treatment of COVID-19. The guideline panel is using a methodologically rigorous process for evaluating the best available evidence and providing treatment recommendations. Two additional guidelines on diagnostic testing and infection prevention also have been developed. These guidelines will be frequently updated as substantive literature becomes available and are accessible on an easy to navigate web and device interface at <http://www.idsociety.org/covid19guidelines>.

There continue to be several ongoing trials evaluating therapeutic agents for the treatment of COVID-19. As data becomes available from these trials and if there is a preponderance of evidence to suggest the use of a therapeutic agent even in the context of clinical trials is no longer warranted it will be removed from future updates of the guideline (and the removal will be noted in the updated guidelines). If there is emerging evidence on the efficacy or safety of a therapeutic agent not mentioned in the current version of the guideline it will be included in future updates of the guideline.

These recommendations are intended to inform patients, clinicians, and other health professionals by providing the latest available evidence.

Methods

This guideline was developed using the GRADE approach for evidence assessment. In addition, given the need for an urgent response to a major public health crisis, the methodological approach was modified according to the Guidelines International Network/McMaster checklist for the development of rapid recommendations [4].

Panel composition

The initial guideline panel assembled in March 2020 was composed of nine members including infectious diseases specialists as well as experts in public health as well as other front-

line clinicians, specializing in pharmacology, pediatrics, medical microbiology, preventive care, critical care, hepatology, nephrology and gastroenterology. Organizational representatives were included from the Society for Healthcare Epidemiology of America (SHEA), and the Pediatric Infectious Diseases Society (PIDS). In May 2020, an additional panel member was included as a representative from the Society of Infectious Diseases Pharmacists (SIDP). The Evidence Foundation provided technical support and guideline methodologists for the development of this guideline.

Disclosure and Management of Potential Conflicts of Interest

The conflict of interest (COI) review group for this guideline includes two representatives from IDSA who are responsible for reviewing, evaluating and approving all disclosures. All members of the expert panel have complied with the COI process for reviewing and managing conflicts of interest, which requires disclosure of any financial, intellectual, or other interest that might be construed as constituting an actual, potential, or apparent conflict, regardless of relevancy to the guideline topic. The assessment of disclosed relationships for possible COI is based on the relative weight of the financial relationship (i.e., monetary amount) and the relevance of the relationship (i.e., the degree to which an association might reasonably be interpreted by an independent observer as related to the topic or recommendation of consideration). The COI review group has ensured that the majority of the panel and chair is without potential relevant (related to the topic) conflicts for the duration of their term on the panel. The chair and all members of the technical team have been determined to be unconflicted.

Question generation

Clinical questions included in this guideline were developed into a PICO format (Population, Intervention, Comparison, Outcomes) [5] and prioritized according to available evidence that met the minimum acceptable criteria (i.e., the body of evidence reported on at least a case-series design, case reports were excluded). Panel members prioritized patient-

important outcomes such as mortality, development of ARDS (need for non-invasive or invasive ventilation) and clinical improvement (such as disease-oriented outcomes inferred by radiological findings or virologic cure), and severe adverse events (SAE) leading to treatment discontinuation. Serious adverse events are death, life threatening reactions, those that require hospitalization, result in disability or permanent damage or require an intervention to prevent permanent impairment [6]. Additional drug specific harms were evaluated when clinically relevant, including possible drug-drug reactions, if applicable.

Search strategy

The National Institute for Health and Care Excellence (NICE) highly-sensitive search was reviewed by the methodologist in consultation with the technical team information specialist and was determined to have high sensitivity [7]. An additional term, COVID, was added to the search strategy used in addition to the treatment terms identified in the PICO questions (**Table s1**). Ovid Medline and Embase were searched from 2019 through September 18, 2020. Horizon scans have been performed regularly during the evidence assessment and recommendation process to locate additional grey literature and manuscript pre-prints. Reference lists and literature suggested by panelists were reviewed for inclusion. No restrictions were placed on language or study type.

Screening and study selection

Two reviewers independently screened titles and abstracts, as well as eligible full-text studies. When acceptable RCTs of effectiveness were found, no additional non-randomized studies or non-comparative evidence (i.e., single-arm case series) were sought. Evidence from single arm studies reporting on non-comparative rates of outcomes of interest were included if a historical control event rate could be estimated from the literature. Reviewers extracted relevant information into a standardized data extraction form.

For several interventions, no direct evidence was available other than case reports or mechanistic considerations. The panel either decided to include plausible indirect evidence and

make a recommendation (e.g., from studies of SARS-CoV) or to provide a short narrative discussion of the intervention.

Data collection and analysis

Data extracted from the available evidence included: mortality, clinical progression or improvement as reported in the studies, virologic clearance, and adverse events. Where applicable, data were pooled using random effects model (fixed effects model for two or fewer trials or pooling of rates) using RevMan [8].

Risk of bias and certainty of evidence

Risk of bias was assessed using the Cochrane Risk of Bias Tool for RCTs and the Risk of Bias Instrument for Non-randomized Studies – of Interventions (ROBINS-I) [9, 10]. The certainty of evidence was assessed using the GRADE approach [11]. Within GRADE, the body of evidence across each outcome is assessed for domains that may reduce or increase one’s certainty in the evidence. Factors that may reduce one’s certainty include risk of bias (study limitations), inconsistency (unexplained heterogeneity across study findings), indirectness (applicability or generalizability to the research question), imprecision (the confidence in the estimate of an effect to support a particular decision) or publication bias (selective publication of studies). One’s certainty in the evidence may be strengthened if the following considerations are present: large or very large magnitude of effect, evidence of a dose-response gradient, or opposing residual confounding. GRADE summary of findings tables were developed in GRADEpro Guideline Development Tool [12].

As higher quality direct evidence for clinical outcomes becomes available, outcomes previously deemed critical by the panel became less important for decision-making. For example, at the time of the first guideline, clinical improvement outcomes (e.g., need for mechanical ventilation) were not reported, only the results of radiographic findings. However, with the recent publication of RCTs and non-randomized studies reporting on direct measures

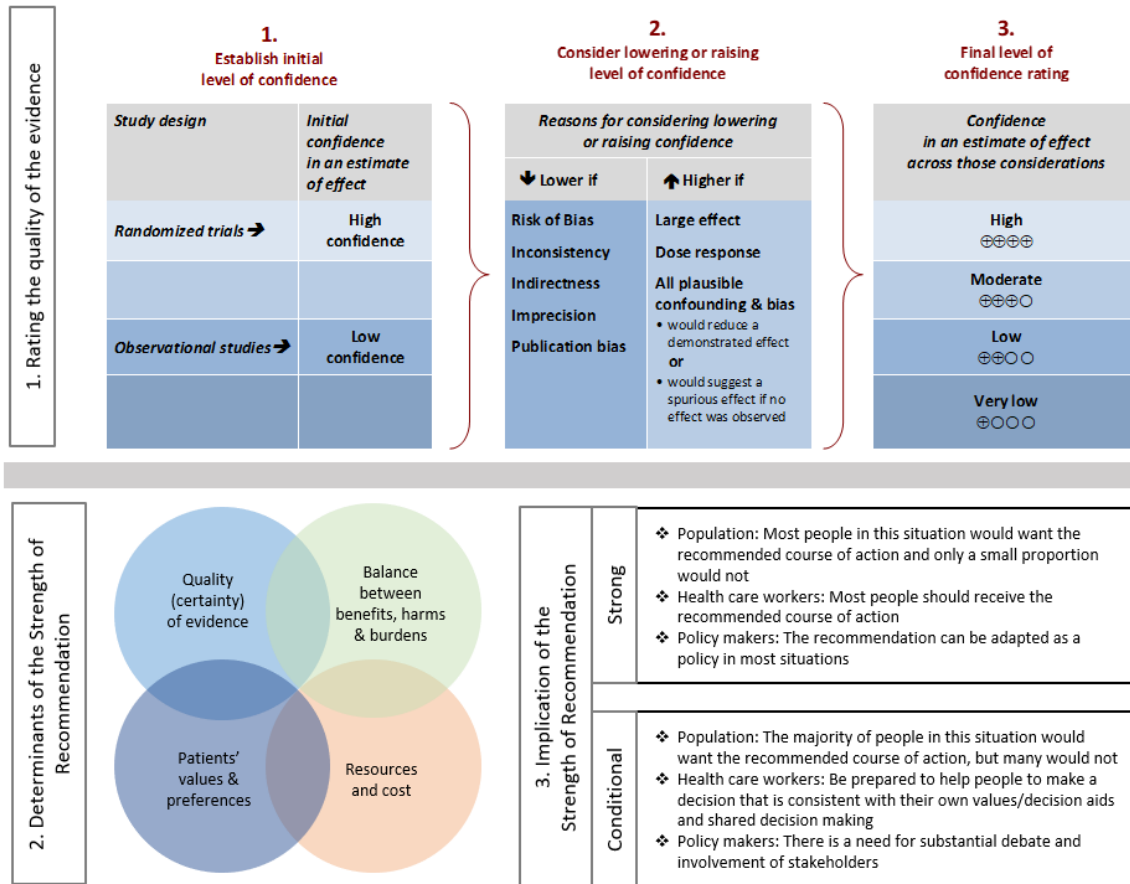
of clinical improvement, results of radiographic studies were deemed to be less critical for decision making.

Evidence to recommendations

The panel considered core elements of the GRADE evidence in the decision process, including Certainty of evidence and balance between desirable and undesirable effects. Additional domains were acknowledged where applicable (feasibility, resource use, acceptability). For all recommendations, the expert panelists reached consensus. Voting rules were agreed on prior to the panel meetings for situations when consensus could not be reached.

As per GRADE methodology, recommendations are labeled as “strong” or “conditional”. The words “we recommend” indicate strong recommendations and “we suggest” indicate conditional recommendations. [Figure 1](#) provides the suggested interpretation of strong and weak recommendations for patients, clinicians, and healthcare policymakers. For recommendations where the comparators are not formally stated, the comparison of interest is implicitly referred to as “not using the intervention”. These recommendations acknowledge the current “knowledge gap” and aim at avoiding premature favorable recommendations for their use and to avoid encouraging the rapid diffusion of potentially ineffective or harmful interventions. Detailed suggestions about the specific research questions that should be addressed are found in the table (see **Table s2**).

Figure 1. Approach and implications to rating the quality of evidence and strength of recommendations using the GRADE methodology (unrestricted use of the figure granted by the U.S. GRADE Network)



Review process

This guideline has been rapidly reviewed and approved by the IDSA Board of Directors Executive Committee external to the guideline development panel. SHEA and PIDS have reviewed and provided endorsement of its contents.

Updating process and terminology

Regular, frequent screening of the literature will take place to determine the need for revisions based on the likelihood that any new data will have an impact on the recommendations. When necessary, the entire expert panel is reconvened to discuss potential changes.

Changes to these guidelines will fall into one of two categories: update or amendment. An update involves a search for new studies, and if any new studies are found, they will be critically appraisal and the pertinent section will be removed and replaced with the updated section. An amendment involves a change or correction to the document, without any search for new studies and their appraisal. It will also involve changes made to clarify or explain a section based on “living” feedback from the readers.

Guideline revisions may result in major, minor, or “patch” version changes, defined as follows:

- Major version (e.g., 1.0.0): Synonymous with a newly published version in the journal. This is usually called a "breaking version", i.e., prior recommendations may not be valid anymore.
- Minor version (e.g., 1.1.0): Includes new information, maybe even added PICOs, but not a breaking version, i.e., existing recommendations are still valid, although new recommendations may be available.
- Patch version (e.g., 1.0.1): Small changes, i.e., typos, adding words, removing words, but there are no material changes to the document or changes in recommendations.

Results

Systematic review and horizon scan of the literature identified 2030 references of which 48 informed the evidence base for these recommendations (**Figure s1**). Characteristics of the included studies can be found in the supplementary materials.

Hydroxychloroquine/Chloroquine; Hydroxychloroquine/Chloroquine plus Azithromycin

Section last reviewed and updated 12/23/2020

Recommendation 1: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends against hydroxychloroquine*. (Strong recommendation, Moderate certainty of evidence)

- **Remark:** Chloroquine is considered to be class equivalent to hydroxychloroquine.

Recommendation 2: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends against hydroxychloroquine* plus azithromycin. (Strong recommendation, Low certainty of evidence)

- **Remark:** Chloroquine is considered to be class equivalent to hydroxychloroquine.

The last literature search was conducted on December 14, 2020.

Why are hydroxychloroquine and hydroxychloroquine plus azithromycin considered for treatment?

Hydroxychloroquine (HCQ) and chloroquine are 4-aminoquinoline drugs developed in the mid-20th century for the treatment of malaria [13]. Hydroxychloroquine differs from chloroquine only in the addition of a hydroxyl group and is associated with a lower incidence of adverse effects with chronic use [13]. Both drugs have been used in the treatment of autoimmune diseases because of their immunomodulatory effects on several cytokines, including interleukin-1 (IL-1) and IL-6 [13]. There is some evidence that these drugs also have antiviral properties against many different viruses, including the coronaviruses [14, 15]. They have demonstrated *in vitro* activity against SARS-CoV-2, which range considerably between studies, but are generally within the range of predicted achievable tissue concentrations [14, 16-18]. The *in vitro* activity, the extensive use for other conditions, and widespread availability of generic versions of the drug made it an attractive option for treatment of COVID-19. Interest in combinations of HCQ with azithromycin (AZ) began when investigators in a small, uncontrolled study of hydroxychloroquine use for COVID-19 noticed a higher frequency of patients achieving virologic response in the six subjects who received AZ to prevent bacterial infection [19]. Azithromycin, widely utilized as an antibacterial agent, has also been shown to

have *in vitro* antiviral activity against a variety of ribonucleic acid viruses [20-22]. While the exact mechanism of antiviral activity is unknown, possibilities include inhibiting endocytosis and limiting viral replication [23] and the induction of interferon [22, 24]. Macrolides have also been shown to have anti-inflammatory activity [25, 26].

Summary of the evidence

Our search identified eight RCTs and seven comparative cohort studies of hospitalized patients with confirmed COVID-19 treated with HCQ with reported mortality, clinical progression or clinical improvement, and adverse events outcomes [27-41] (**Table s3a**) ([Table 1](#)).

In addition, we identified one RCT, four comparative cohort studies, and one case-control study reporting adjusted analyses of hospitalized patients with confirmed COVID-19 treated with HCQ plus AZ with reported mortality, failure of virologic clearance (assessed with polymerase chain reaction [PCR] test), clinical improvement, and adverse events (i.e., significant QT prolongation leading to treatment discontinuation) [27, 28, 37, 39, 41, 42] (**Table s3b**) ([Table 2](#)).

Benefits

Hydroxychloroquine

Five RCTs showed a trend toward mortality among patients with COVID-19 treated with HCQ compared to those who were not (relative risk [RR]: 1.08; 95% confidence interval [CI]: 0.99, 1.19, Moderate certainty in the evidence) ([Table 1](#)) [28, 29, 33].

Hydroxychloroquine + Azithromycin

One RCT could not exclude the risk of in-hospital mortality among patients treated with HCQ+AZ compared to those not receiving HCQ or HCQ+AZ (hazard ratio [HR]: 0.64; 95% CI: 0.18, 2.21; Low certainty of evidence [CoE]) [28]. Three non-randomized studies failed to identify an association between treatment with HCQ+AZ and mortality: Ip reported an adjusted HR of 0.98 (95% CI: 0.75, 1.28); Magagnoli reported an adjusted HR in a subset after propensity

score adjustment of 0.89 (95% CI: 0.45, 1.77); Rosenberg 2020 reported an adjusted HR of 1.35 (95% CI: 0.79, 2.40) [37, 39, 41]. As stated in the HCQ section, one non-randomized study reported a reduction in mortality among patients receiving HCQ+AZ (HR: 0.29; 95% CI: 0.22, 0.40); however, it failed to adjust for the critical confounder of disease severity and imbalances in steroid use [27]. As described in the HCQ section, similar methodologic concerns exist among patients allocated to HCQ+AZ in the Arshad study, leading to several sources of bias in interpreting their favorable results.

Harms

Hydroxychloroquine

One RCT reported that persons treated with HCQ experienced a longer time until hospital discharge (median 16 days compared with 13 days) and lower probability of being discharged alive within the 28-day study period (rate ratio: 0.92; 95% CI: 0.85, 0.99) [29]. In addition, persons treated with HCQ who were not on mechanical ventilation at baseline were more likely to be placed on mechanical ventilation during follow up (rate ratio: 1.10; 95% CI: 0.92, 1.31; Low CoE) [29, 32]. Across the body of evidence from four RCTs, treatment with HCQ may increase the risk of experiencing adverse events (RR: 2.36; 95% CI: 1.49, 3.75; Low CoE) and severe adverse events (adjusted odds ratio: 1.26; 95% CI: 0.56, 2.84; Low CoE) [28, 30, 31, 35]. One RCT and two non-randomized studies suggest increased risk of QT prolongation among patients treated with HCQ compared to those not receiving HCQ (RR: 8.47; 95% CI: 1.14, 63.03; Low CoE and RR: 2.89; 95% CI: 1.62, 5.16; Very low CoE, respectively) [28, 38, 39]. In addition, Rosenberg 2020 reported 16% of patients in the HCQ arm experienced arrhythmias compared with 10% in the non-HCQ arm (RR: 1.56; 95% CI: 0.97, 2.50; Very low CoE).

Gastrointestinal side effects occurred in 7% of patients in a prospective cohort study in 224 COVID-19 uninfected patients with systemic lupus erythematosus (SLE) who received either chloroquine or hydroxychloroquine for routine care [43].

While the 4-aminoquinolines, chloroquine and HCQ, have not been demonstrated to cause hemolysis in people with glucose-6-phosphate dehydrogenase (G6PD) deficiency [44, 45],

case reports of hemolysis have emerged when these agents have been used for the treatment of COVID-19 [46-48]. It is possible that infection with SARS-CoV-2 may trigger hemolysis in G6PD deficient individuals in the absence of a 4-aminoquinolone. Caution should be exercised in administering these agents to G6PD deficient individuals with COVID-19, particularly if used for extended durations.

Renal clearance accounts for 15-25% of total clearance of HCQ; however, dose adjustments are not recommended with kidney dysfunction. Chloroquine and HCQ are metabolized by cytochrome P450 isoenzymes 2C8, 2D6, and 3A4 [49]. Therefore, inhibitors and inducers of these enzymes may result in altered pharmacokinetics of these agents.

Hydroxychloroquine + Azithromycin

One RCT suggests increased risk of QT prolongation among patients treated with HCQ+AZ compared to those not receiving HCQ (RR: 8.50; 95% CI: 1.16, 62.31; Low CoE) [28]. Two studies described significant QT prolongation in 10 of 95 patients treated with HCQ+AZ, illustrating the high risk for clinically relevant arrhythmias with this treatment [50, 51]. In addition, several case reports of QT prolongation related to HCQ have also been published [52-55]. A case-control study of persons with COVID-19 treated with HCQ+AZ compared to healthy, untreated controls reported higher values of minimum (415 vs. 376 ms), mean (453 vs. 407 ms) and maximum QTc-interval (533 vs. 452 ms) among COVID-19 cases (n=22) compared to controls (n=34) [42].

Additional case reports have cited the risk of a prolonged QT prolongation, torsades de pointes, and ventricular tachycardia in patients without COVID-19 receiving AZ alone. In a large cohort study, patients taking a five-day course of AZ had an increased risk of sudden cardiac death with a HR of 2.71 (1.58-4.64) vs. 0.85 (0.45-1.60), compared to patients receiving either no antibiotic or amoxicillin, respectively [56]. Given the cumulative effect on cardiac conduction seen with HCQ and AZ, if this combination was used, baseline and follow-up echocardiogram (ECG) monitoring would be indicated, as well as careful surveillance for other concomitant medications known to prolong the QT interval.

Azithromycin has a low risk for cytochrome P450 interactions [57]; however, additional pharmacologic adverse events including gastrointestinal effects and QT prolongation need to be carefully considered, particularly in the outpatient setting where frequent ECG monitoring is not feasible.

Providers are encouraged to visit resources such as <https://www.covid19-druginteractions.org/> to aid in the evaluation and management of drug interactions with current and emerging investigational agents for COVID-19.

Other considerations

The panel agreed that the overall certainty of evidence against treatment with HCQ was moderate due to concerns with imprecision around the risk for a trend towards harms from increased mortality. When considering the addition of AZ, the overall certainty of the evidence was low; however, the panel recognized even greater concern with the toxicity. In addition, based on the moderate certainty of increased QT prolongation, the panel determined that this demonstrated certain harm with uncertain benefit; therefore, the panel made a strong recommendation against HCQ+AZ.

Conclusions and research needs for this recommendation

The guideline panel recommends against the use of either HCQ alone or in combination with AZ in the hospital setting as higher certainty benefits (e.g., mortality reduction) are now highly unlikely even if additional high quality RCTs would become available.

This recommendation does not address the use of azithromycin for secondary bacterial pneumonia in patients with COVID-19 (**Table s2**).

Table 1. GRADE evidence profile, Recommendation 1

Question: Hydroxychloroquine compared to no hydroxychloroquine for hospitalized patients with COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Hydroxychloroquine	no HCQ	Relative (95% CI)	Absolute (95% CI)		
Mortality (RCTs) (follow up: range 22 days to 49 days)												
5 ^{1,2,3,4,5}	randomized trials	not serious ^a	not serious	not serious ^b	serious ^c	none	561/2976 (18.9%)	908/4532 (20.0%)	RR 1.08 (0.99 to 1.19)	16 more per 1,000 (from 2 fewer to 38 more)	⊕⊕⊕○ MODERATE	CRITICAL
Clinical status (assessed with: 7-point scale; higher signifies worsening severity)												
1 ²	randomized trials	serious ^d	not serious	not serious	serious ^e	none	159	173	-	median 1.21 higher (0.69 higher to 2.11 higher)	⊕⊕○○ LOW	CRITICAL
Progression to invasive mechanical ventilation												
2 ^{1,3}	randomized trials	serious ^f	not serious	not serious	serious ^c	none	193/2162 (8.9%)	281/3447 (8.2%)	RR 1.10 (0.92 to 1.31)	8 more per 1,000 (from 7 fewer to 25 more)	⊕⊕○○ LOW	CRITICAL
Arrhythmias												
1 ⁶	observational studies	very serious ^g	not serious	not serious	very serious ^{e,h}	none	44/271 (16.2%)	23/221 (10.4%)	RR 1.56 (0.97 to 2.50)	58 more per 1,000 (from 3 fewer to 156 more)	⊕○○○ VERY LOW	CRITICAL
Adverse events, any												
4 ^{2,7,8,9}	randomized trials	serious ⁱ	not serious	not serious	serious ^e	none	94/315 (29.8%) ^j	18/176 (10.2%) ^k	RR 2.36 (1.49 to 3.75)	139 more per 1,000 (from 50 more to 281 more)	⊕⊕○○ LOW	IMPORTANT

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Hydroxychloroquine	no HCQ	Relative (95% CI)	Absolute (95% CI)		

Severe AEs (assessed with: untoward medical event leading to death, a life-threatening experience, prolongation of hospitalization, or persistent or significant disability or incapacity)

1 ⁴	randomized trials	not serious	not serious	not serious	very serious ^e	none	14/242 (5.8%)	11/237 (4.6%)	OR 1.26 (0.56 to 2.84) ⁱ	11 more per 1,000 (from 20 fewer to 75 more)	⊕⊕○○ LOW	CRITICAL
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QT prolongation (RCTs)

1 ²	randomized trials	not serious	not serious	not serious	very serious ^h	none	13/89 (14.6%)	1/58 (1.7%)	RR 8.47 (1.14 to 63.03)	129 more per 1,000 (from 2 more to 1,000 more)	⊕⊕○○ LOW	IMPORTANT
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QT prolongation (NRS)

2 ^{6,10}	observational studies	very serious ^{g,m}	not serious	not serious	serious ^h	none	46/355 (13.0%)	13/311 (4.2%)	RR 2.89 (1.62 to 5.16)	79 more per 1,000 (from 26 more to 174 more)	⊕○○○ VERY LOW	IMPORTANT
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GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; RR: Risk ratio; OR: Odds ratio

Explanations

- Co-interventions were provided to patients in both studies but balanced across arms.
- Cavalcanti 2020 excludes persons receiving supplemental oxygen at a rate of more than 4 liters per minute.
- The 95% CI cannot exclude the potential for no benefit or harm.
- Cavalcanti was an open-label trial.

- e. The 95% CI includes the potential for both benefit and harm. Few events suggest the potential for fragility in the estimate.
- f. Few events suggest the potential for fragility in the estimate.
- g. Concerns with unmeasured and residual confounding. Multiple co-interventions received across arms.
- h. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- i. Did not report on blinding (including outcome adjudication committee), sequence generation or allocation concealment; Chen J 2020: all patients received nebulized alpha-interferon, 80% vs. 67.7% of subjects received Abidol in the hydroxychloroquine vs. placebo arm, respectively. Two subjects in the control arm received lopinavir/ritonavir.
- j. Chen J 2020: 4 AEs include diarrhea, fatigue and transient AST elevation. Chen Z 2020: 1 rash, 1 headache. Tang 2020: 21 AEs include disease progression (1%), URI (1%), diarrhea (10%), vomiting (3%).
- k. 3 AEs reported in 2 patients include: AST elevation, creatinine elevation and anemia
- l. aOR: age, sex, baseline COVID Outcome Scale category, baseline Sequential Organ Failure Assessment score, and duration of acute respiratory infection symptoms prior to randomization
- m. Mahevas 2020 does not report on AEs in the comparator arm.

References

1. 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): 2030-40.
2. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without Azithromycin in Mild-to-Moderate Covid-19. *N Engl J Med* **2020**.
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**.
4. Self WH, Semler MW, Leither L, et al. Effect of hydroxychloroquine on clinical status at 14 days in hospitalized patients with COVID-19: A randomized clinical trial. *JAMA* **2020**
5. Ulrich RJ, Troxel AB, Carmody E, et al. Treating COVID-19 With Hydroxychloroquine (TEACH): A Multicenter, Double-Blind Randomized Controlled Trial in Hospitalized Patients *Open Forum Infect Dis* **2020**
6. 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**.
7. Chen J, LIU D, LIU L, et al. A pilot study of hydroxychloroquine in treatment of patients with moderate COVID-19. *Journal of Zhejiang University (Medical Sciences)* **2020**; 49(1): 0-.
8. Chen Z, Hu J, Zhang Z, et al. Efficacy of hydroxychloroquine in patients with COVID-19: results of a randomized clinical trial. *medRxiv* **2020**.
9. 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.
10. Mahevas M, Tran V-T, Roumier M, et al. No evidence of clinical efficacy of hydroxychloroquine in patients hospitalized for COVID-19 infection with oxygen requirement: results of a study using routinely collected data to emulate a target trial. *MedRxiv* **2020**.

Table 2. GRADE evidence profile, Recommendation 2

Question: Hydroxychloroquine and azithromycin compared to no hydroxychloroquine/azithromycin for hospitalized patients with COVID-19

Certainty assessment							No of patients		Effect		Certainty	Importance
No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Hydroxychloroquine and azithromycin	no HCQ/azithromycin	Relative (95% CI)	Absolute (95% CI)		

Mortality (RCTs) (follow up: range 22 days to 49 days)

1 ¹	randomized trials	not serious ^a	not serious	not serious ^b	very serious ^{c,d}	none	5/172 (2.9%)	6/173 (3.5%)	HR 0.64 (0.18 to 2.21)	12 fewer per 1,000 (from 28 fewer to 40 more)	⊕⊕○○ LOW	CRITICAL
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Mortality (NRS)

3 ^{2,3,4}	observational studies	very serious ^e	not serious	not serious	serious ^d	none	Three non-randomized studies failed to identify an association between persons treated with HCQ + AZ and mortality: Ip reported an adjusted HR of 0.98 (95% CI: 0.75, 1.28); Magagnoli reported an adjusted HR in a subset after propensity score adjustment of 0.89 (95% CI: 0.45, 1.77); Rosenberg 2020 reported an adjusted hazard ratio (HR) of 1.35 (95% CI: 0.79, 2.40)(Ip, Magagnoli 2020, Rosenberg 2020).			⊕○○○ VERY LOW	CRITICAL
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Clinical status (assessed with: 7-point scale, higher values represent worse clinical outcomes)

1 ¹	randomized trials	serious ^f	not serious	not serious ^b	serious ^{d,g}	none	172	173	-	MD 0.99 higher (0.57 higher to 1.73 higher)	⊕⊕○○ LOW	CRITICAL
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Virologic Failure (follow up: range 5 days to 6 days; assessed with: PCR Test)

2 ^{5,6,7}	observational studies	very serious ^h	serious ⁱ	serious ^j	serious ^c	none	29/71 (40.8%) ^k	12/12 (100.0%) ^l	not estimable		⊕○○○ VERY LOW	IMPORTANT
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QT prolongation (RCTs)

1 ¹	randomized trials	not serious	not serious	serious ^{m,n}	serious ^c	none	17/116 (14.7%)	1/58 (1.7%)	RR 8.50 (1.16 to 62.31)	129 more per 1,000 (from 3 more to 1,000 more)	⊕⊕○○ LOW	IMPORTANT
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QT prolongation (NRS)

2 ^{7,8}	observational studies	very serious ^h	not serious	serious ⁿ	serious ^c	none	10/95 (10.5%) ⁿ	-	-	-	⊕○○○ VERY LOW	IMPORTANT
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Serious adverse events

1 ¹	randomized trials	serious ^f	not serious	not serious ^o	serious ^{c,d}	none	5/239 (2.1%)	0/50 (0.0%)	RR 2.34 (0.13 to 41.61)	0 fewer per 1,000 (from 0 fewer to 0 fewer)	⊕⊕○○ LOW	CRITICAL
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GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; HR: Hazard Ratio; RR: Risk ratio

Explanations

- a. Co-interventions were provided to patients but balanced across arms. Cavalcanti 2020 was open label; however, likely did not influence the outcome of mortality.
- b. Cavalcanti 2020 excludes persons receiving supplemental oxygen at a rate of more than 4 liters per minute.
- c. A very small number of events. Optimal information size not met.
- d. The 95% CI includes the potential for both benefit and harm.
- e. Concerns with unmeasured and residual confounding. Multiple co-interventions received across arms.
- f. Cavalcanti was an open-label trial.
- g. Optimal information size not met.
- h. No contemporaneous control groups; no adjustment for baseline severity, resulting in high risk for residual confounding
- i. 2 case series from France showed divergent results
- j. Surrogate marker for mortality or resolution of COVID-19.
- k. Gautret reported 21/61 patients as positive at day 6 (estimate from supplied graph); Molina reported 8/10 patients positive at day 5 or 6. Pooled rates of virologic failure using fixed effects inverse variance method resulted in a 43% failure rate (95% CI, 32% to 54%)
- l. Gautret reported on a historical viral clearance rate in symptomatic patients from a separate hospital. Criteria for selection of patients remains unclear, as presumably a sizable number of untreated patients could have been available with data on viral clearance.
- m. Indirect measure of arrhythmia-specific mortality.
- n. Azithromycin and hydroxychloroquine can independently cause QT prolongation. Used together there can be an additive effect. Caution should be exercised with other agents known to prolong the QT interval.
- o. Molina 2020: 1/11 leading to treatment discontinuation; Chorin 2020: 9/84 with significant QTc prolongation of more than 500 ms.
- p. Cavalcanti 2020 serious adverse events included pulmonary embolism, QTc prolongation, myocardial infarction, abdominal-wall hemorrhage.

References

1. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without Azithromycin in Mild-to-Moderate Covid-19. *N Engl J Med* **2020**.
2. 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**.
3. Magagnoli J, Narendran S, Pereira F, et al. Outcomes of hydroxychloroquine usage in United States veterans hospitalized with Covid-19. *Med* **2020**.
4. Ip A, Berry DA, Hansen E, et al. Hydroxychloroquine and Tocilizumab Therapy in COVID-19 Patients-An Observational Study. *medRxiv* **2020**.
5. 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.
6. 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: an observational study. [Pre-print - not peer reviewed]. **2020**.
7. Molina JM, Delaugerre C, 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. *Médecine et Maladies Infectieuses* **2020**.
8. Chorin E, Dai M, Shulman E, et al. The QT Interval in Patients with SARS-CoV-2 Infection Treated with Hydroxychloroquine/Azithromycin. *medRxiv* **2020**.

Lopinavir/Ritonavir

Section last reviewed and updated 11/22/2020

Recommendation 3: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends against the use of the combination lopinavir/ritonavir. (Strong recommendation, Moderate certainty of evidence)

The last literature search was conducted on November 18, 2020.

Why is lopinavir plus ritonavir considered for treatment?

Lopinavir/ritonavir is a protease inhibitor that was FDA-approved for the treatment of HIV in September 2000. Ritonavir is added to the combination as a pharmacokinetic enhancer due to its strong inhibition of cytochrome P450 3A4, a metabolic pathway for lopinavir metabolism. Lopinavir/ritonavir demonstrated in vitro inhibition of SARS CoV-1 and MERS-CoV replication [58-60]. A trial of lopinavir/ritonavir and ribavirin vs historical controls in SARS CoV-1 patients, showed a reduced rate of ARDS and mortality in those receiving lopinavir/ritonavir. This study had limitations including a control group from early in the outbreak when management strategies likely differed significantly [61]. During the MERS outbreak, case reports cited efficacy of lopinavir/ritonavir with interferon in the management of MERS patients [62, 63]. During the early phase of COVID-19, triple combination of interferon beta-1b, lopinavir-ritonavir, and ribavirin shortened the duration of viral shedding and hospital stay in patients with mild to moderate COVID-19 in an open-label, randomized, phase II trial [64].

Summary of the evidence

Three RCTs reported on treatment with combination lopinavir/ritonavir or placebo for hospitalized patients with COVID-19 [32, 65, 66] ([Table 3](#)). The trials reported on the following outcomes: mortality, failure of clinical improvement (measured using a 7-point scale or hospital discharge), need for mechanical ventilation, and adverse events leading to treatment discontinuation.

Benefits

Among hospitalized patients with COVID-19, treatment with lopinavir/ritonavir failed to show or exclude a beneficial effect on mortality or need for invasive mechanical ventilation (RR: 1.00; 95% CI: 0.89, 1.13; moderate certainty of evidence and RR: 1.12; 95% CI: 0.93, 1.34; low CoE). Similarly, lopinavir/ritonavir may reduce failure of clinical improvement at 14 days, but it is uncertain (RR: 0.78; 95% CI: 0.63, 0.97; very low CoE).

Harms

RECOVERY reported 1/1588 serious adverse event due to treatment with lopinavir-ritonavir [66]; however, nearly 14% of lopinavir/ritonavir recipients in Cao 2020 were unable to complete the full 14-day course of administration. This was due primarily to gastrointestinal adverse events, including anorexia, nausea, abdominal discomfort, or diarrhea, as well as two serious adverse events, both acute gastritis. Two recipients had self-limited skin eruptions. Such side effects, including the risks of hepatic injury, pancreatitis, more severe cutaneous eruptions, and QT prolongation, and the potential for multiple drug interactions due to CYP3A inhibition, are well documented with this drug combination. The side-effect profile observed in these trials raise concerns about the use of higher or more prolonged lopinavir–ritonavir dose regimens in efforts to improve outcomes.

Other considerations

The panel determined the certainty of evidence to be moderate due to concerns with imprecision. The guideline panel made a strong recommendation against treatment with the combination of lopinavir/ritonavir for hospitalized patients with COVID-19.

Conclusions and research needs for this recommendation

The guideline panel recommends against treatment with lopinavir/ritonavir in hospitalized patients with COVID-19.

Table 3. GRADE evidence profile, Recommendation 3

Question: Lopinavir-ritonavir compared to no Lopinavir-ritonavir for hospitalized patients with severe COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Lopinavir/Ritonavir	Placebo	Relative (95% CI)	Absolute (95% CI)		
Mortality (follow up: 28 days)												
3 ^{1,2,3}	randomized trials	not serious ^a	not serious	not serious	serious ^b	none	538/3111 (17.3%) ^c	938/4896 (19.2%)	RR 1.00 (0.89 to 1.13)	0 fewer per 1,000 (from 21 fewer to 25 more)	⊕⊕⊕○ MODERATE	CRITICAL
Invasive mechanical ventilation (follow up: 28 days)												
2 ^{1,3}	randomized trials	serious ^{a,d}	not serious	not serious	serious ^b	none	166/1655 (10.0%)	297/3380 (8.8%)	RR 1.12 (0.93 to 1.34)	11 more per 1,000 (from 6 fewer to 30 more)	⊕⊕○○ LOW	CRITICAL
AEs leading to treatment discontinuation												
1 ¹	randomized trials	serious ^a	not serious	not serious	very serious ^e	none	Nearly 14% of lopinavir–ritonavir recipients were unable to complete the full 14-day course of administration. This was due primarily to gastrointestinal adverse events, including anorexia, nausea, abdominal discomfort, or diarrhea, as well as two serious adverse events, both acute gastritis. Two recipients had self-limited skin eruptions. Such side effects, including the risks of hepatic injury, pancreatitis, more severe cutaneous eruptions, and QT prolongation, and the potential for multiple drug interactions due to CYP3A inhibition, are well documented with this drug combination. The side-effect profile observed in the current trial arouses concern about the use of higher or more prolonged lopinavir–ritonavir dose regimens in efforts to improve outcomes.				⊕○○○ VERY LOW	IMPORTANT
Failure of clinical improvement at 14 days (follow up: 14 days)												
1 ¹	randomized trials	serious ^a	not serious	not serious	very serious ^f	none	54/99 (54.5%)	70/100 (70.0%)	RR 0.78 (0.62 to 0.97)	154 fewer per 1,000 (from 266 fewer to 21 fewer)	⊕○○○ VERY LOW	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Lopinavir/Ritonavir	Placebo	Relative (95% CI)	Absolute (95% CI)		
GRADE Working Group grades of evidence												
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect												
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different												
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect												
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect												
Risk of bias: Study limitations												
Inconsistency: Unexplained heterogeneity across study findings												
Indirectness: Applicability or generalizability to the research question												
Imprecision: The confidence in the estimate of an effect to support a particular decision												
Publication bias: Selective publication of studies												

CI: Confidence interval; RR: Risk ratio

Explanations

- Unblinded studies which can affect outcomes that require judgment, such as how investigators judge clinical improvement or decide to stop the treatment in patients with side effects.
- 95% CI may not include a meaningful difference.
- Modified intention to treat data from Cao 2020 used for this outcome; some deaths were excluded when drug was not given.
- One patient randomized to the lopinavir-ritonavir arm in Cao 2020 was mechanically ventilated at baseline.
- Small number of events making estimates highly uncertain
- The upper boundary of the 95% confidence interval crosses the threshold of meaningful improvement as the worst case estimate is a 3% RRR.

References

- 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**.
- Pan H, Peto R, Karim QA, et al. Repurposed antiviral drugs for COVID-19; interim WHO SOLIDARITY trial results. MedRxiv **2020**. Available at: <https://doi.org/10.1101/2020.10.15.20209817> [Preprint 15 October 2020].
- RECOVERY Collaborative Group, Horby PW, Mafham M, et al. Lopinavir-ritonavir in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. The Lancet **2020**; 396(10259): 1345-52.

Glucocorticoids

Section last reviewed and updated 9/25/2020

Recommendation 4: Among hospitalized critically ill patients* with COVID-19, the IDSA guideline panel recommends dexamethasone rather than no dexamethasone. (Strong recommendation, Moderate certainty of evidence)

- **Remark:** If dexamethasone is unavailable, equivalent total daily doses of alternative glucocorticoids may be used. Dexamethasone 6 mg IV or PO for 10 days (or until discharge) or equivalent glucocorticoid dose may be substituted if dexamethasone unavailable. Equivalent total daily doses of alternative glucocorticoids to dexamethasone 6 mg daily are methylprednisolone 32 mg and prednisone 40 mg.

Recommendation 5: Among hospitalized patients with severe, but non-critical, COVID-19 the IDSA guideline panel suggests dexamethasone rather than no dexamethasone. (Conditional recommendation, Moderate certainty of evidence)**

- **Remark:** Dexamethasone 6 mg IV or PO for 10 days (or until discharge) or equivalent glucocorticoid dose may be substituted if dexamethasone unavailable. Equivalent total daily doses of alternative glucocorticoids to dexamethasone 6 mg daily are methylprednisolone 32 mg and prednisone 40 mg.

Recommendation 6: Among hospitalized patients with non-severe* COVID-19 without hypoxemia requiring supplemental oxygen, the IDSA guideline panel suggests against the use of glucocorticoids. (Conditional recommendation, Low certainty of evidence)**

Severity definitions:

*Critical illness is defined as patients on mechanical ventilation and ECMO. Critical illness includes end organ dysfunction as is seen in sepsis/septic shock. In COVID-19, the most commonly reported form of end organ dysfunction is ARDS

**Severe illness is defined as patients with $\text{SpO}_2 \leq 94\%$ on room air, including patients on supplemental oxygen.

***Non-severe illness is defined as patient with a $\text{SpO}_2 > 94\%$ not requiring supplemental oxygen.

The last literature search was conducted on September 4, 2020 and we identified eight RCTs and seven comparative non-randomized studies.

Why are corticosteroids considered for treatment?

In the early days of the SARS-CoV-2 pandemic, based on experience in both SARS and MERS, recommendations [67] cautioned against the use of systemic corticosteroids due to risk of worsening clinical status, delayed viral clearance, and adverse events [68-70]. Given the hyper-inflammatory state in COVID-19, immunomodulatory approaches, including steroids, continue to be evaluated to address both ARDS and systemic inflammation. ARDS stemming from dysregulated systemic inflammation may translate into prolonged ventilatory requirements and in-hospital mortality. In non-viral ARDS settings there is increasing support for the role of steroids in the management of ARD [71]. A recent multicenter RCT in patients with moderate to severe ARDS demonstrated a reduced number of ventilatory days and reduction in mortality with use of a 10-day regimen of dexamethasone [72].

Summary of the evidence

Critical illness

Our search identified one systematic review that analyzed eight RCTs reporting on treatment with glucocorticoids among 1,844 critically ill patients with COVID-19 [73]. Three RCTs reported on patients treated with low- and high-dose dexamethasone [72, 74, 75]; three RCTs reported on patients treated with low-dose hydrocortisone [76-78]; and two RCTs reported on patients treated with high-dose methylprednisolone [73, 79]. The definition of critically ill varied across trials; however, the majority of patients had ARDS.

Severe and non-severe illness

Our search identified one RCT, one “partially” randomized trial, one prospective cohort, and five retrospective cohort studies [74, 80-86]. The RCT provided the best available evidence on treatment with corticosteroids for persons with COVID-19 [74] ([Tables 4-6](#)). Corral-Gudino et al. reported on a study that randomized patients to receive methylprednisolone or standard of care; however, patients expressing a preference for methylprednisolone were assigned to the same treatment arm [80]. Corral-Gudino et al. did not report the disaggregated results from the randomized trial; therefore, succumbing to the same potential for bias as reported subsequently for the non-randomized studies. The non-randomized studies had significant limitations with controlling for multiple co-interventions and disease severity at baseline [81-86]. All non-randomized studies had concerns with risk of bias due to lack of adjustment for critical confounders or potential for residual confounding. Timing of receipt, dose and duration of corticosteroids varied across studies.

The RECOVERY trial is a randomized trial among hospitalized patients in the United Kingdom [74]. In that study, 2,104 participants were randomized to receive dexamethasone (6 mg daily for up to 10 days) and 4,321 were randomized to usual care. The RECOVERY trial reported on the outcomes of mortality and hospital discharge. Participants and study staff were not blinded to the treatment arms.

Benefits

Critical illness

Among hospitalized, critically ill patients, the odds of mortality at 28 days was 34% less among patients treated with glucocorticoids than among patients not treated with glucocorticoids (OR: 0.66; 95% CI: 0.54; 0.82; High CoE). In addition, at 28 days, patients receiving dexamethasone were more likely to be discharged from the hospital (RR: 1.11; 95% CI: 1.04, 1.19; Moderate CoE).

Severe illness

Among hospitalized patients, 28-day mortality was 17% lower in the group that received dexamethasone than in the group that did not receive dexamethasone (RR 0.83; 0.74-0.92; Moderate CoE). In addition, at 28 days, patients receiving dexamethasone were more likely to be discharged from the hospital (RR: 1.11; 95% CI: 1.04, 1.19; Moderate CoE).

Non-severe illness

In a sub-group analyses of patients without hypoxia not receiving supplemental oxygen, there was no evidence for benefit and a trend toward harm with dexamethasone in participants who were not on supplemental oxygen (RR 1.22; 0.86, 1.75; Low CoE).

Harms

A systematic review of six studies did not report a difference in the events of serious adverse events experienced by patients randomized to receive treatment with glucocorticoids or no treatment with glucocorticoids (64/354 among those receiving glucocorticoids vs. 80/342 among those not receiving glucocorticoids).

Patients receiving a short course of steroids may experience hyperglycemia, neurological side effects (e.g., agitation/confusion), adrenal suppression, and risk of bacterial and fungal infection [81, 87, 88].

Other considerations

Critical illness

The panel agreed that the overall certainty of the evidence for treatment with glucocorticoids for patients with critical COVID-19 was moderate due to concerns with indirectness and imprecision.

Severe illness

The panel agreed the overall certainty of evidence for treatment with glucocorticoids for patients with severe COVID-19 as moderate due to concerns with indirectness since the evidence was from dexamethasone.

Non-severe illness

The panel agreed that the overall certainty of evidence for patients without hypoxemia requiring supplemental oxygen as low due to concerns with risk of bias (post hoc analysis) and imprecision.

The panel agreed the overall certainty of evidence for treatment with glucocorticoids for patients with severe COVID-19 as moderate due to concerns with indirectness since the evidence was

from dexamethasone. The panel agreed that the overall certainty of evidence for patients without hypoxemia requiring supplemental oxygen as low due to concerns with risk of bias (post hoc analysis) and imprecision.

Conclusions and research needs for this recommendation

The guideline panel recommends dexamethasone for patients with critical COVID-19. The guideline panel suggests dexamethasone for patients with severe COVID-19. If dexamethasone is not available, then alternative glucocorticoids may be used (see details above). The guideline panel suggests against glucocorticoids for patients with COVID-19 without hypoxemia requiring supplemental oxygen.

Additional research is needed to inform the generalizability of treatment with different glucocorticoids for patients with COVID-19 (**Table s2**).

Table 4. GRADE evidence profile, Recommendation 4

Question: Glucocorticoids compared to no glucocorticoids for critically ill patients with COVID-19

Certainty assessment							No of patients		Effect		Certainty	Importance
No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	corticosteroids	no corticosteroids	Relative (95% CI)	Absolute (95% CI)		
Mortality (follow up: 28 days)												
7 ¹	randomized trials	not serious	not serious	not serious	not serious	none	280/749 (37.4%)	485/1095 (44.3%)	OR 0.66 (0.54 to 0.82)	99 fewer per 1,000 (from 143 fewer to 48 fewer)	⊕⊕⊕⊕ HIGH	CRITICAL
Hospital discharge (follow up: 28 days)												
1 ²	randomized trials	not serious ^a	not serious	serious ^b	not serious	none	1360/2104 (64.6%)	2639/4321 (61.1%)	RR 1.11 (1.04 to 1.19)	67 more per 1,000 (from 24 more to 116 more)	⊕⊕⊕○ MODERATE	IMPORTANT
Serious adverse events												
6 ¹	randomized trials	not serious	not serious	not serious	serious ^c	none	6 trials reported 64 events among 354 patients randomized to corticosteroids and 80 events among 342 patients randomized to standard care (Stern 2020).				⊕⊕⊕○ MODERATE	CRITICAL

CI: Confidence interval; **OR:** Odds ratio; **RR:** Risk ratio

Explanations

- a. Analysis adjusted for baseline age.
- b. Indirectness due to different health care system (allocation of intensive care resources in an unblinded study). Indirectness to other corticosteroids.
- c. The 95% CI includes the potential for both harm as well as benefit. Few events reported do not meet the optimal information size and suggest fragility in the estimate.

References

1. 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.
2. Horby P, Lim WS, Emberson J, et al. Effect of Dexamethasone in Hospitalized Patients with COVID-19: Preliminary Report. medRxiv 2020: 2020.06.22.20137273

Table 5. GRADE evidence profile, Recommendation 5

Question: Glucocorticoids compared to no glucocorticoids for hospitalized patients with severe but not critical COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	glucocorticoids	no glucocorticoids	Relative (95% CI)	Absolute (95% CI)		
Mortality (follow up: 28 days)												
1 ¹	randomized trials	not serious ^a	not serious	serious ^b	not serious	none	454/2104 (21.6%)	1065/4321 (24.6%)	RR 0.83 (0.74 to 0.92)	42 fewer per 1,000 (from 64 fewer to 20 fewer)	⊕⊕⊕○ MODERATE	CRITICAL
Hospital discharge (follow up: 28 days)												
1 ¹	randomized trials	not serious ^a	not serious	serious ^b	not serious	none	1360/2104 (64.6%)	2639/4321 (61.1%)	RR 1.11 (1.04 to 1.19)	67 more per 1,000 (from 24 more to 116 more)	⊕⊕⊕○ MODERATE	IMPORTANT
Adverse events												
							Patients receiving a short course of steroids may experience hyperglycemia, neurological side effects (e.g., agitation/confusion), adrenal suppression, and risk of infection (Salton 2020; Henzen 2000; Siemieniuk 2015).			-	CRITICAL	
GRADE Working Group grades of evidence												
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect												
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different												
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect												
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect												
Risk of bias: Study limitations												
Inconsistency: Unexplained heterogeneity across study findings												
Indirectness: Applicability or generalizability to the research question												
Imprecision: The confidence in the estimate of an effect to support a particular decision												
Publication bias: Selective publication of studies												

CI: Confidence interval; **RR:** Risk ratio

Explanations

- a. Analysis adjusted for baseline age.
- b. Indirectness due to different health care system (allocation of intensive care resources in an unblinded study). Indirectness to other corticosteroids.

Reference

1. Horby P, Lim WS, Emberson J, et al. Effect of Dexamethasone in Hospitalized Patients with COVID-19: Preliminary Report. medRxiv 2020: 2020.06.22.20137273. 2020.

Table 6. GRADE evidence profile, Recommendation 6

Question: Glucocorticoids compared to no glucocorticoids for hospitalized patients with COVID-19 not receiving supplemental oxygen

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	glucocorticoids	no glucocorticoids	Relative (95% CI)	Absolute (95% CI)		

Mortality (follow up: 28 days)

1 ¹	randomized trials	serious ^a	not serious	not serious	serious ^b	none	85/501 (17.0%)	137/1034 (13.2%)	RR 1.22 (0.93 to 1.61)	29 more per 1,000 (from 9 fewer to 81 more)	⊕⊕○○ LOW	CRITICAL
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Hospital discharge (follow up: 28 days)

1 ¹	randomized trials	serious ^a	not serious	not serious	serious ^c	none	366/501 (73.1%)	791/1034 (76.5%)	RR 0.99 (0.87 to 1.12)	8 fewer per 1,000 (from 99 fewer to 92 more)	⊕⊕○○ LOW	IMPORTANT
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Adverse events

							Patients receiving a short course of steroids may experience: hyperglycemia, neurological side effects (e.g., agitation/confusion), adrenal suppression, and risk of infection (Salton 2020; Henzen 2000; Siemieniuk 2015).			-		CRITICAL
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GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; **RR:** Risk ratio

Explanations

- RoB due to post-hoc subgroup effect among persons not receiving supplemental oxygen.
- The 95% CI includes the potential for appreciable harm and cannot exclude the potential for benefit. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- The 95% CI cannot exclude the potential for either appreciable harm or benefit.

Last updated February 22, 2021 and posted online at www.idsociety.org/COVID19guidelines.

Please check website for most updated version of these guidelines.

Reference

1. Horby P, Lim WS, Emberson J, et al. Effect of Dexamethasone in Hospitalized Patients with COVID-19: Preliminary Report. medRxiv **2020**: 2020.06.22.20137273.

Interleukin-6 Inhibitors

Section last reviewed and updated on 2/17/2021

Recommendation 7: Among hospitalized adults with progressive severe* or critical COVID-19 who have elevated markers of systemic inflammation, the IDSA guideline panel suggests tocilizumab in addition to standard of care (i.e., steroids) rather than standard of care alone. (Conditional recommendation, Low certainty of evidence)**

- **Remarks:**

- Patients, particularly those who respond to steroids alone, who put a high value on avoiding possible adverse events of tocilizumab and a low value on the uncertain mortality reduction, would reasonably decline tocilizumab.
- In the largest trial on the treatment of tocilizumab, criterion for systemic inflammation was defined as CRP ≥ 75 mg/L.

Severity definitions:

*Severe illness is defined as patients with SpO₂ $\leq 94\%$ on room air, including patients on supplemental oxygen.

**Critical illness is defined as patients on mechanical ventilation and ECMO. Critical illness includes end organ dysfunction as is seen in sepsis/septic shock. In COVID-19, the most commonly reported form of end organ dysfunction is ARDS.

The last literature search was conducted on February 11, 2021.

Why is tocilizumab considered for treatment?

Some patients with COVID-19 develop a hyperinflammatory syndrome that is characterized by elevations in proinflammatory cytokines and multiorgan dysfunction also known as the immunopathology of SARS-CoV-2 infection. The significance of these findings is unclear, however early descriptions found that those with elevated IL-6 levels and evidence of hyperinflammation had increased rates of more severe disease [89, 90]. Tocilizumab, a monoclonal anti-IL-6-receptor

blocking antibody, has been proposed as a therapeutic agent to mitigate hyperinflammation associated with COVID-19. Tocilizumab is FDA-approved for various rheumatologic conditions as well as cytokine release syndrome associated with CAR-T cell therapy.

Sarilumab, another IL-6 receptor antagonist, is currently FDA-approved for rheumatoid arthritis. Sarilumab has been used in open-label cohort studies for the management of severe COVID-19 and has undergone evaluation in unpublished RCTs for moderate and severe COVID-19 [91-95].

Summary of the evidence

Our search identified eight RCTs (including pre-prints) that reported on patients with severe COVID-19 randomized to treatment with tocilizumab (8 mg/kg) or placebo/usual care [96-103]. Gordon 2020, Horby 2021, Rosas 2020, and Veiga 2021 allowed for patients to be on mechanical ventilation at randomization, whereas the other trials included patients with a lower disease severity (e.g., allowed supplemental oxygen but excluded those on higher levels of oxygen support) or included patients with severe COVID with an inflammatory phenotype.

One trial, RECOVERY, contributed the majority of the weight in the analysis [98]. RECOVERY trial participants must have demonstrated clinical evidence of progressive COVID-19, which was defined as <92% oxygen saturation on room air or receiving oxygen and CRP \geq 75 mg/L. Use of steroids was balanced across both the participants receiving tocilizumab or not receiving tocilizumab. Following recommendations for treatment with glucocorticoids, 82% of participants in both arms received dexamethasone. While RECOVERY did not blind participants or healthcare personnel to the treatment arm randomized to, this likely would not introduce bias in the objective measurement of the outcome of mortality; however, was considered as a risk of bias consideration for the more subjectively measured outcomes, clinical deterioration, along with the total body of evidence contributing to those outcomes ([Table 7](#)). There is limited safety data in the preliminary report.

Both RECOVERY and REMAP CAP (the two tocilizumab trials that reported a benefit) initiated treatment early (randomization at median of two days of hospitalization in RECOVERY; <24 hours in

the ICU for REMAP-CAP), suggesting tocilizumab may be more beneficial in people with early rapidly progressive disease.

Benefits

Among hospitalized patients, tocilizumab showed a trend toward reduced mortality at 28 days compared to no tocilizumab treatment (RR: 0.91; 95% CI: 0.79, 1.04); moderate CoE). Tocilizumab demonstrated a lower relative risk of clinical deterioration, defined as death, need for mechanical ventilation, ECMO, or ICU admission, compared to placebo/usual care, RR: 0.83 (0.77, 0.89; moderate CoE). Four studies were not blinded, while healthcare personnel and outcome assessors were blinded in the remaining three trials. The panel noted that tocilizumab causes reduction in CRP levels, which would reveal the treatment arm designations of the patients, therefore introducing bias for the more subjectively measured outcomes of clinical deterioration and serious adverse events.

Harms

Serious adverse events among patients receiving tocilizumab did not differ from those not receiving tocilizumab (RR: 0.89; 95% CI: 0.74, 1.07; low CoE). An additional trial attributed treatment with tocilizumab to three serious adverse events; however, did not report events among patients not receiving tocilizumab [98]. Previously, tocilizumab has been associated with gastrointestinal perforations in non-COVID-19 settings, and case reports of bowel perforations have recently emerged with the use of tocilizumab for COVID-19 [104-107]. Increased infection risks have been noted in uncontrolled studies, and it is possible that this risk may be compounded by the combination of glucocorticoids and tocilizumab. [108, 109].

Other considerations

While the overall certainty of evidence for the trend toward a reduction in mortality was moderate, the panel believes that differences in mortality rates across the trials may be the result of the differences in baseline severity of study participants and timing of tocilizumab receipt in the disease course. In REMAP-CAP, tocilizumab was administered within 24 hours of participants' initiating organ support in an intensive care unit, raising the possibility that this may be the optimal

time to administer the drug. In RECOVERY, tocilizumab was administered to participants with oxygen saturation <92% on room air or receiving oxygen therapy, and CRP ≥75 mg/L. Given the reduction in clinical deterioration and trend toward mortality reduction, the guideline panel made a conditional recommendation for treatment of adults with tocilizumab.

The use of tocilizumab, as with other therapeutic agents that can suppress the immune system, presents additional considerations and potential concerns when used in immunocompromised hosts. The panel did not conduct an analysis of available data to assess differences in efficacy and/or adverse effects of tocilizumab among oncology or other immunocompromised patients at this time.

Conclusions and research needs for this recommendation

The guideline panel suggests tocilizumab for hospitalized adults with COVID-19.

Additional research is needed to understand the efficacy of tocilizumab when taken at different times during the course of disease. For example, there are no data to guide recommendations in patient <18 years old at this time. In addition, future studies are needed to inform the generalizability of tocilizumab with different IL-6 receptor inhibitors for patients with COVID-19 (**Table s2**). At the time of update, preliminary data from a trial of treatment with sarilumab has been shared as a pre-print [96]; however, number of patients who received sarilumab is limited (n=45) and the published manuscript was not available for analysis or inclusion to inform this recommendation. Other studies of sarilumab have not been made available.

Table 7. GRADE evidence profile, Recommendation 7

Question: Tocilizumab compared to no tocilizumab for hospitalized patients with COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tocilizumab	no tocilizumab	Relative (95% CI)	Absolute (95% CI)		

Mortality (follow up: range 28 days to 30 days)

8 1,2,3,4,5,6,7,8	randomized trials	not serious ^a	not serious	not serious	serious ^b	none	810/3280 (24.7%)	893/3054 (29.2%)	RR 0.91 (0.79 to 1.04)	26 fewer per 1,000 (from 61 fewer to 12 more)	⊕⊕⊕○ MODERATE	CRITICAL
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Clinical deterioration (follow up: range 14 days to 30 days)

7 1,2,3,4,5,6,8	randomized trials	serious ^c	not serious	not serious ^d	not serious	none	799/2712 (29.5%)	939/2503 (37.5%)	RR 0.83 (0.77 to 0.89)	64 fewer per 1,000 (from 86 fewer to 41 fewer)	⊕⊕⊕○ MODERATE	CRITICAL
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Serious Adverse Events

7 1,2,3,4,5,6,7,e	randomized trials	serious ^c	not serious	not serious	serious ^f	none	210/1249 (16.8%)	141/946 (14.9%)	RR 0.89 (0.74 to 1.07)	16 fewer per 1,000 (from 39 fewer to 10 more)	⊕⊕○○ LOW	CRITICAL
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GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; **RR:** Risk ratio

Explanations

- a. Although some studies did not blind participants or investigators, this is unlikely to affect the mortality outcome.

- b. 95% CI includes benefits as well as harms.
- c. Some studies lacked blinding and due to the mechanism of tocilizumab (reduction in inflammatory marker), unblinding likely occurred in the blinded studies.
- d. Definition of clinical deterioration varied, with all studies including need for ventilation and death, but other studies included need for ICU admission (2 studies) or PaO₂/FiO₂ ratio of less than 150 mmHg (1 study).
- e. The 95% CI includes both potential for harm as well as benefit; Few events reported do not meet the optimal information size and suggest fragility in the estimate.

References

1. Gordon AC, Mouncey PR, Al-Beidh F, et al. Interleukin-6 Receptor Antagonists in Critically Ill Patients with Covid-19 – Preliminary report. medRxiv **2021**: Available at: <https://www.medrxiv.org/content/10.1101/2021.01.07.21249390v2.full> [Preprint 9 January 2021].
2. Rosas I, Bräu N, Waters M, et al. Tocilizumab in hospitalized patients with COVID-19 pneumonia. medRxiv **2020**: Available at: <https://doi.org/10.1101/2020.08.27.20183442> [Preprint 12 September 2020].
3. 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* **2020**; 181(1): 32-40.
4. 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.
5. 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* **2020**; 181(1): 24-31.
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: 2333-44.
7. 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.
8. 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**: Available at: <https://doi.org/10.1101/2021.02.11.21249258> [Preprint 11 February 2021].

Convalescent Plasma for COVID-19 Treatment

Section last reviewed and updated 9/4/2020

Recommendation 8: Among patients who have been admitted to the hospital with COVID-19, the IDSA guideline panel recommends COVID-19 convalescent plasma only in the context of a clinical trial. (Knowledge gap)

The last literature search was conducted on August 21, 2020 and we identified two RCTs and nine non-randomized studies in OVID.

Why is convalescent plasma considered for treatment?

Convalescent plasma (CP) has been used as passive immunotherapy for prevention and treatment of infections for over 100 years [110, 111]. The predominant proposed protective mechanism is thought to be pathogen neutralization, although antibody dependent cellular cytotoxicity and phagocytosis may also play a role. With the advent of effective antimicrobial therapy (i.e., “the antibiotic era”) CP fell out of favor. In recent years, interest in this approach has been revived as a means of addressing viral epidemics such as Ebola, SARS-1 and MERS. Studies of CP derived from people who had recovered from those specific infections showed encouraging results, but were typically small, non-randomized and largely descriptive [112-114]. In the current pandemic, CP obtained from individuals who recovered from COVID-19 has been used in over 75,000 patients with moderate to severe infection as part of an expanded access program [115]. When measurement of neutralizing antibody titers is available, the FDA recommends neutralizing antibody titers of at least 1:160. Such assays have not been widely available and titers in plasma used in the expanded access program have often not been assessed prior to infusion. Multiple prospective clinical trials are in progress utilizing plasma with an IgG ELISA titer cutoff of $\geq 1:320$. Titers at that level are seen in about 80% of donors [116]. The probability of obtaining a neutralizing antibody titer of $\geq 1:160$ is highest (80% or greater) when the ELISA IgG titer is $\geq 1:1,350$ [117]. In an analysis of a convalescent plasma expanded access program, higher levels of antibodies were associated with significant improvements in mortality compared to those receiving CP with lower concentrations of neutralizing antibodies [115]. Regarding

timing of treatment: Based on historical experience and emerging data, efficacy is expected to be best when CP is given at earlier stages of the disease and particularly prior to when patients become critically ill [118, 119]. The analysis of the convalescent plasma expanded access program suggests the most benefit is seen when CP is given in the first three days from diagnosis [115]. On August 23, 2020, the FDA issued EUA for investigational convalescent plasma for the treatment of COVID-19 in hospitalized patients [120].

Summary of the evidence

Our search identified two RCTs, four comparative cohort studies, and three publications from a large (n=35,322), single-arm registry study among hospitalized patients with COVID-19 receiving COVID-19 convalescent plasma reporting on the outcomes of mortality, worsening oxygenation, and transfusion-related adverse events [115, 117-119, 121-125] ([Table 8](#)) ([Table s11](#)). This recommendation was informed by evidence from the two RCTs and the most recent registry study [115, 118, 122, 124], as they provided the best available evidence.

Two open-label trials randomized 189 patients to receive a transfusion with COVID-19 convalescent plasma [118, 122]. Both trials had concerns with risk of bias due to lack of adjustment for critical confounders or potential for residual confounding. Timing of receipt of COVID-19 convalescent plasma during the clinical course of the patients' illness varied across studies [118, 122]. Joyner 2020b provided comparative analyses examining early (≤ 3 days) vs later (> 4 days) receipt of convalescent plasma among 1,076 patients with severe or life-threatening COVID-19 enrolled in the US FDA Expanded Access Program for COVID-19 convalescent plasma study for whom relevant data was available. In addition, Joyner 2020c reported on safety outcomes of over 20,000 patients enrolled in the same US FDA Expanded Access Program for COVID-19 convalescent plasma study.

Benefits

Convalescent plasma transfusion failed to show or to exclude a beneficial or detrimental effect on mortality based on the body of evidence from RCTs (RR: 0.60; 95% CI: 0.33, 1.10; very low CoE); however, non-randomized studies suggest a decrease in mortality at 7- and 30-days (RR: 0.75; 95% CI: 0.61, 0.93; moderate CoE and RR: 0.65; 95% CI: 0.46, 0.92; moderate CoE, respectively). Similarly,

receipt of COVID-19 convalescent plasma may reduce the odds of worsening oxygenation (adjusted OR: 0.86; 95% CI: 0.75, 0.98; very low CoE); however, the evidence is uncertain because of concerns with risk of bias ([Table 8](#)).

Harms

In the largest safety study [124] (n=20,000), within four hours of completion of convalescent plasma transfusion authors reported 146 serious adverse events classified as transfusion reactions (<1% of all transfusions) [124]. Of these, 63 deaths were reported (0.3%), 13 judged as possibly or probably related to the transfusion. The non-mortality serious adverse events include 37 reports of transfusion-associated circulatory overload (TACO), 20 cases of transfusion-related acute lung injury (TRALI), and 26 cases of severe allergic transfusion reactions.

Within seven days of transfusion, 1,711 deaths were reported (mortality rate: 8.56%; 95% CI: 8.18, 8.95). In addition, 1,136 serious adverse events were reported: 643 cardiac events (569 judged as unrelated to the transfusion); 406 sustained hypotensive events requiring intravenous pressor support; and 87 thromboembolic or thrombotic events (55 judged as unrelated to the transfusion).

In another smaller study of 52 patients randomized to receive convalescent plasma transfusions, two subjects developed transfusion-related adverse events (e.g., chills and rash; shortness of breath, cyanosis, and severe dyspnea) within 6 hours of receipt [118]. No adverse events were reported among patients in either Gharbharan 2020 or Duan 2020.

Other considerations

The panel agreed on the overall certainty of evidence as very low due to concerns with risk of bias, mostly driven by the uncertainty of trade-offs between desirable and undesirable consequences as an untreated comparison group was unavailable for the largest body of evidence [124].

Conclusions and research needs for this recommendation

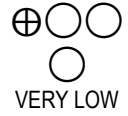


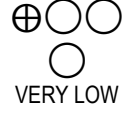
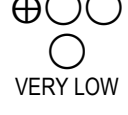
The guideline panel continues to recommend COVID-19 convalescent plasma only in the context of a clinical trial. Additional clinical trials are needed to determine whether there is a benefit of treatment with COVID-19 convalescent plasma for patients with COVID-19 (**Table s2**). Existing data

suggests that if a benefit exists, CP is most useful when given early and with a high titer of neutralizing antibodies; future trials should attempt to compare outcomes of CP given in this optimal setting to the standard of care.

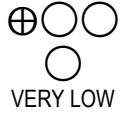
With the end of the expanded access program, clinicians may not have access to clinical trials to enroll patients for CP but may do so through the EUA. Clinicians who choose to give CP outside of a trial should have a detailed discussion with patients about the lack of certainty of benefits, and potential risks before administering this therapy. Clinicians are also encouraged to utilize available registries or other methods for capturing data on patient experience and outcomes, as well as to report any adverse events.

Table 8. GRADE evidence profile, Recommendation 8

Question: Convalescent plasma compared to no convalescent plasma for hospitalized patients with COVID-19

Certainty assessment							No of patients		Effect		Certainty	Importance
No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	convalescent plasma	no convalescent plasma	Relative (95% CI)	Absolute (95% CI)		
Mortality (RCT) (follow up: range 15 days to 60 days)												
2 ^{1,2}	randomized trials	serious ^{a,b}	not serious	not serious	very serious ^c	none	14/95 (14.7%)	23/94 (24.5%)	RR 0.60 (0.33 to 1.10)	98 fewer per 1,000 (from 164 fewer to 24 more)		CRITICAL
Mortality at 30 days (NRS)												
1 ³	observational studies	serious ^{d,e}	not serious	not serious ^e	not serious	none ^f	115/515 (22.3%) ^g	166/561 (29.6%)	RR 0.75 (0.61 to 0.93) ^{e,h}	74 fewer per 1,000 (from 115 fewer to 21 fewer)		CRITICAL
Mortality at 7 days (NRS)												
1 ³	observational studies	serious ^{d,e}	not serious	not serious ^e	not serious	none ^f	46/515 (8.9%) ^g	77/561 (13.7%)	RR 0.65 (0.46 to 0.92) ^{e,i}	48 fewer per 1,000 (from 74 fewer to 11 fewer)		CRITICAL
Worsening oxygenation (follow up: 14 days)												
1 ⁴	observational studies	very serious ^j	not serious	not serious	very serious ^k	none	7/39 (17.9%)	38/156 (24.4%)	OR 0.86 (0.75 to 0.98)	27 fewer per 1,000 (from 49 fewer to 4 fewer)		IMPORTANT
SAEs (transfusion-associated circulatory overload, transfusion-related acute lung injury, severe allergic transfusion reaction) (follow up: 4 hours)												
1 ⁵	observational studies	extremely serious ^l	not serious	not serious	not serious	none	SAEs from 20,000 transfused patients: Within first 4 hours, of the SAEs, 63 deaths were reported (0.3% of all transfusions) and 13 of those deaths were judged as possibly or probably related to the transfusion of COVID-19 convalescent plasma. There were 83 non-death SAEs reported, with 37 reports of transfusion-associated circulatory overload (TACO), 20 reports of transfusion-related acute lung injury (TRALI), and 26 reports of severe allergic transfusion reaction.				CRITICAL	

SAEs (mortality, cardiac, thrombotic, sustained hypotensive events requiring intervention) (follow up: 7 days)

1 ⁵	observational studies	extremely serious ¹	not serious	not serious	not serious	none	SAEs from 20,000 transfused patients: Within 7 days of transfusion, 1,711 deaths (8.56%) and 1,136 serious adverse events (5.68%) were reported. Non-mortality SAEs included: 643 cardiac events (569 judged as unrelated to the transfusion); 406 sustained hypotensive events requiring intravenous pressor support; and 87 thromboembolic or thrombotic events (55 judged as unrelated to the transfusion).	 VERY LOW	CRITICAL
<p>GRADE Working Group grades of evidence</p> <p>High certainty: We are very confident that the true effect lies close to that of the estimate of the effect</p> <p>Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different</p> <p>Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect</p> <p>Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect</p>									
<p>Risk of bias: Study limitations</p> <p>Inconsistency: Unexplained heterogeneity across study findings</p> <p>Indirectness: Applicability or generalizability to the research question</p> <p>Imprecision: The confidence in the estimate of an effect to support a particular decision</p> <p>Publication bias: Selective publication of studies</p>									

CI: Confidence interval; **RR:** Risk ratio; **HR:** Hazard Ratio; **OR:** Odds ratio

Explanations

- a. Li 2020 time between symptom onset and randomization was over 14 days for >90% (median 30 days), no adjustment for co-interventions, allocation concealment methods not reported and participants and healthcare professionals not blinded.
- b. Gharbharan 2020 was an open-label trial, allocation concealment not reported, and no adjustments for co-interventions.
- c. The 95% CI includes the potential for appreciable benefit; however, cannot exclude the potential for harm. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- d. Joyner 2020 adjusted for time epoch, gender, race, age at enrollment (as categories), and indicator variables having already developed one or more severe COVID-19 conditions, being on a ventilator, use of hydroxychloroquine, use of remdesivir, and use of steroids prior to transfusion.
- e. Comparator arm received low titer convalescent plasma, not no convalescent plasma, which was postulated to be less effective than the high titer. The directionality, since the comparator group did not receive placebo, may have underestimated the effectiveness of convalescent plasma (biased toward the null).
- f. Mortality analyses suggests a decreasing trend of mortality between low, moderate, and high IgG groups.
- g. Additional analysis included a timing comparison between transfusing at \leq to 3 days from diagnosis (not symptoms) and 4+ days: 7 day mortality: 1,340/15,407 (8.7%) vs. 2,366/19,915 (11.9%) - RR 0.73 (95% CI 0.69 - 0.78); 30 day mortality: 3,329/15,407 (21.6%) vs. 5,323/19,915 (26.7%) - RR 0.81 (95% CI 0.78 - 0.84). Low certainty evidence. Overall, the adjusted 30-day mortality in patients treated within 3 days of diagnosis with high antibody levels (20%) compared favorably to those treated beyond 3 days with low antibody level plasma (30%) - RR 0.77.
- h. Crude relative risk. Adjusted inverse relative risk = 1.18 (95% CI: 0.99, 1.41).
- i. Crude relative risk. Adjusted inverse relative risk = 1.45 (95% CI: 1.00, 2.03).
- j. Liu 2020 propensity score matching was enforced on the administration of hydroxychloroquine and azithromycin, intubation status and duration, length of hospital stay, and oxygen requirement on the day of transfusion; however, there may be some residual confounding.
- k. The 95% CI includes the potential for appreciable benefit; however, may not include a clinically meaningful benefit. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- l. No comparative effects available. Some subjectivity in classification of outcomes as transfusion related.

Last updated February 22, 2021 and posted online at www.idsociety.org/COVID19guidelines.

Please check website for most updated version of these guidelines.

References

1. 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**.
2. Gharbharan A, Jordans CC, GeurtsvanKessel C, et al. Convalescent Plasma for COVID-19. A randomized clinical trial. *MEDRxiv* **2020**.
3. Joyner MJ, Senefeld JW, Klassen SA, et al. Effect of convalescent plasma on mortality among hospitalized patients with COVID-19: initial three-month experience. *medRxiv* **2020**.
4. Liu ST, Lin H-M, Baine I, et al. Convalescent plasma treatment of severe COVID-19: A matched control study. *medRxiv* **2020**.
5. Joyner MJ, Bruno KA, Klassen SA, et al. Safety Update: COVID-19 Convalescent Plasma in 20,000 Hospitalized Patients. *Mayo Clin Proc* **2020**; 95(9): 1888-97

Remdesivir

Section last reviewed and updated 11/22/2020

Recommendation 9: In hospitalized patients with severe* COVID-19, the IDSA panel suggests remdesivir over no antiviral treatment. (Conditional recommendation, Moderate certainty of evidence)

- **Remark:** For consideration in contingency or crisis capacity settings (i.e., limited remdesivir supply): Remdesivir appears to demonstrate the most benefit in those with severe COVID-19 on supplemental oxygen rather than in patients on mechanical ventilation or ECMO.

*Severe illness is defined as patients with SpO₂ ≤94% on room air, and those who require supplemental oxygen, mechanical ventilation, or ECMO.

Recommendation 10: In patients on supplemental oxygen but not on mechanical ventilation or ECMO, the IDSA panel suggests treatment with five days of remdesivir rather than 10 days of remdesivir. (Conditional recommendation, Low certainty of evidence)

- **Remark:** In patients on mechanical ventilation or ECMO, the duration of treatment can be 10 days.

Recommendation 11: In patients with COVID-19 admitted to the hospital without the need for supplemental oxygen and oxygen saturation >94% on room air, the IDSA panel suggests against the routine use of remdesivir. (Conditional recommendation, Very low certainty of evidence)

The last literature search was conducted on November 3, 2020 and we identified four RCTs and two non-randomized studies.

Why is remdesivir considered for treatment?

Remdesivir (GS-5734) is an antiviral drug with potent in vitro activity against a range of RNA viruses including MERS-CoV, SARS-CoV 1 & 2 [126-128]. Remdesivir acts by causing premature termination of viral RNA transcription [128]. Its use improved disease outcomes and reduced viral loads in SARS-CoV-1 infected mice [127]. In rhesus macaques therapeutic treatment with remdesivir

showed reduction in SARS-CoV-2 loads, pathologic changes and progression of clinical disease [129]. In this same animal model, remdesivir treatment initiated 12 hours post-inoculation reduced clinical signs, virus replication in the lungs, and decreased the presence and severity of lung lesions.

Summary of the evidence

Hospitalized patients with oxygen saturation >94% without supplemental oxygen

Three RCTs compared treatment with five days of remdesivir (200 mg day one, 100 mg daily days 2-5), 10 days of remdesivir (200 mg day one, 100 mg daily days 2-10), or no remdesivir for patients hospitalized with oxygen saturation >94% on room air [32, 130, 131] ([Table 9](#)). The outcomes assessed were mortality, clinical improvement, and serious adverse events. ACTT-1 and SOLIDARITY provided post-hoc analyses among patients with mild-to-moderate disease [32, 130]. Randomization and lack of blinding failed to control for or balance receipt of co-interventions (e.g., treatment with dexamethasone, tocilizumab, hydroxychloroquine, and lopinavir/ritonavir) equally across arms in Spinner et al (2020) [131]. In addition, the Spinner et al did not adjust for severity of disease.

Hospitalized patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen, on mechanical ventilation, and ECMO

Three RCTs comparing treatment with remdesivir (200 mg day one, 100 mg daily days 2-10) against no remdesivir treatment [32, 130, 132], and one RCT comparing five days of treatment (200 mg day one, 100 mg daily days 2-5) against 10 days (200 mg day one, 100 mg daily days 2-10) of treatment [133] served as the best available evidence among hospitalized persons with severe COVID-19 ([Tables 9-11](#)). The outcomes assessed were mortality, time to clinical improvement, need for mechanical ventilation, serious adverse events, and adverse events leading to treatment discontinuation.

All trials used different definitions of severe disease for participants. Adaptive Covid-19 Treatment Trial (ACTT-1) participants were considered to have severe disease if they required mechanical ventilation, supplemental oxygen, if SpO₂ was 94% or lower while breathing ambient air, or if they had tachypnea (respiratory rate ≥24 breaths per minute) [130]. Within the SOLIDARITY trial (available only as a pre-print at this time), participants with severe disease were receiving mechanical ventilation [32]. In Wang 2020, severe participants had a SpO₂ ≤94% while breathing room air or a ratio

of arterial oxygen partial pressure to fractional inspired O₂ of ≤ 300 mm Hg and radiologically confirmed pneumonia.

Updated analyses include the final analysis from the ACTT-1 and the interim analysis of the SOLIDARITY trial [32, 130]. SOLIDARITY reported mortality among persons remaining in hospital up to the duration of the study; however, among patients discharged before the end of the study, mortality may not have been collected completely. The study by Wang et al (2020) was stopped early due to lack of recruitment into the trial due to decreased incidence in China.

Randomization performed in Goldman 2020 failed to establish prognostic balance between baseline clinical status among the 397 patients randomized into the treatment arms, with patients in the 10-day arm more severely ill at study entry. Even with the adjusted analysis, residual confounding is possible. In addition, participants, healthcare workers, and outcome assessors were not blinded to the treatment arms.

Benefits

Hospitalized patients with oxygen saturation $>94\%$ without supplemental oxygen

Treatment with a five- or ten-day course of remdesivir failed to show or to exclude a reduction in mortality when compared with no remdesivir (RR: 0.69; 95% CI: 0.36, 1.34; Very low CoE). A five-day course of remdesivir may increase clinical improvement over no remdesivir (RR: 1.16; 95% CI: 1.00, 1.34; Very low CoE) but a 10-day course of remdesivir was not associated with improved clinical status as compared with no remdesivir. Patients with mild-to-moderate disease receiving treatment with remdesivir had similar median time to recovery (median 5 vs. 5 days; Rate ratio: 1.22; 95% CI: 0.82, 1.81; Very low CoE).

Hospitalized patients with SpO₂ $\leq 94\%$ on room air, including patients on supplemental oxygen, on mechanical ventilation and ECMO

The pooled analysis failed to show a mortality benefit at 28 days (RR: 0.92; 95% CI: 0.77, 1.10; Low CoE) [32, 130, 132]. Patients receiving treatment with remdesivir trend toward greater clinical improvement at 28 days than patients not receiving remdesivir (RR: 1.13; 95% CI: 0.91, 1.41; Low CoE) [132]. In addition, based on a post-hoc analysis of patients with severe COVID-19 receiving treatment

with remdesivir had a shorter median time to recovery (median 11 vs 18 days; Rate ratio: 1.31; 95% CI: 1.12, 1.52; Low CoE) and decreased need for mechanical ventilation (RR: 0.57; 95% CI: 0.42, 0.79; Moderate CoE) [130].

In the study by Goldman et al that compared five and ten days of treatment, the shorter course of remdesivir showed a trend toward decreased mortality (RR: 0.75; 95% CI: 0.51, 1.12; Low CoE) and increased clinical improvement at 14 days (RR: 1.19; 95% CI: 1.01, 1.40; Low CoE); however, the evidence is uncertain because the persons in the 10-day group had more severe disease at baseline and there is the possibility of residual confounding despite the adjusted analysis [133].

Harms

Hospitalized patients with oxygen saturation >94% without supplemental oxygen

Patients treated with five days of remdesivir do not appear to experience greater serious adverse events than those not receiving remdesivir (RR: 0.64; 95% CI: 0.31, 1.31; Very low CoE).

Hospitalized patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen, on mechanical ventilation and ECMO

Patients treated with remdesivir do not appear to experience greater SAEs (grade 3/4) than those not receiving remdesivir (RR: 0.87; 95% CI: 0.59, 1.28; Moderate CoE) [130, 132].

Patients receiving five days of remdesivir may experience fewer SAEs and AEs leading to treatment discontinuation than patients receiving 10 days of remdesivir (RR: 0.61; 0.44, 0.85; Low CoE and RR: 0.44; 95% CI: 0.21, 0.95; Low CoE, respectively); however, this evidence is uncertain because of the increased severity of disease among patients in the 10-day arm [133].

Other considerations

Hospitalized patients with oxygen saturation >94% without supplemental oxygen

The panel agreed that the overall certainty of the evidence for treatment of patients with an oxygen saturation >94% with remdesivir compared to no remdesivir was very low due to concerns with study limitations and imprecision. Because of the study limitations and the relatively small effect of remdesivir in patients with moderate COVID-19, the panel suggests remdesivir not be used routinely in

these patients. There is a need for more rigorous trials to assess the benefits and harms of remdesivir in patients with moderate COVID-19.

Hospitalized patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen, on mechanical ventilation and ECMO

The panel agreed that the overall certainty of the evidence for treatment of persons with severe disease with remdesivir compared to no remdesivir treatment was moderate due to concerns with imprecision. Given the inconsistent definition used in the evidence to describe baseline severity, the panel recognized a knowledge gap when assessing whether greater benefit could be attained for patients with oxygen saturation >94% and no supplemental oxygen; however, they agreed that the reported data supported the prioritization of remdesivir among persons with severe but not critical COVID-19.

The panel agreed on the overall certainty of the evidence for treatment with a five-day course compared to a 10-day course of treatment as low due to concerns with risk of bias and imprecision. The panel recognized the benefit of a shorter course of treatment, if providing similar or greater efficacy, on the availability of remdesivir. However, in a subgroup analysis of mechanically ventilated patients, the duration of treatment was 10 days in ACCT-1 trial; therefore, the panel recognized that a longer course of treatment could be desirable in this population.

Pediatric use

There are no published data on the use of remdesivir for treatment of hospitalized pediatric patients with COVID-19. An ongoing study of remdesivir in this population [134] is using 5 mg/kg on day one (maximum dose 200 mg) followed by 2.5 mg/kg daily in patients over 14 days of age, gestational age more than 37 weeks, and weight greater than or equal to 2.5 kg. The FDA EUA applies to patients weighing over 3.5 kg and applies to the lyophilized powder formulation only.

Conclusions and research needs for this recommendation

The guideline panel suggests against remdesivir for routine treatment of patients with oxygen saturation >94% and no supplemental oxygen; however, strongly urges continued study through recruitment into RCTs.

The guideline panel suggests remdesivir rather than no remdesivir for treatment of severe COVID-19 in hospitalized patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen, on mechanical ventilation and ECMO. Additional clinical trials are needed to provide increased certainty about the potential for both benefit and harms of treatment with remdesivir, as well as understand the benefit of treatment based on disease severity.

Table 9. GRADE evidence profile, Recommendation 9

Question: Remdesivir compared to no antiviral treatment for hospitalized patients with COVID-19 and oxygen saturation >94% without supplemental oxygen

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	remdesivir	no remdesivir	Relative (95% CI)	Absolute (95% CI)		
Mortality (follow up: range 11 days to 29 days)												
2 ^{1,2,3}	randomized trials	very serious ^{a,b,c}	not serious	not serious	serious ^d	none	15/1100 (1.4%)	20/914 (2.2%)	RR 0.69 (0.36 to 1.34)	7 fewer per 1,000 (from 14 fewer to 7 more)	⊕○○○ VERY LOW	CRITICAL
Time to recovery (follow up: 29 days)												
1 ²	randomized trials	serious ^c	not serious	not serious	very serious ^d	none	54/55 (98.2%)	46/50 (92.0%)	Rate ratio 1.22 (0.82 to 1.81)	34 more per 1,000 (from 46 fewer to 70 more)	⊕○○○ VERY LOW	CRITICAL
Clinical improvement at day 11 (assessed with: >=2-pt improvement on 7-pt scale; higher = better)												
1 ¹	randomized trials	very serious ^{a,b}	not serious	not serious	serious ^e	none	134/191 (70.2%)	121/200 (60.5%)	RR 1.16 (1.00 to 1.34) ^f	97 more per 1,000 (from 0 fewer to 206 more)	⊕○○○ VERY LOW	CRITICAL
Serious adverse events												
2 ^{1,2}	randomized trials	very serious ^{a,b,c}	not serious	not serious	serious ^d	none	11/246 (4.5%)	18/249 (7.2%)	RR 0.64 (0.31 to 1.31)	26 fewer per 1,000 (from 50 fewer to 22 more)	⊕○○○ VERY LOW	CRITICAL
GRADE Working Group grades of evidence												
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect												
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different												
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect												
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect												

Certainty assessment							No of patients		Effect		Certainty	Importance
No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	remdesivir	no remdesivir	Relative (95% CI)	Absolute (95% CI)		
<p>Risk of bias: Study limitations</p> <p>Inconsistency: Unexplained heterogeneity across study findings</p> <p>Indirectness: Applicability or generalizability to the research question</p> <p>Imprecision: The confidence in the estimate of an effect to support a particular decision</p> <p>Publication bias: Selective publication of studies</p>												

CI: Confidence interval; RR: Risk ratio

Explanations

- Spinner et al. co-treatments were not balanced between arms: 45% of patients randomized to control arm received HCQ or CQ compared to 11% in 10-day arm or 8% in 5-day arm; lopinavir/ritonavir was 22% in control arm, 6% in 10-day arm, and 5% in 5-day arm.
- Open-label trial design may have led to different clinical practices (co-interventions and time of hospital discharge).
- Post-hoc analysis of patients with mild-moderate disease from ACTT-1 (Beigel 2020) and SOLIDARITY (Pan 2020) may introduce bias.
- The 95% CI includes the potential for both appreciable benefit as well as the potential for harm. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- The 95% CI may not include a clinically meaningful benefit.
- Spinner 2020 reported an odds ratio of 1.65 (95% CI: 1.09, 2.48); however, compared to relative risks, odds ratios tend to overestimate the effect with baseline risk is high.

References

- 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.
- Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the Treatment of Covid-19 - Final Report. *N Engl J Med* 2020.
- Pan H, Peto R, Karim QA, et al. Repurposed antiviral drugs for COVID-19; interim WHO SOLIDARITY trial results. *MedRxiv* 2020. Available at: <https://doi.org/10.1101/2020.10.15.20209817> [Preprint 15 October 2020].

Table 10. GRADE evidence profile, Recommendation 10

Question: Remdesivir compared to no antiviral treatment for hospitalized patients with severe COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	remdesivir	no remdesivir	Relative (95% CI)	Absolute (95% CI)		
Mortality (follow up: range 28 days to 29 days)												
3 ^{1,2,3}	randomized trials	serious ^{a,b,c}	not serious	not serious	serious ^d	none	369/2726 (13.5%)	374/2593 (14.4%)	RR 0.92 (0.77 to 1.10)	12 fewer per 1,000 (from 33 fewer to 14 more)	⊕⊕○○ LOW	CRITICAL
Time to recovery (follow up: 29 days)												
1 ²	randomized trials	serious ^c	not serious	not serious	not serious	none	345/486 (71.0%)	306/471 (65.0%)	Rate ratio 1.31 (1.12 to 1.52)	97 more per 1,000 (from 41 more to 147 more)	⊕⊕⊕○ MODERATE	CRITICAL
Clinical improvement (follow up: 28 days)												
1 ¹	randomized trials	not serious ^{a,b}	not serious	not serious	very serious ^d	none	103/158 (65.2%)	45/78 (57.7%)	RR 1.13 (0.91 to 1.41)	75 more per 1,000 (from 52 fewer to 237 more)	⊕⊕○○ LOW	CRITICAL
Need for mechanical ventilation (follow up: 29 days)												
1 ²	randomized trials	not serious	not serious	not serious	serious ^e	none	52/402 (12.9%)	82/364 (22.5%)	RR 0.57 (0.42 to 0.79)	97 fewer per 1,000 (from 131 fewer to 47 fewer)	⊕⊕⊕○ MODERATE	CRITICAL
Serious adverse events (grade 3/4)												
2 ^{1,2}	randomized trials	not serious	not serious	not serious	serious ^f	none	44/632 (7.0%)	53/545 (8.9%)	RR 0.88 (0.74 to 1.06)	11 fewer per 1,000 (from 25 fewer to 6 more)	⊕⊕⊕○ MODERATE	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	remdesivir	no remdesivir	Relative (95% CI)	Absolute (95% CI)		

Hospitalization

1 ¹	randomized trials	not serious ^{a,b}	not serious	not serious	very serious ^d	none	158	78	-	MD 1 days higher (0.12 higher to 1.88 higher)	⊕⊕○○ LOW	IMPORTANT
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Duration of mechanical ventilation

1 ¹	randomized trials	not serious ^{a,b}	not serious	not serious	serious ^d	none	158	78	-	MD 8.5 days lower (9.14 lower to 7.86 lower)	⊕⊕⊕○ MODERATE	IMPORTANT
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GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; HR: Hazard Ratio; RR: Risk ratio; OR: Odds ratio; MD: Mean difference

Explanations

- a. Co-interventions received in Wang 2020 include: interferon alpha-2b, lopinavir/ritonavir, vasopressors, antibiotics, corticosteroid therapy and were balanced between arms.
- b. Wang 2020 stopped early due to lack of recruitment. Trial initiated after reduction in new patient presentation (most patients enrolled later in the disease).
- c. Post-hoc analysis of patients with severe disease from Pan 2020 and Beigel 2020 may introduce bias.
- d. The 95% CI may not include a clinically meaningful effect.
- e. Few events do not meet the optimal information size and suggest fragility in the estimate.
- f. The 95% CI cannot exclude the potential for benefit or harm. Also, few events do not meet the optimal information size.

Last updated February 22, 2021 and posted online at www.idsociety.org/COVID19guidelines.

Please check website for most updated version of these guidelines.

References

1. 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): 1569-78.
2. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the Treatment of Covid-19 - Final Report. *N Engl J Med* **2020**.
3. Pan H, Peto R, Karim QA, et al. Repurposed antiviral drugs for COVID-19; interim WHO SOLIDARITY trial results. *MedRxiv* **2020**. Available at: <https://doi.org/10.1101/2020.10.15.20209817> [Preprint 15 October 2020].

Table 11. GRADE evidence profile, Recommendation 11

Question: Remdesivir 5 days compared to remdesivir 10 days for hospitalized patients with severe (not critically ill) COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	remdesivir 5 days	remdesivir 10 days	Relative (95% CI)	Absolute (95% CI)		
Mortality												
1 ¹	randomized trials	serious ^b	not serious	not serious	serious ^a	none	16/200 (8.0%)	21/197 (10.7%)	HR 0.75 (0.40 to 1.39)	27 fewer per 1,000 (from 64 fewer to 42 more)	⊕⊕○○ LOW	CRITICAL
Clinical improvement at 14 days												
1 ¹	randomized trials	serious ^b	not serious	not serious	serious ^c	none	129/200 (64.5%)	107/197 (54.3%)	RR 1.19 (1.01 to 1.40)	103 more per 1,000 (from 5 more to 217 more)	⊕⊕○○ LOW	CRITICAL
SAEs												
1 ¹	randomized trials	serious ^b	not serious	not serious	serious ^c	none	42/200 (21.0%)	68/197 (34.5%)	RR 0.61 (0.44 to 0.85)	135 fewer per 1,000 (from 193 fewer to 52 fewer)	⊕⊕○○ LOW	CRITICAL
AEs leading to treatment discontinuation												
1 ¹	randomized trials	serious ^{b,d}	not serious	not serious	serious ^c	none	9/200 (4.5%)	20/197 (10.2%)	RR 0.44 (0.21 to 0.95)	57 fewer per 1,000 (from 80 fewer to 5 fewer)	⊕⊕○○ LOW	CRITICAL

CI: Confidence interval; **RR:** Risk ratio

Explanations

- The 95% CI includes the potential for both appreciable benefit, as well as appreciable harm. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- Goldman 2020 did not blind participants, healthcare workers or outcome assessors. After randomization, disease severity was greater in the 10-day arm; while the analysis adjusted for baseline characteristics including disease severity, there is still the potential for residual confounding.

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- c. The lower boundary of the 95% CI may not include a clinically meaningful effect. Few events reported do not meet the optimal information size and suggest fragility in the estimate.
- d. Goldman stratified adverse events by days 1-5, 6-10. AEs leading to treatment discontinuation during days 1-5 were 9 (4%) in the 5-day arm and 14 (7%) in the 10-day arm.

Reference

1. 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**

Famotidine

Section last reviewed and updated 6/22/2020

Recommendation 12: Among hospitalized patients with severe COVID-19, the IDSA panel suggests against famotidine use for the sole purpose of treating COVID-19 outside of the context of a clinical trial. (Conditional recommendation, very low certainty of evidence)

The last literature search was conducted on June 18, 2020 and we identified one non-randomized study in OVID. There were no new non-indexed RCTs available.

Why is famotidine considered for treatment?

Anecdotal reports from China suggest that patients infected with coronavirus who were receiving famotidine, a H₂ receptor antagonist to treat conditions such as acid reflux and peptic ulcer disease, had improved survival vs. those receiving proton pump inhibitors (PPIs) [135]. This post hoc finding summarized below has led to interest in the drug, though no predominant theory describing a mechanism for its efficacy yet exists. One theory is that famotidine, like many other compounds, binds and therefore inhibits the coronavirus main protease, 3C-like main protease (3CLpro) [136].

Summary of the evidence

Our search identified one cohort study that compared 84 patients treated with famotidine against 1,536 patients not receiving treatment with famotidine [137] ([Table 12](#)). Fifteen percent of patients in the famotidine group (13/84) started famotidine at home before presenting to the hospital. In addition, a subset of 420 patients not treated with famotidine were matched on baseline characteristics to the treated patients.

Benefits

Famotidine may decrease the composite outcome of death or intubation (HR: 0.42; 95% CI: 0.21, 0.85; Very low CoE); however, the evidence is very uncertain ([Table 12](#)).

Harms

Famotidine is well tolerated. Common adverse events include diarrhea or constipation but occur in less than 5% of people. Severe adverse events occur in less than 1% of persons taking famotidine.

Other considerations


The panel determined that the certainty of evidence to be very low due to concerns with risk of bias, imprecision, and possible publication bias. The panel agreed that critically ill patients (i.e., mechanically ventilated) may have been more likely to receive PPIs than famotidine, thus potentially allocating more prognostically favorable patients to the famotidine group; however, the study did not report a protective effect associated with the use of PPIs.

Conclusions and research needs for this recommendation

The guideline panel suggests against famotidine for the sole purpose of treating COVID-19, unless in the context of a clinical trial. Additional clinical trials are needed to inform research for treatment with famotidine for patients with COVID-19 (**Table s2**).

Table 12. GRADE evidence profile, Recommendation 12

Question: Famotidine compared to no famotidine for hospitalized patients with severe COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	famotidine	no famotidine	Relative (95% CI)	Absolute (95% CI)		
Death or intubation (follow up: 30 days)												
1 ¹	observational studies	serious ^a	not serious	not serious	serious ^b	publication bias strongly suspected ^c	8/84 (9.5%)	332/1536 (21.6%)	HR 0.42 (0.21 to 0.85)	119 fewer per 1,000 (from 166 fewer to 29 fewer)	 VERY LOW	CRITICAL

SAEs

0	observational studies						Post-marketing and registrational reported common adverse events include constipation (1.2%-1.4%), diarrhea (1.7%), dizziness (1.3%) and headache (1%-4.7%), but overall famotidine is well tolerated. Rare but serious adverse events (<1%) include Stevens-Johnson syndrome, toxic epidermal necrolysis, necrotizing enterocolitis, anaphylaxis, angioedema, rhabdomyolysis, seizure, hospital-acquired pneumonia, interstitial pneumonia. (Micromedex)			-	CRITICAL
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GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; **HR:** Hazard Ratio

Explanations

- Freedberg analysis adjusted for baseline characteristics of age, sex, race/ethnicity, BMI, comorbidities, and initial oxygen requirement (room air, nasal cannula, non-rebreather); however, 27% in the control arm were missing information on BMI. Potential residual confounding due to provision of famotidine being used in less sick/severe cases and PPIs in severe cases. Co-interventions/treatments were not reported (HCQ provided but not disaggregated across arms) and could modify the effect of the intervention. Approximately 15% of patients started famotidine at home, prior to hospitalization, which may lead to earlier co-interventions.
- Number of events is less than the optimal information size, which may suggest fragility in the estimate of effect.
- Concerns about selective reporting due to unavailability of disaggregated data for outcomes of mortality or intubation, missing supplemental files, and raw data for primary outcome from propensity-matched control group.

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Reference

1. 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**.

Neutralizing Antibodies

Section last reviewed and updated 1/29/2021

Recommendation 13: Among hospitalized patients with severe COVID-19, the IDSA guideline panel recommends against bamlanivimab. (Strong recommendation, Moderate certainty of evidence)

Recommendation 14: Among ambulatory patients with COVID-19, the IDSA guideline panel suggests against the routine use of bamlanivimab. (Conditional recommendation, Very low certainty of evidence)

- **Remark:** In ambulatory patients with COVID-19 or in patients with mild-to-moderate COVID-19 admitted to the hospital for management of conditions other than COVID-19 who are at increased risk (defined by the [FDA EUA](#) [138]), bamlanivimab is a reasonable treatment option if, after informed decision-making, the patient puts a high value on the uncertain benefits and a low value on uncertain adverse events. For EUA criteria, see [Figure 2](#).

Recommendation 15: Among ambulatory patients with COVID-19, the IDSA guideline panel suggests against the routine use of casirivimab/imdevimab. (Conditional recommendation, Very low certainty of evidence)

- **Remark:** In ambulatory patients with COVID-19 or in patients with mild-to-moderate COVID-19 admitted to the hospital for management of conditions other than COVID-19 who are at increased risk (as defined by the [FDA EUA](#) [139]), casirivimab/imdevimab is a reasonable treatment option if, after informed decision-making, the patient puts a high value on the uncertain benefits and a low value on uncertain adverse events. For EUA criteria, see [Figure 2](#).

Figure 2. U.S. Food and Drug Administration Emergency Use Authorization Criteria for the use of Bamlanivimab and Casirivimab with Imdevimab^{a,1,2}

This EUA is for the use of the unapproved products, bamlanivimab and casirivimab with imdevimab, for the treatment of mild to moderate COVID-19 in adults and pediatric patients (12 years of age and older weighing at least 40 kg) with positive results of direct SARS-CoV-2 viral testing, and who are at high risk for progressing to severe COVID-19 and/or hospitalization.

High risk is defined as patients who meet at least one of the following criteria:

- Have a body mass index (BMI) ≥ 35
- Have chronic kidney disease
- Have diabetes
- Have immunosuppressive disease
- Are currently receiving immunosuppressive treatment
- Are ≥ 65 years of age
- Are ≥ 55 years of age AND have
 - cardiovascular disease, OR
 - hypertension, OR
 - chronic obstructive pulmonary disease/other chronic respiratory disease.
- Are 12 – 17 years of age AND have
 - BMI ≥ 85 th percentile for their age and gender based on [CDC growth charts](https://www.cdc.gov/growthcharts/), OR
 - sickle cell disease, OR
 - congenital or acquired heart disease, OR
 - neurodevelopmental disorders, for example, cerebral palsy, OR
 - a medical-related technological dependence, for example, tracheostomy, gastrostomy, or positive pressure ventilation (not related to COVID-19), OR
 - asthma, reactive airway or other chronic respiratory disease that requires daily medication for control.

- a. These criteria refer to Recommendation 14 (the use of bamlanivimab in ambulatory patients with COVID-19) and Recommendation 15 (the use of casirivimab/imdevimab in ambulatory patients with COVID-19).

References

1. U.S. Food and Drug Administration. Fact Sheet for Health Care Providers: Emergency Use Authorization (EUA) of Bamlanivimab. Available at: <https://www.fda.gov/media/143603/download>. Accessed 15 November 2020.
2. U.S. Food and Drug Administration. Fact Sheet for Health Care Providers: Emergency Use Authorization (EUA) of Casirivimab and Imdevimab. Available at: <https://www.fda.gov/media/143892/download>. Accessed 3 February 2021.

The last literature search was conducted on January 27, 2021 and we identified three RCTs.

Why are neutralizing antibodies considered for treatment?

Neutralizing antibodies directed at the receptor-binding domain of SARS-CoV-2 spike protein are being evaluated as prophylactic and therapeutic agents for COVID-19. In animal models there is evidence that antibody therapy may more rapidly reduce viral load in the upper and lower airways of infected animals resulting in reduced viral-induced pathology [140, 141]. Additionally, antibody mediated enhancement of disease has not been detected in animal models [141] but this potential phenomenon should be closely monitored in the future studies.

Potential advantages of neutralizing antibodies include the ability to quantify levels of neutralizing activity and the possibility of conferring protection more rapidly than with vaccine-induced immune responses (which generally take several weeks).

Antibody treatments have been and continue to be evaluated in both hospitalized and ambulatory patients. For outpatients, there may be logistical challenges since the infrastructure for administration of intravenous (IV) infusions does not exist in most ambulatory care settings. There may also be concerns about spread of contagion when administering IV infusions in clinics.

On November 9, 2020, the FDA released an emergency use authorization (EUA) for monoclonal antibody therapy bamlanivimab [138] and on November 21, 2020, the FDA released an EUA for the combination of casirivimab and imdevimab [139].

Summary of the evidence

Our search identified three RCTs reporting on treatment with neutralizing antibodies (bamlanivimab or combination of casirivimab/imdevimab) for patients with COVID-19 with ages ranging from 18 to 86 years [142-144] ([Tables 13-15](#)). One RCT, stopped early for futility, reported on hospitalized patients with COVID-19 randomized to treatment with either a single infusion of bamlanivimab (7000 mg) or placebo (ACTIV-3/TICO). One Phase II RCT reported on non-hospitalized patients with recently diagnosed mild or moderate COVID-19 randomized to treatment with either a single infusion of neutralizing antibody bamlanivimab in one of three

doses (700 mg, 2800 mg, or 7000 mg) or placebo [143]. One RCT reported on non-hospitalized patients with COVID-19 randomized to treatment with a single infusion of neutralizing antibody combination of casirivimab/imdevimab in one of two doses (2.4 g or 8.0 g) or placebo [144].

Benefits

Bamlanivimab

Among patients hospitalized for COVID-19, treatment with bamlanivimab compared to placebo could not exclude the risk of no benefit for the outcome of mortality (HR: 2.00; 95% CI: 0.67, 5.99; moderate CoE). Clinical improvement, as defined as a decrease in a pulmonary ordinal scale, may not be meaningfully different among patients hospitalized for COVID-19 who receive treatment with bamlanivimab or placebo (OR: 0.85; 0.56, 1.29; moderate CoE).

Among ambulatory patients, bamlanivimab demonstrated a lower relative risk of hospitalization, including visits to the emergency room, compared to no bamlanivimab (RR: 0.26; 95% CI: 0.09, 0.75; very low CoE). The very low certainty of evidence was due to indirectness, as the treatment may not have been provided to enough patients at risk of developing severe disease to be representative of the general population, and imprecision, due to few events recorded. Bamlanivimab may increase viral clearance at three days (mean difference: -0.49; 95% CI: -0.87, -0.11; low CoE); however, there may not be a meaningful difference at 11 days as measured by change from baseline SARS-CoV-2 viral load (mean difference: -0.22; 95% CI: -0.60, 0.15; low CoE).

Casirivimab/imdevimab

Among ambulatory patients, casirivimab/imdevimab demonstrated a lower relative risk of COVID-19 medically attended visits compared to no casirivimab/imdevimab (RR: 0.51; 95% CI: 0.17, 1.54; very low CoE). The very low certainty of evidence was due to indirectness, as the treatment may not have been provided to enough patients at risk of developing severe disease to be representative of the general population, and imprecision, due to few events recorded. Casirivimab/imdevimab may decrease viral load at seven days (mean difference: -0.41; 95% CI: -

0.71, -0.10; low CoE). The effect of casirivimab/imdevimab on reducing SARS-CoV-2 levels is most evident in people who are seronegative at baseline and have not developed their own antibody response.

Harms

Bamlanivimab

Serious adverse events at five and 28 days among patients hospitalized for COVID-19 receiving bamlanivimab may not be meaningfully different from those receiving placebo (RR: 1.85; 95% CI: 0.34, 9.97; moderate CoE and RR: 0.93, 95% CI: 0.27, 3.14; moderate CoE, respectively). Similarly, infusion-related adverse events may not be meaningfully different between patients hospitalized for COVID-19 receiving bamlanivimab or placebo (OR: 1.64, 95% CI: 0.79, 3.44; moderate CoE).

Serious adverse events among ambulatory patients receiving bamlanivimab may not be meaningfully different from those receiving placebo (RR: 0.15; 95% CI: 0.01, 3.78; low CoE). Patients receiving bamlanivimab did experience more infusion-related adverse events, including pruritus, flushing, rash, and facial swelling (RR: 1.62; 95% CI: 0.34, 7.70; low CoE).

Casirivimab/imdevimab

Serious adverse events and adverse events (e.g., grade 2 or higher hypersensitivity reactions or infusion-related reactions) among patients receiving casirivimab/imdevimab may not be meaningfully different from those receiving placebo (RR: 0.26; 95% CI: 0.02, 2.88; low CoE and RR: 0.53; 95% CI: 0.08, 3.69; low CoE, respectively).

Other considerations

Bamlanivimab

The panel agreed that the overall certainty of evidence for treatment with bamlanivimab for patients hospitalized for COVID-19 is moderate due to concerns with fragility

in the estimate from the small number of events reported. The guideline panel made a strong recommendation against treatment with bamlanivimab for patients hospitalized for COVID-19. The panel was moderately certain that any relevant benefit (reduction in mortality or clinical improvement) could be excluded.

The panel agreed that the overall certainty of evidence for treatment with bamlanivimab for ambulatory patients with COVID-19 is very low due to concerns with indirectness and imprecision. The guideline panel made a conditional recommendation against routine treatment with bamlanivimab. This decision was based on the imprecision of the data, as the number of clinical events in this phase II trial were low, and uncertainty that the outcome of avoidance of hospitalization and emergency room visits predicts meaningful outcomes such as avoidance of ICU visits, need for mechanical ventilation, and death. In addition, the endpoint of viral clearance, as measured by reduction in viral load, failed to demonstrate consistency across doses or time-points. The panel recognized that there may be equity and feasibility issues with the implementation of infusion in outpatients to consider, specifically the personnel and financial resources required and implementability of infection prevention considerations.

Casirivimab/imdevimab

The panel agreed that the overall certainty of evidence for treatment with casirivimab/imdevimab for ambulatory patients with COVID-19 is very low due to concerns with indirectness and imprecision. The guideline panel made a conditional recommendation against routine treatment with casirivimab/imdevimab. This decision was based on the imprecision of the data, as the number of clinical events in this phase II trial were low, and uncertainty that the outcome of avoidance of medically attended visits predicts meaningful outcomes such as avoidance of ICU visits, need for mechanical ventilation, and death. The panel recognized that there may be equity and feasibility issues with the implementation of infusion in outpatients to consider, specifically the personnel and financial resources required and implementability of infection prevention considerations.

Conclusions and research needs for this recommendation

The guideline panel recommends against use of bamlanivimab for patients hospitalized for COVID-19.

The guideline panel suggests against routine use of bamlanivimab or the combination of casirivimab/imdevimab for ambulatory patients with COVID-19. The panel recognizes that persons, including those at increased risk of progressing to severe COVID-19 (as defined by the FDA EUA [138, 139] who place a higher value on the uncertain benefits and a lower value on the uncertain adverse events, may reasonably select this treatment after careful discussion with their clinician.

The guideline panel recognized the need for continued research and accrual of evidence, particularly trials on patient important outcomes, existing and new neutralizing antibodies, and neutralizing antibodies for prophylaxis (**Table s2**).

Table 13. GRADE evidence profile, Recommendation 13

Question: Bamlanivimab compared to no bamlanivimab for patients hospitalized for COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	bamlanivimab	no bamlanivimab	Relative (95% CI)	Absolute (95% CI)		
Mortality												
1 ¹	randomized trials	not serious	not serious	not serious	serious ^a	none	9/163 (5.5%)	5/151 (3.3%)	HR 2.00 (0.67 to 5.99)	32 more per 1,000 (from 11 fewer to 150 more)	⊕⊕⊕○ MODERATE	CRITICAL
Clinical improvement at day 5 (assessed with: pulmonary ordinal outcome (scale 1-7; 1 = least severe))												
1 ¹	randomized trials	not serious	not serious	not serious	serious ^a	none	161	150	OR 0.85 (0.56 to 1.29) ^b	-	⊕⊕⊕○ MODERATE	CRITICAL
Serious adverse events (follow up: 5 days)												
1 ¹	randomized trials	not serious	not serious	not serious	serious ^a	none	4/163 (2.5%)	2/151 (1.3%)	RR 1.85 (0.34 to 9.97)	11 more per 1,000 (from 9 fewer to 119 more)	⊕⊕⊕○ MODERATE	CRITICAL
Serious adverse events (follow up: 28 days)												
1 ¹	randomized trials	not serious	not serious	not serious	serious ^a	none	5/163 (3.1%)	5/151 (3.3%)	RR 0.93 (0.27 to 3.14)	2 fewer per 1,000 (from 24 fewer to 71 more)	⊕⊕⊕○ MODERATE	IMPORTANT
Infusion-related adverse event												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	bamlanivimab	no bamlanivimab	Relative (95% CI)	Absolute (95% CI)		
1 ¹	randomized trials	not serious	not serious	not serious	serious ^a	none	23/163 (14.1%)	21/151 (13.9%)	OR 1.64 (0.79 to 3.44) ^c	70 more per 1,000 (from 26 fewer to 218 more)	⊕⊕⊕○ MODERATE	IMPORTANT

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; **HR:** Hazard Ratio; **OR:** Odds ratio; **RR:** Risk ratio

Explanations

- The 95% CI includes the potential for both appreciable benefit as well as the potential for harm. Few events reported do not meet the optimal information size and suggest fragility of the estimate
- Study-provided odds ratio adjusted for baseline ordinal category and trial pharmacy.
- Study-provided odds ratio adjusted for the trial pharmacy.

References

- ACTIV-3/TICO LY-CoV555 Study Group, Grund B, Barkauskas CE, et al. A Neutralizing Monoclonal Antibody for Hospitalized Patients with Covid-19. N Engl J Med **2020**.

Table 14. GRADE evidence profile, Recommendation 14

Question: Bamlanivimab compared to no bamlanivimab for non-hospitalized patients with COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	bamlanivimab	no bamlanivimab	Relative (95% CI)	Absolute (95% CI)		
Hospitalization (including ED visits) with COVID-19 (follow up: 29 days)												
1 ¹	randomized trials	not serious	not serious	serious ^a	very serious ^b	none	5/309 (1.6%)	9/143 (6.3%)	RR 0.26 (0.09 to 0.75)	47 fewer per 1,000 (from 57 fewer to 16 fewer)	⊕○○○ VERY LOW	CRITICAL
Viral clearance (follow up: 3 days; assessed with: change from baseline in SARS-CoV-2 viral load)												
1 ¹	randomized trials	not serious	not serious	serious ^{a,c}	serious ^b	none	309	143	-	MD 0.49 lower (0.87 lower to 0.11 lower)	⊕⊕○○ LOW	IMPORTANT
Viral clearance (follow up: 11 days; assessed with: change from baseline in SARS-CoV-2 viral load)												
1 ¹	randomized trials	not serious	not serious	serious ^{a,c}	serious ^d	none	309	143	-	MD 0.22 lower (0.6 lower to 0.15 higher)	⊕⊕○○ LOW	IMPORTANT
Serious adverse events (upper abdominal pain)												
1 ¹	randomized trials	not serious	not serious	not serious	very serious ^d	none	0/309 (0.0%)	1/143 (0.7%)	RR 0.15 (0.01 to 3.78)	6 fewer per 1,000 (from 7 fewer to 19 more)	⊕⊕○○ LOW	CRITICAL

Infusion-related adverse events

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	bamlanivimab	no bamlanivimab	Relative (95% CI)	Absolute (95% CI)		
1 ¹	randomized trials	not serious	not serious	not serious	very serious ^d	none	7/309 (2.3%)	2/143 (1.4%)	RR 1.62 (0.34 to 7.70)	9 more per 1,000 (from 9 fewer to 94 more)	⊕⊕○○ LOW	CRITICAL
<p>GRADE Working Group grades of evidence High certainty: We are very confident that the true effect lies close to that of the estimate of the effect Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect</p>												
<p>Risk of bias: Study limitations Inconsistency: Unexplained heterogeneity across study findings Indirectness: Applicability or generalizability to the research question Imprecision: The confidence in the estimate of an effect to support a particular decision Publication bias: Selective publication of studies</p>												

CI: Confidence interval; RR: Risk ratio; MD: Mean difference

Explanations

- Uncertain that the treatment was provided in enough patients at risk of developing severe disease to be representative of the general population.
- The 95% CI may not include a meaningful difference. Few events reported suggests fragility of the estimate.
- Measure of viral clearance is a surrogate outcome for hospital admission, need for intensive care, intubation and death.
- The 95% CI includes values that suggest either an increase or decrease in harm. Few events reported suggests fragility of the estimate.

References

- Chen P, Nirula A, Heller B, et al. SARS-CoV-2 Neutralizing Antibody LY-CoV555 in Outpatients with Covid-19. N Engl J Med **2021**; 384(3): 229-37.

Table 15. GRADE evidence profile, Recommendation 15

Question: Casirivimab/imdevimab compared to no casirivimab/imdevimab for non-hospitalized patients with COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	casirivimab/imdevimab	no casirivimab/imdevimab	Relative (95% CI)	Absolute (95% CI)		
Medically attended visit, COVID-19-related (assessed with: ≥1 visit within 29 days)												
1 ¹	randomised trials	not serious	not serious	serious ^a	very serious ^{b,c}	none	6/182 (3.3%)	6/93 (6.5%)	RR 0.51 (0.17 to 1.54)	32 fewer per 1,000 (from 54 fewer to 35 more)	⊕○○○ VERY LOW	CRITICAL
Viral load (follow up: 7 days)												
1 ¹	randomised trials	not serious	not serious	serious ^{a,d}	serious ^{b,e}	none	143	78	-	MD 0.41 log₁₀ copies/ml lower (0.71 lower to 0.1 lower)	⊕⊕○○ LOW	CRITICAL
Adverse events (assessed with: grade 2 or higher hypersensitivity reactions or infusion-related reactions)												
1 ¹	randomised trials	not serious	not serious	not serious	very serious ^{b,c}	none	2/176 (1.1%)	2/93 (2.2%)	RR 0.53 (0.08 to 3.69)	10 fewer per 1,000 (from 20 fewer to 58 more)	⊕⊕○○ LOW	IMPORTANT
Serious adverse events												
1 ¹	randomised trials	not serious	not serious	not serious	very serious ^{b,c}	none	1/176 (0.6%)	2/93 (2.2%)	RR 0.26 (0.02 to 2.88)	16 fewer per 1,000 (from 21 fewer to 40 more)	⊕⊕○○ LOW	CRITICAL
GRADE Working Group grades of evidence												
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect												
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different												
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect												
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect												

Certainty assessment							No of patients		Effect		Certainty	Importance
No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	casirivimab/ imdevimab	no casirivimab/ imdevimab	Relative (95% CI)	Absolute (95% CI)		
<p>Risk of bias: Study limitations Inconsistency: Unexplained heterogeneity across study findings Indirectness: Applicability or generalizability to the research question Imprecision: The confidence in the estimate of an effect to support a particular decision Publication bias: Selective publication of studies</p>												

CI: Confidence interval; **RR:** Risk ratio; **MD:** Mean difference

Explanations

- Uncertain that the treatment was provided to enough patients at risk of developing severe disease to be representative of the general population
- Few events suggests fragility of the estimate.
- 95% CI includes the potential for both meaningful benefit and harm.
- Measure of viral clearance is a surrogate outcome for hospital admission, need for intensive care, intubation, and death.
- 95% CI cannot exclude the possibility of no benefit.

References

- Weinreich DM, Sivapalasingam S, Norton T, et al. REGN-COV2, a Neutralizing Antibody Cocktail, in Outpatients with Covid-19. N Engl J Med **2021**; 384(3): 238-51.

Baricitinib

New section developed 12/23/2020

Recommendation 16: Among hospitalized patients with severe* COVID-19 who cannot receive corticosteroids because of a contraindication, the IDSA guideline panel suggests use of baricitinib with remdesivir rather than remdesivir alone. (Conditional recommendation, Low certainty of evidence)

- **Remark:** Baricitinib 4 mg daily dose for 14 days (or until hospital discharge). The benefits of baricitinib plus remdesivir for persons on mechanical ventilation are uncertain. See [remdesivir](#) section for dose and duration.

*Severe illness is defined as patients with SpO₂ ≤94% on room air, including patients on supplemental oxygen, oxygen through a high-flow device, or non-invasive ventilation.

Recommendation 17: Among hospitalized patients with COVID-19, the IDSA guideline panel recommends treatment with baricitinib plus remdesivir plus corticosteroids only in the context of a clinical trial. (Knowledge gap)

The literature search was conducted December 14, 2020 and we identified one RCT.

Why is baricitinib considered for treatment?

Baricitinib, a Janus kinase inhibitor currently FDA-approved for the treatment of rheumatoid arthritis (RA), is being investigated in multiple studies for treatment of COVID-19. The proposed benefits of baricitinib in the management of COVID-19 may be two-fold as it has both anti-inflammatory and potential antiviral activity. Janus kinase mediates cytokine signaling, which contributes to inflammation; Janus kinase inhibitors, therefore, may decrease cytokine-mediated inflammation. Baricitinib inhibits host intracellular membrane proteins AP2-associated protein kinase 1 (AAK1) and also binds cyclin G-associated kinase (GAK), both thought to play a role in receptor mediated endocytosis of many viruses including Ebola,

dengue, Hepatitis C, and SARS CoV-2 [145-147]. Baricitinib has been evaluated in people with COVID-19 in non-randomized studies [148-151].

Summary of the evidence

Our literature search identified one randomized controlled trial RCT that reported on the use of baricitinib (4 mg daily dose) plus remdesivir in hospitalized patients with moderate and severe COVID-19. This trial was conducted as the second stage of the Adaptive COVID-19 Treatment Trial (ACTT-2), where subjects were randomized to receive combination therapy with baricitinib and remdesivir or remdesivir alone [152] ([Table 16](#)). Randomization was stratified by disease severity classified by an ordinal scale of clinical status (4+5 vs 6+7). In this trial, severe disease was defined as patients with an ordinal scale of 6 (high flow oxygen and non-invasive ventilation) or 7 (mechanical ventilation or ECMO). Mild-moderate disease was defined as patients with an ordinal scale of 4 (hospitalized, but not requiring supplemental oxygen) or 5 (requiring supplemental oxygen).

Benefits

In ACTT-2, the combination of baricitinib and remdesivir showed a trend towards lower mortality (4.7% vs. 7.1%; rate ratio: 0.65; 95% CI 0.39, 1.09; Moderate CoE). In patients stratified within the severe COVID-19 pneumonia group, defined as 6 or 7 on the ordinal scale, subjects who received baricitinib and remdesivir were more likely to experience clinical recovery (defined as a value of <4 on the ordinal scale) at day 28 (69.3% vs. 59.7%; rate ratio 1.29; 95% CI 1.00, 1.66; Moderate CoE). The original stratification was altered as 40 subjects were misclassified at baseline; however, re-analysis of the original stratified data produced a similar result. Patients in the baricitinib arm were less likely to require initiation of mechanical ventilation or ECMO through day 29 (10% vs. 15.2%; RR: 0.66; 95% CI 0.46, 0.93; Low CoE). In summary, it appeared that patients requiring supplemental oxygen or non-invasive ventilation at baseline benefitted most from baricitinib; the benefit was less clear in patients already on mechanical ventilation. As glucocorticoids were not commonly used at the time of the trial, it remains uncertain whether baricitinib would provide additional benefits beyond standard glucocorticoid use.

Harms

In ACTT-2, patients receiving baricitinib and remdesivir had a lower risk of developing any serious adverse events through day 28 (16% vs. 21%; RR 0.76; 95% CI 0.59,0.99; Moderate CoE) whether or not thought to be related to the study drug. In this trial, the overall rate of new infections was lower in the baricitinib plus remdesivir group compared with remdesivir alone (30 patients [5.9%] versus 57 patients [11.2%]) [152]. However, patients who received concomitant glucocorticoids had a higher incidence of serious or non-serious infection as compared with those who did not: 25.1% and 5.5% respectively. It was not specified what proportion of these patients were in the baricitinib combination group versus the control group in the study.

Based on experience in clinical trials for RA, baricitinib has been found to be associated with an increased risk of adverse effects including infections (especially upper respiratory tract infections), thrombosis, lymphopenia, anemia, increases in lipids, elevations in liver enzymes, and elevations in creatinine phosphokinase [153]. Many of these side effects are thought to be dose related, with increased incidence in patients taking baricitinib 4 mg compared with 2 mg. Patients in ACTT-2 received baricitinib 4 mg daily for two weeks or until discharge, a shorter duration than those taking the drug for RA. In clinical trials for RA, baricitinib was associated with a numerically higher risk of upper respiratory tract infections and herpes simplex and herpes zoster infections compared with placebo [154]. Opportunistic infections have been reported in patients taking baricitinib.

Patients with COVID-19 have been found to have abnormalities in coagulation parameters and might have an elevated risk of thrombosis [155]. Baricitinib has been found to increase incidence of thrombosis compared with placebo in clinical trials for its FDA approval for rheumatoid arthritis, especially at a higher dose of 4 mg daily [153]. During the 16-week treatment period in RA trials, VTE occurred in five patients treated with baricitinib 4 mg daily, compared with zero in the 2 mg daily and placebo groups. Arterial thrombosis occurred in two patients treated with baricitinib 4 mg, two patients treated with baricitinib 2 mg, and one patient on placebo. In ACTT-2, the percentage of patients reported to have VTE was numerically higher in the combination group (21 patients [4.1%] vs 16 patients [3.1%]) although it was

similar overall (absolute difference 1%, 95% CI -1.3 to 3.3) [152]. Of note, all patients in the trial were recommended to receive VTE prophylaxis if they had no contraindication.

Other considerations

The panel agreed on the overall certainty of evidence as low due to concerns with risk of bias, driven by the use of data from post-hoc analyses, and imprecision, which recognized the limited events and concerns with fragility in the group who likely benefited most (those requiring supplemental oxygen or non-invasive ventilation). The guideline panel recognized the uncertainty of potential harms of baricitinib with remdesivir given in combination with corticosteroids (dexamethasone is recommended for patients with severe or critical disease); however, noted the importance of suggesting baricitinib plus remdesivir as an option for persons unable to receive corticosteroids.

Conclusions and research needs for this recommendation


The guideline panel suggests baricitinib with remdesivir for persons who cannot receive corticosteroids. Baricitinib plus remdesivir should be reserved for patients who cannot take corticosteroids because dexamethasone has been proven to reduce mortality in patients hospitalized with COVID-19 who require supplemental oxygen or mechanical ventilation and, for this reason, dexamethasone is recommended by the panel for this group. It is uncertain whether baricitinib plus remdesivir will have the same benefit as dexamethasone, and there are insufficient data to recommend the use of dexamethasone along with baricitinib plus remdesivir. The guideline panel recommends baricitinib with remdesivir in combination with corticosteroids only in the context of a clinical trial. Additional clinical trials are needed to better understand the potential harms when baricitinib is given with corticosteroids and whether there is a benefit of treatment for patients with COVID-19 (**Table s2**).

Table 16. GRADE evidence profile, Recommendation 16

Question: Baricitinib with remdesivir compared to remdesivir for hospitalized patients with COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	baricitinib + RDV	RDV	Relative (95% CI)	Absolute (95% CI)		
Mortality (follow up: 28 days)												
1 ¹	randomized trials	not serious	not serious	not serious	serious ^a	none	24/515 (4.7%)	37/518 (7.1%)	HR 0.65 (0.39 to 1.09)	24 fewer per 1,000 (from 43 fewer to 6 more)	⊕⊕⊕○ MODERATE	CRITICAL
Clinical recovery - hospitalized requiring supplemental O2/receiving noninvasive ventilation or high-flow O2 (ordinal 5+6) (assessed with: Ordinal scale <4)												
1 ¹	randomized trials	serious ^b	not serious	not serious	serious ^c	none	344/391 (88.0%)	316/389 (81.2%)	RR 1.08 (1.02 to 1.15)	65 more per 1,000 (from 16 more to 122 more)	⊕⊕○○ LOW	CRITICAL
Clinical recovery - receiving noninvasive ventilation or high-flow O2, invasive mechanical ventilation or ECMO (ordinal 6+7; stratified) (assessed with: Ordinal scale <4)												
1 ¹	randomized trials	not serious ^d	not serious	not serious	serious ^e	none	122/176 (69.3%)	114/191 (59.7%)	HR 1.29 (1.00 to 1.66) ^d	93 more per 1,000 (from 0 fewer to 182 more)	⊕⊕⊕○ MODERATE	CRITICAL
New use of mechanical ventilation or ECMO (follow up: 29 days)												
1 ¹	randomized trials	serious ^f	not serious	not serious	serious ^g	none	46/461 (10.0%)	70/461 (15.2%)	RR 0.66 (0.46 to 0.93)	52 fewer per 1,000 (from 82 fewer to 11 fewer)	⊕⊕○○ LOW	CRITICAL

Serious adverse events (follow up: 28 days)

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	baricitinib + RDV	RDV	Relative (95% CI)	Absolute (95% CI)		
1 ¹	randomized trials	not serious	not serious	not serious	serious ^g	none	81/507 (16.0%)	107/509 (21.0%)	RR 0.76 (0.59 to 0.99) ^h	50 fewer per 1,000 (from 86 fewer to 2 fewer)	 MODERATE	CRITICAL
<p>GRADE Working Group grades of evidence</p> <p>High certainty: We are very confident that the true effect lies close to that of the estimate of the effect</p> <p>Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different</p> <p>Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect</p> <p>Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect</p> <p>Risk of bias: Study limitations</p> <p>Inconsistency: Unexplained heterogeneity across study findings</p> <p>Indirectness: Applicability or generalizability to the research question</p> <p>Imprecision: The confidence in the estimate of an effect to support a particular decision</p> <p>Publication bias: Selective publication of studies</p>												

CI: Confidence interval; RR: Risk ratio; HR: Hazard Ratio; OR: Odds ratio; RDV: Remdesivir

Explanations

- 95% CI includes substantial benefits as well as substantial harms
- Non-stratified subgroup post-hoc analysis.
- Lower boundary of the 95% CI crosses our threshold for a meaningful difference.
- Data from table S6. Although described as "analysis as randomized" in this stratum of severe COVID-19 patients, the analysis included moving patient from a baseline of "moderate" to "severe" post hoc (19 in the baricitinib group vs 21 in the placebo group), thus altering the original stratification. However, re-analysis using to original strata data (ordinal scale 6 and 7 from table 2) and 28-day cutoff (as a binary, non-time to event analysis) produce a similar result (RR 1.2, 95% CI 1.005 to 1.43). Not rated down for post-hoc analysis concerns.
- 95% CI includes substantial benefits as well as no effect
- Not a predefined stratum. Secondary analysis.
- Less than 300 events; concern for fragility
- SAEs in 5 or more participants in any preferred term by treatment group. 6/507 were thought related to study drug in the baricitinib group; 5/509 were thought to be related to the study drug in the placebo group.

Reference

- Kalil AC, Patterson TF, Mehta AK, et al. Baricitinib plus Remdesivir for Hospitalized Adults with Covid-19. N Engl J Med **2020**.

Ivermectin

Section last reviewed and updated 2/13/2021

Recommendation 18: In hospitalized patients with severe COVID-19, the IDSA panel suggests against ivermectin use outside of the context of a clinical trial. (Conditional recommendation, very low certainty of evidence)

Recommendation 19: In outpatients with COVID-19, the IDSA panel suggests against ivermectin use outside of the context of a clinical trial. (Conditional recommendation, very low certainty of evidence)

The last literature search was conducted February 8, 2021.

Why is ivermectin considered for treatment?

Ivermectin is an anti-parasitic agent that is FDA-approved for onchocerciasis and strongyloidiasis and is used off-label for the treatment of many parasitic infections. Although it has in vitro activity against some viruses, it has no proven therapeutic utility. Ivermectin does have some in vitro activity against SARS-CoV-2 [156], but concentrations needed to obtain the in vitro IC50 are considerably higher than those achieved in human plasma and lung tissue [157]. Since Ivermectin is generally well-tolerated, it was empirically evaluated in uncontrolled studies for COVID-19, alone and in combination with other off-label medications.

Summary of the evidence

Our search identified seven studies in patients with COVID-19 with ages ranging between 8 and 86 years that reported on the outcomes of mortality, symptom resolution, viral clearance, and adverse events, and informed the evidence review for inpatients and outpatients [158-164]. Eligible studies compared treatment with ivermectin against a placebo or standard of care. Studies comparing ivermectin to a non-placebo, active comparison (i.e., a different agent considered a possible treatment for COVID-19 infection by clinicians) or that did

not provide a comparison arm were not included in these analyses. Several studies did not meet eligibility for inclusion in this review. Four trials compared ivermectin to hydroxychloroquine (active comparison) [165-168]; two trials examined ivermectin as prophylactic treatment [169, 170]; and three trials did not provide study data in a peer-reviewed, published or pre-print manuscript [168, 171, 172].

The studies that informed the recommendations for hospitalized patients included five RCTs [158-160, 162, 163] and two non-randomized studies [161, 164]. Four RCTs [160, 162, 173, 174] informed the recommendation for outpatients. Each of them compared an active treatment arm of ivermectin to an inactive comparison (e.g., standard of care with or without placebo). Studies that compared ivermectin to other therapy (e.g., HCQ) were excluded, as the presence of a non-placebo, active comparator may bias the effectiveness of ivermectin.

Among the five RCTs, the risk of bias was high in two trials because of unsuccessful randomization into treatment and control groups. Hashim et al., 2020 inadequately randomized participants by allocating them to respective treatment arms on odd and even days, as well as assigning all critically ill patients to the ivermectin arm, and Podder et al., 2020 allocated participants based on odd or even registration numbers. In addition, across all the RCTs, there were concerns due to lack of blinding of study personnel, which may lead to over- or under-estimates of treatment effects, particularly for subjective outcomes (e.g., symptom resolution, adverse events).

Benefits

Inpatients

The evidence is very uncertain, but studies suggested that ivermectin may decrease mortality among persons with COVID-19 (RR: 0.57; 95% CI: 0.36, 0.90; very low CoE). Persons receiving treatment with ivermectin rather than no ivermectin may trend toward increased symptom resolution and viral clearance (RR: 1.07; 95% CI: 0.69, 1.65; very low CoE and RR: 1.33; 95% CI: 1.00, 1.78; very low CoE, respectively).

Outpatients

The evidence is very uncertain, but one study suggested that ivermectin may reduce the time to recovery among outpatients with COVID-19 (mean difference: 7.32 days fewer; 95% CI: 9.25 to 5.39 days fewer; very low CoE). Similarly, the evidence is very uncertain; however, there may be a trend toward mortality reduction, and viral clearance at day 7 (RR: 0.12; 95% CI: 0.01, 2.09; very low CoE and RR: 0.93; 95% CI: 0.63, 1.37; very low CoE, respectively).

Harms

In doses typically used for the treatment of parasitic infections, ivermectin is well-tolerated. We are unable to exclude the potential for adverse events among hospitalized and non-hospitalized persons with COVID-19 treated with ivermectin rather than no ivermectin, which was informed by the same body of evidence (RR: 1.00; 95% CI: 0.39, 2.58; very low CoE).

Other considerations

The panel determined the certainty of evidence of treatment of ivermectin for hospitalized and non-hospitalized patients to be very low due to concerns with risk of bias and imprecision. In addition, there were concerns about publication bias, as the available evidence consisted mostly of positive trials of smaller size. The guideline panel made a conditional recommendation against treatment of COVID-19 with ivermectin outside of the context of a clinical trial for both patients with COVID-19 hospitalized or in the outpatient setting.

Conclusions and research needs for this recommendation

The guideline panel suggests against ivermectin for the treatment of hospitalized patients with COVID-19, unless in the context of a clinical trial. The guideline panel suggests against ivermectin for the treatment of outpatients with COVID-19, unless in the context of a clinical trial. Well-designed, adequately powered, and well-executed clinical trials are needed to inform decisions on treating COVID-19 with ivermectin (**Table s2**).

Table 17. GRADE evidence profile, Recommendation 18

Question: Ivermectin compared to no ivermectin for patients with COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ivermectin	no ivermectin	Relative (95% CI)	Absolute (95% CI)		
Mortality (NRS)												
4 ^{1,2,3,4}	observational studies	serious ^a	not serious	not serious	serious ^b	none	28/271 (10.3%)	35/260 (13.5%)	RR 0.57 (0.36 to 0.90)	58 fewer per 1,000 (from 86 fewer to 13 fewer)	⊕○○○ VERY LOW	CRITICAL
Symptom resolution (follow up: 7 days)												
1 ⁵	randomized trials	serious ^c	not serious	not serious	very serious ^b	none	16/25 (64.0%)	15/25 (60.0%)	RR 1.07 (0.69 to 1.65)	42 more per 1,000 (from 186 fewer to 390 more)	⊕○○○ VERY LOW	CRITICAL
Viral clearance at day 7 (RCT) (follow up: range 7 days to 29 days)												
3 ^{4,6,7}	randomized trials	serious ^d	not serious	serious ^e	very serious ^b	none	29/54 (53.7%)	22/55 (40.0%)	RR 1.33 (1.00 to 1.78)	132 more per 1,000 (from 0 fewer to 312 more)	⊕○○○ VERY LOW	IMPORTANT
Adverse events (follow up: 28 days)												
1 ⁴	randomized trials	not serious	not serious	not serious	very serious ^b	none	7/12 (58.3%)	8/12 (66.7%)	RR 0.88 (0.47 to 1.63)	80 fewer per 1,000 (from 353 fewer to 420 more)	⊕⊕○○ LOW	IMPORTANT
GRADE Working Group grades of evidence												
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect												
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different												
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect												
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect												

Risk of bias: Study limitations

Inconsistency: Unexplained heterogeneity across study findings

Indirectness: Applicability or generalizability to the research question

Imprecision: The confidence in the estimate of an effect to support a particular decision

Publication bias: Selective publication of studies

CI: Confidence interval; **RR:** Risk ratio

Explanations

- a. Concerns with unmeasured and residual confounding. Gorial 2020 single arm with historical control. Hashim 2020 used even vs. odd days to place subjects into treatment groups with critical patients not included in the placebo group. In Rajtal, corticosteroids were used in 19.6% of usual care patients vs. 39.8% of ivermectin patients.
- b. The 95% CI includes the potential for both appreciable benefit as well as the potential for harm. Few events reported do not meet the optimal information size and suggest fragility in the estimate
- c. Open label trial may lead to bias with measurement of subjective outcomes.
- d. Podder 2020 assigns participants based on odd or even registration numbers. Also, 20 patients were excluded following randomization without sensitivity analysis to explore imbalance across treatment arms.
- e. Viral clearance is a surrogate for clinical improvement, such as hospitalization, need for ICU care and mechanical ventilation.

References

1. Gorial FI, Mashhadani S, Sayaly HM, et al. Effectiveness of ivermectin as add-on therapy in COVID-19 management (pilot trial). medRxiv 2020: Available at: <https://doi.org/10.1101/2020.07.07.20145979> [Epub ahead of print 8 July 2020].
2. Hashim HA, Maulood MF, Rasheed AM, Fatak DF, Kabah KK, Abdulmir AS. Controlled randomized clinical trial on using Ivermectin with Doxycycline for treating COVID-19 patients in Baghdad, Iraq. medRxiv 2020: Available at: <https://doi.org/10.1101/2020.10.26.20219345> [Preprint 27 October 2020].
3. 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 Ivermectin in COVID Nineteen Study. Chest 2021; 159(1): 85-92.
4. 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. EClinicalMedicine 2020: [In press] Available at: <https://doi.org/10.1016/j.eclinm.2020.100720>.
5. Chachar AZK, Khan KA, Asif M, Tanveer K, Khaqan A, Basri R. Effectiveness of Ivermectin in SARS-CoV-2/COVID-19 Patients. Int J Sci 2020; 9(09): 31-5.
6. 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: 214-6.
7. Podder CS, Chowdhury N, Sina MI, Ul Haque WMM. Outcome of ivermectin treated mild to moderate COVID-19 cases: a single-centre, open-label, randomised controlled study. IMC J Med Sci 2020; 14(2): 002. [Epub ahead of print 3 September 2020]

Table 18. GRADE evidence profile, Recommendation 19

Question: Ivermectin compared to no ivermectin for patients not admitted to the hospital for management of COVID-19

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ivermectin	no ivermectin	Relative (95% CI)	Absolute (95% CI)		
Mortality (NRS)												
4 ^{1,2,3,4}	randomized trials	serious ^a	not serious	not serious	very serious ^b	none	0/165 (0.0%)	4/167 (2.4%)	RR 0.12 (0.01 to 2.09)	21 fewer per 1,000 (from 24 fewer to 26 more)	⊕○○○ VERY LOW	CRITICAL
Progression to severe disease (assessed with: need for invasive ventilation)												
3 ^{1,2,4}	randomized trials	serious ^c	not serious	not serious	very serious ^b	none	1/115 (0.9%)	5/117 (4.3%)	RR 0.21 (0.03 to 1.72)	34 fewer per 1,000 (from 41 fewer to 31 more)	⊕○○○ VERY LOW	CRITICAL
Viral clearance at day 7 (RCT) (follow up: range 6 days to 29 days)												
3 ^{2,3,4}	randomized trials	serious ^c	not serious	serious ^{d,e}	very serious ^b	none	33/117 (28.2%)	36/119 (30.3%)	RR 0.93 (0.63 to 1.37)	21 fewer per 1,000 (from 112 fewer to 112 more)	⊕○○○ VERY LOW	IMPORTANT
Time to recovery (assessed with: days)												
1 ¹	randomised trials	serious ^c	not serious	not serious ^f	very serious ^g	none	48	48	-	MD 7.32 days fewer (9.25 fewer to 5.39 fewer)	⊕○○○ VERY LOW	IMPORTANT
Adverse events (follow up: 28 days)												
2 ^{2,3}	randomised trials	serious ^c	not serious	not serious	very serious ^b	none	5/53 (9.4%)	5/57 (8.8%)	RR 1.00 (0.39 to 2.58)	0 fewer per 1,000 (from 54 fewer to 139 more)	⊕○○○ VERY LOW	IMPORTANT

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ivermectin	no ivermectin	Relative (95% CI)	Absolute (95% CI)		
GRADE Working Group grades of evidence												
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect												
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different												
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect												
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect												
Risk of bias: Study limitations												
Inconsistency: Unexplained heterogeneity across study findings												
Indirectness: Applicability or generalizability to the research question												
Imprecision: The confidence in the estimate of an effect to support a particular decision												
Publication bias: Selective publication of studies												

CI: Confidence interval; RR: Risk ratio

Explanations

- Concerns with unmeasured and residual confounding. Gorial 2020 single arm with historical control. Hashim 2020 used even vs. odd days to place subjects into treatment groups with critical patients not included in the placebo group. In Rajtal, corticosteroids were used in 19.6% of usual care patients vs. 39.8% of ivermectin patients.
- The 95% CI includes the potential for both appreciable benefit as well as the potential for harm. Few events reported do not meet the optimal information size and suggest fragility of the estimate
- Open label trial may lead to bias with measurement of subjective outcomes.
- Viral clearance is a surrogate for clinical improvement, such as hospitalization, need for ICU care and mechanical ventilation.
- Roy 2021 reported viral clearance at day 6.
- Ivermectin was combined with doxycycline.
- Number of events is less than the optimal information size, which may suggest fragility in the estimate of effect.

References

- Hashim HA, Maulood MF, Rasheed AM, Fatak DF, Kabah KK, Abdulmir AS. Controlled randomized clinical trial on using Ivermectin with Doxycycline for treating COVID-19 patients in Baghdad, Iraq. medRxiv **2020**: Available at: <https://doi.org/10.1101/2020.10.26.20219345> [Preprint 27 October 2020].
- 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. EClinicalMedicine **2020**: [In press] Available at: <https://doi.org/10.1016/j.eclinm.2020.100720>.
- Bukhari SKHS, Asghar A, Perveen N, et al. Efficacy of Ivermectin in COVID-19 Patients with Mild to Moderate Disease. medRxiv **2021**: Available at: <https://doi.org/10.1101/2021.02.02.21250840> [Preprint 5 February 2021].
- Ravikirti, Roy R, Pattadar C, et al. Ivermectin as a potential treatment for mild to moderate COVID-19—A double blind randomized placebo-controlled trial. medRxiv **2021**: Available at: <https://doi.org/10.1101/2021.01.05.21249310> [Preprint 9 January 2021].

Narrative summaries of treatments undergoing evaluation

In addition to the clinical questions addressed above, the panel identified several treatments currently undergoing evaluation for which additional data are needed to rate recommendations. Narrative summaries for these treatments are provided below.

HIV antivirals

Last reviewed 4/11/2020; no updates made since 4/11/2020

In vitro antiviral activity of darunavir against SARS-CoV-2 showed no activity at clinically relevant concentrations. Three randomized, open-label clinical trials are currently listed on evaluating darunavir/cobicistat as a potential therapeutic option for COVID-19. Janssen, the manufacturer of darunavir/cobicistat has reported that one of these trials [175] has concluded that darunavir/cobicistat plus conventional treatments was not effective in achieving viral clearance at day seven post randomization, compared to conventional treatments alone. Clinical outcomes of this trial including rate of critical illness and mortality 14 days after randomization, have not been reported to date.

Lopinavir-ritonavir combined with interferon beta or other antivirals

Last reviewed and updated 9/4/2020

Lopinavir-ritonavir is a combination of protease inhibitors for the treatment of HIV infection. Lopinavir-ritonavir has been shown to have *in vitro* antiviral activity against beta-coronaviruses such as SARS-CoV, and MERS-CoV [58, 60, 61, 176]. Since lopinavir-ritonavir is not specifically designed for treatment of coronavirus, lopinavir-ritonavir alone may not demonstrate a difference from placebo in reducing viral load when treatment was initiated at a median of 13 days after symptoms onset [61]. In an open-label treatment trial, lopinavir-ritonavir with ribavirin reduced the mortality and requirement of intensive care support of hospitalized SARS patients compared with historical control [61]. Many interferons, especially

interferon beta have been shown to have modest in-vitro antiviral activity against SARS-CoV and MERS-CoV [58, 176]. Lopinavir-ritonavir or interferon beta-1b has been shown to reduce viral load of MERS-CoV and improve lung pathology in a nonhuman primate model of common marmoset [60].

An RCT on the triple combination of lopinavir-ritonavir, ribavirin, and interferon beta-1b, compared with single agent lopinavir-ritonavir for 14 days was conducted in the treatment of 127 adult patients admitted to hospital with COVID-19 [64]. Patients who had NEWS2 of least one, and with symptom duration of 14 days or less were recruited and randomly assigned to either triple combination or control group in a ratio of 2:1. Treatment with triple combination was well tolerated, and had a significantly shorter median time to suppress the viral load in nasopharyngeal specimen, and a significantly shorter time to alleviate symptoms, and resulted in shorter hospital stay. Since the median number of days from symptom onset to the start of study treatment was five days, only one patient in the control group received ventilator support and no patient died during the study. It is not possible to generalize the effectiveness of triple therapy in critically ill patients.

Lopinavir-ritonavir was further investigated in two retrospective cohort studies using HCQ [177] and arbidol [178], an indole-derivative licensed for decades in Russia and China against influenza, for comparison. Lopinavir-ritonavir was associated with more rapid viral clearance (median, 21 days vs. 28 days) than HCQ in 65 mild to moderate COVID-19 patients in South Korea, but there was no difference in time to clinical improvement [177]. Lopinavir-ritonavir was found to be inferior to arbidol in terms of viral clearance on day 14 after admission. But the number of patients was small (n=50) and all patients received atomized inhalation of recombinant human interferon- α 2b injection. The efficacy of arbidol monotherapy remains uncertain [178].

Subcutaneous injection of interferon β -1a was used for the treatment of 42 severe COVID-19 adult patients in an open-label randomized clinical trial in Iran. Although there was no significant improvement in time to clinical response in the interferon-treated group, the overall mortality at 28 days was reduced in the interferon-treated then the control group (19% vs. 43.6%, $p=0.015$) [179].

COVID-19 convalescent plasma for prophylaxis

Last reviewed and updated 9/4/2020

Studies of CP for treatment of hospitalized patients with COVID-19 were discussed in a previous section. Use of CP as prophylaxis in individuals with high-risk exposure to SARS-CoV-2 is under study, with at least five clinical trials in clinicaltrials.gov as of August 6, 2020 that include arms in which individuals exposed to SARS-CoV-2 but without disease may receive CP [180-184]. Issues associated with regulatory concerns, safety, workflow, and trial design were recently reviewed [185]. Distinct from the polyclonal antibodies present in CP, monoclonal antibodies specific for respiratory viruses have also been used in certain populations for protection against disease in specific high-risk populations [186, 187], and animal models have suggested utility in prophylaxis against SARS coronavirus infection [188]. There are multiple trials listed in clinicaltrials.gov of different SARS-CoV-2 monoclonal antibodies for treatment or prophylaxis, with other potential monoclonal antibodies in earlier stages of development. No data on safety or efficacy are yet reported.

Ribavirin

Last reviewed 4/11/2020; no updates made since 4/11/2020

There are only *in vitro* data available on the activity of ribavirin on SARS-CoV-2 currently. The EC₅₀ (half maximal effective concentrations) was significantly higher than for chloroquine and remdesivir, so it appears less potent *in vitro* compared to these agents [16]. There are limited clinical studies in SARS-CoV-1 and MERS-CoV infections. In a systematic review of ribavirin treatment in patients infected with SARS-CoV-1, 26 studies were classified as inconclusive, and four showed possible harm [189]. In a retrospective observational study in patients with MERS-CoV infection, the combination of ribavirin and interferon, compared to no antiviral treatment, was not associated with improvement in the 90-day mortality or more rapid MERS-CoV RNA clearance [190].

Osetamivir

Last reviewed 4/11/2020; no updates made since 4/11/2020

Osetamivir is a neuraminidase inhibitor used for prophylaxis and treatment of influenza. Given its specificity for an enzyme not found on coronaviruses, it is unclear what the mechanism of action would be against COVID-19. However, this has been used in combinations of antiviral therapy in Wuhan [191] and continues to be explored as a therapeutic option as part of combination regimens. Two trials evaluating combination regimens are underway in Wuhan [192, 193] as well as a trial in Thailand proposing different combinations [194]. None of the trials or case reports have examined osetamivir as monotherapy.

Intravenous immunoglobulin

Last reviewed and updated 9/4/2020

Intravenous immunoglobulin (IVIg) has been used as an adjuvant to treat a variety of pathogens either as a pooled product or in a concentrated more pathogen focused (hyperimmune) form. As the community from which a given batch of IVIg is derived from includes increasing numbers of individuals who have recovered from SARS-CoV-2, the possibility of protective antibodies being present in the pooled product is increased. However, the potential utility of IVIg for the treatment of SARS-CoV-2 is unknown at this time. Its use has been reported in a few patients with COVID-19 [195], but studies are needed to determine if there may be a role for IVIg in the treatment of SARS-CoV-2.

One open-label trial randomized patients with COVID-19 ($\text{SPO}_2 \leq 96\%$ on ≥ 4 liters O_2 by nasal cannula but not on mechanical ventilation) to either three days of IVIg (n=16) or no IVIg (n=17) [196]. During the study period (30 days or hospital discharge), two patients in the IVIg arm and seven in the standard of care arm required mechanical ventilation, one patient in the IVIg arm and three patients in the standard of care arm died. No adverse events were reported in the IVIg arm. Co-treatments with remdesivir, convalescent plasma, and corticosteroids were balanced across arms at baseline; however, methylprednisolone was provided with each IVIg

dose in the treatment arm, and co-interventions provided during the treatment period were unbalanced. One retrospective cohort reported on 58 patients who received IVIg; however, the study did not identify a standard of care group and multiple co-treatments were provided [197]. Two case series reported on eight patients [195, 198] with severe COVID-19 who received IVIg for five consecutive days. All patients were discharged from the hospital.

Should NSAIDS be stopped in patients with COVID-19?

Last reviewed and updated 9/4/2020

The role of nonsteroidal anti-inflammatory drugs (NSAIDs) in the management of SARS-CoV-2 was debated widely in the first few months of the COVID-19 pandemic. The discussion was prompted by warnings from European health officials regarding the possibility of increased risk of infection or severity of disease in those taking NSAIDs. These concerns were based on early unconfirmed reports in four patients and supported by theoretical mechanistic concerns about the role NSAIDs play in SARS-CoV-2 pathogenesis. Human coronaviruses, including SARS-CoV-2, use ACE2 to bind to human targets and gain entry into target cells [199]. It has been theorized that NSAIDs, due to upregulation in ACE2 in human target cells, may lead to an increased risk of infection or a more severe course of COVID-19 in those taking NSAIDs. In addition, there are well known risks of non-steroidal anti-inflammatory agents including cardiovascular, gastrointestinal and renal adverse events [200, 201]. In the setting of bacterial pneumonia, NSAIDs may impair recruitment of polymorphonuclear cells, resulting in a delayed inflammatory response and resolution of infection, however a causal relationship has not been established [202, 203].

A case-control study from Italy published in May 2020 did not demonstrate an increased risk of SARS-CoV-2 infection in those taking NSAIDs chronically (adjusted OR: 1.06; 95% CI 0.98, 1.15) [204]. In April 2020, the WHO produced a scientific brief detailing a systematic review that included 73 studies in patients with acute respiratory infections. While no direct studies for patients with MERS, SARS or SARS-CoV-2 were available for analysis, there was no evidence of adverse events [205]. In a large registry trial that included data from five hospitals in

Massachusetts, there was a lower risk of hospitalization in those with SARS-CoV-2 prescribed naproxen or ibuprofen, however it is difficult to determine if these patients were actively taking these medications at the time of COVID-19 diagnosis [206]. Randomized controlled trials are currently underway to better understand the safety of NSAIDs in the management of patients with COVID-19 [207, 208].

Should ACE inhibitors and ARBs for hypertension be stopped in patients with COVID-19?

Last reviewed and updated 9/4/2020

Angiotensin converting enzyme 2 (ACE2) is the entry receptor for SARS-CoV-2 on human cells. Animal experiments have shown mixed findings on the effect of angiotensin-converting enzyme inhibitors (ACEI) and angiotensin receptor blockers (ARBs) on ACE2 levels and activity, leading to two contrasting hypotheses in COVID-19 [209-211]. The harmful hypothesis is that ACEIs and ARBs may increase the risk of infection and severity of COVID-19 via increased ACE2 expression. On the contrary, infection with other coronaviruses have been shown to decrease ACE2 levels *in vitro* [212], which may lead to increased angiotensin II activity resulting in pulmonary, cardiovascular and other end organ damage in patients with COVID-19 [209, 213]. This has led to speculation about a beneficial hypothesis that ACEI and ARBs may have a therapeutic role in COVID-19, by inhibiting the renin-angiotensin-aldosterone axis.

There have been several recent observational studies on the effects of ACEIs and ARBs in patients tested for and diagnosed with COVID-19. A multi-center retrospective study [214] evaluated 1,128 patients admitted to 9 hospitals in Hubei province, China with COVID-19 including 188 (17%), who were on an ACEI or ARB. The risk of 28-day all-cause mortality was lower in ACEI/ARB group vs non-ACEI/ARB group (IRD: -0.24; 95% CI: -0.43, -0.05). After adjusting the all-cause mortality was still lower in the ACEI/ARB group compared to the non-ACEI/ARB group (HR: 0.42; 95% CI 0.15, 0.89). Another single center retrospective study [215] among 1178 hospitalized patients with COVID-19, had 362 patients with hypertension and 115 were on ACEI/ARBs. There was no difference between those with severe vs non-severe illness in

use of ACEIs (9.2% vs 10.1%; $P = .80$), and ARBs (24.9% vs 21.2%; $P = 0.40$). There was also no difference between non-survivors and survivors in use of ACEIs (9.1% vs 9.8%; $P = 0.85$) and ARBs (19.5% vs 23.9%; $P = 0.42$).

Another study [216] among 1200 COVID-19 patients hospitalized in two hospitals in London, UK observed that chronic ACEI/ARB use was not associated with an increase in severity of COVID-19. Within their cohort of 1200 patients, 399 (33.3%) were on an ACEI/ARB and while unadjusted odds of critical care admission or death within 21 days were not significantly different between patients on ACEI/ARB vs not (OR 0.83; 95% CI 0.64, 1.07), adjustment for age, sex and co-morbidities presented an OR of 0.63 (95% CI 0.47, 0.84, $p < 0.01$) for the composite outcomes in patients on ACEI/ARB. An observational study from Italy [217] evaluated multiple predictors of in-hospital mortality in 311 patients with hypertension and COVID-19. The patients in this study were significantly older, with a higher BMI, comorbidities, and severity of disease. In a multivariate Cox regression analysis chronic use of ACEI and ARBs (aHR, 0.97; 95% CI: 0.68, 1.39; $P = .88$) were not associated with an increase in in-hospital mortality.

A population-based case-control study [204] from Lombardy, Italy compared 6272 COVID-19 patients with 30,759 controls matched on sex, age, and municipality of residence. In a logistic-regression multivariate analysis, use of ARBs or ACEI did not show an association with COVID-19 among cases (aOR, 0.95, 95% CI 0.86 to 1.05 for ARBs and 0.96, 95% CI, 0.87 to 1.07 for ACEI). It also did not show an association with severe or fatal disease (for ARBs, aOR 0.83; 95% CI 0.63, 1.10; for ACEI, aOR 0.91; 95% CI 0.69, 1.21). Reynolds et al [218] analyzed data available for patients tested for COVID-19, available in the electronic medical records for New York University Langone Health system. In the study, 12,594 patients were tested, 5,894 (46.8%) were positive and 1,002 of these patients (17.0%) had severe illness. They performed propensity score matching and a Bayesian analysis to assess the relationship between various classes of antihypertensives including ACEI and ARBs and the likelihood of a positive COVID-19 test and severe disease. The study did not show a positive association for ACEI and ARBs with having a positive test for SARS-CoV-2 or developing severe infection. A retrospective cohort study using data from Danish national administrative registries, had an unadjusted 30-day mortality of 18.1% in the group with ACEI/ARB use compared to the 7.3% in the nonuser group,

but the association was not significant after adjustment for age, sex and medical history (aHR 0.83; 95% CI: 0.67, 1.03). In that study, ACEI/ARB use compared with other antihypertensive agents was not significantly associated with higher incidence of COVID-19 (a HR 1.05 95% CI 0.80–1.36) [219]. One retrospective cohort study done in severe COVID-19 patient's showed ACEI/ARB use, after adjusting for other variables, to be independently associated with elevated creatinine >10.1 mg/L (OR 3.22; 95% CI: 2.28, 4.54). Consistent ACEI/ARB use was independently associated with AKI stage ≥ 1 (ALT ratio 3.28; 95% CI: 2.17, 4.94) [220].

Data from these observational studies suggest that ACEI and ARBs do not increase the risk of acquiring COVID-19, developing severe disease or death. One study showed possible increase risk of renal dysfunction in severe COVID-19. There are limitations though inherent to retrospective observational studies, especially differences in unmeasured prognostic factors between the compared groups that might be responsible for the difference in outcomes and not treatment with ACEI or ARBs. Most professional scientific and medical societies have recommended that ACEI or ARBs be continued in people who have an indication for these medications [221-223].

Antibacterials and antifungals

Last reviewed and updated 9/4/2020

Patients with COVID-19 often present to hospitals with viral pneumonia with accompanying febrile illness and respiratory symptoms. Differential diagnoses may include bacterial pneumonia, for which antibiotics are prescribed. Concerns for bacterial superinfections also exist. Studies performed early in the COVID-19 pandemic reported high percentages of antibiotic use in China (58-95%) [1, 191, 224], Spain (74%) [225], and New York (65%) [226]. These studies are not granular and do not report if they describe co-infection at presentation or the development of superinfection, limiting the ability to ascertain the reasons for antibiotic use.

Data reporting co-infection in patients presenting with COVID-19 for care is sparse. Rawson and colleagues reviewed 18 studies of human coronavirus infections reporting co-

infections, of which nine were COVID-19 [227]. These cumulatively reported a bacterial and fungal co-infection rate of 8% (62/806). The studies evaluated were heterogeneous. One brief report of 393 patients in New York reported a bacteremia rate of 5.6%, which varied significantly between patients receiving invasive mechanical ventilation (15/126 [11.9%]) and those who were not (4/222 [1.8%]) [228]. Another study looked at 88,201 blood cultures performed during March 2020 in New York, comparing order volume, positivity, and etiologies between patients with COVID-19 and others during the time period [229]. The study found a significantly lower rate of bacteremia in COVID-19 patients (3.8%) than either COVID-19 negative (8%) or untested (7.1%) ($p < 0.001$). When commensal skin organisms were excluded, the positivity rate in COVID-19 patients was 1.6% [229]. A study in Texas reviewed the use of antibiotics and incidence of coinfections in 147 PCR-positive COVID-19 patients [230]. Eighty-seven (59%) patients received empiric antibiotics, though none of the 47 (32%) patients with respiratory cultures had positive results. 112 patients (76%) had blood cultures collected also, and while nine were positive, eight of those were considered contaminants [230].

The apparent discordance between bacterial and fungal co-infection in patients with COVID-19 at presentation and the use of antibacterial therapy has potential negative effects, namely in antimicrobial resistance. Publications report on patients with severe and critical COVID-19 patients treated with immunomodulatory therapies, including corticosteroids, IL-6 antagonists, IL-1 antagonists, and others [231]. In one preprint examining outcomes of in a cohort of 154 patients receiving invasive mechanically ventilation, mortality was reduced in patients treated with tocilizumab (IPTW-adjusted model, HR 0.55; 95% CI 0.33, 0.90); however, superinfections were more commonly reported (54% vs 26%, $p < 0.001$), primarily due to ventilator-associated pneumonia [109]. Initiating and continuing empiric antibiotics at the time of admission may lead to superinfections that are antibiotic resistant [232].

Favipiravir

Last reviewed and updated 9/4/2020

Favipiravir is a purine analogue that inhibits the RNA dependent RNA polymerase of influenza and other RNA viruses [233]. The drug is approved in Japan for treatment of influenza.

However, because of its teratogenicity risk, favipiravir should not be given during pregnancy and there are substantial concerns about its use in women in child-bearing potential.

In terms of its potential role in COVID-19, favipiravir has *in vitro* activity against SARS-CoV-2 [16]. However, it is uncertain whether adequate drug levels can be achieved in vivo to inhibit SARS-CoV-2. There have been small clinical trials with this drug in people with COVID-19. In a non-randomized, open-label study in China [234], oral favipiravir was associated with shorter time to viral clearance and greater improvement in chest imaging than lopinavir/ritonavir (in both groups, the oral antiviral was given with aerosolized alpha-interferon). However, because the study was small and not randomized, it was not possible to conclude that favipiravir is effective in treating COVID-19. A randomized, open-label trial compared favipiravir to umifenovir, an antiviral approved in Russia and China, in people with COVID-19 [235]. The clinical recovery rate at day seven was not significantly different between the two groups. There appeared to be an impact of favipiravir in the sub-group of people who did not have critical illness, but more data are needed. An exploratory clinical trial, also conducted in China, randomized 30 hospitalized adults with COVID-19 into a baloxavir marboxil, favipiravir or control group. There was no apparent effect of favipiravir (or baloxivir) on viral clearance [236]. There are ongoing clinical trials assessing favipiravir for treatment of COVID-19.

Immunomodulatory agents

Last reviewed and updated 9/4/2020

Some patients with COVID-19 develop a hyperinflammatory state that may incorporate elements of cytokine release syndrome seen in conditions such as secondary hemophagocytic lymphohistiocytosis (sHLH). The etiology is unclear, but patients who develop significantly elevated CRP, ferritin, and D-dimer levels with the syndrome have an increased risk of mortality, associated with respiratory failure, multiorgan dysfunction, and hypercoagulability. Numerous immunomodulatory agents are under investigation to address this immunologic complication.

IL-1 inhibitors: Anakinra is an FDA approved IL-1-beta inhibitor that is currently FDA-approved for rheumatoid arthritis and Neonatal-Onset Multisystem Inflammatory Disease. High- and low-dose anakinra was investigated in a recent retrospective cohort study in Italian patients with COVID-19, moderate to severe ARDS, and hyperinflammation. Patients receiving anakinra were compared to a historical control group with COVID-19 who fulfilled eligibility criteria for anakinra. The low-dose anakinra group was stopped early due to lack of effect. In the high-dose anakinra group, 3/29 (10%) patients died vs. 7/16 (44%) in the historical control group, however there was no difference in the rates of mechanical ventilation-free survival [237]. Anakinra is being investigated in numerous trials including this randomized placebo-controlled trial [238]. Canakinumab is another IL-1-beta antagonist with limited human data for COVID-19 that is being studied in a phase III clinical trial [239, 240].

Janus kinase inhibitors: Baricitinib, a Janus kinase inhibitor (anti-JAK) currently FDA-approved for the treatment of rheumatoid arthritis, is being investigated in multiple studies for COVID-19. The proposed benefits of baricitinib in the management of COVID-19 are two-fold as it has both anti-inflammatory and likely antiviral activity. Janus kinase mediates cytokine signaling which contributes to inflammation, which may reduce risk of the associated hyperinflammatory syndrome and ARDS. Baricitinib inhibits AP2-associated protein kinase 1 (AAK1) and also binds G-associated kinase (GAK), both thought to play a role in receptor mediated endocytosis of many viruses including SARS-CoV-2 [147]. In an open-label non-randomized study from Italy, baricitinib with lopinavir/ritonavir (n=12) were compared to lopinavir/ritonavir (n=12) alone at one institution over two consecutive time periods. After two weeks in the baricitinib group, no patients required ICU transfer and 7/12 (58%) were discharged. In the lopinavir/ritonavir group, 4/12 (33%) required ICU transfer and only 1/12 patients were discharged by day 14. No serious adverse events or infections occurred in the baricitinib group [148]. In the ACTT-2 trial, baricitinib is being compared to remdesivir and numerous other RCTs are currently underway to better understand the role of baricitinib in the management of COVID-19 [241-245].

GM-CSF inhibitors: Monoclonal antibodies that bind to GM-CSF are under investigation for the treatment of hyperinflammation associated with COVID-19. GM-CSF inhibitors are postulated

to disrupt the downstream signaling of pro-inflammatory cytokines. One agent, mavrimumab was studied in a single center non-randomized cohort study in non-ventilated patients in Italy. Trial participants had SARS-CoV-2 infection with a PaO₂: FiO₂ ratio < 300 mm Hg, pulmonary infiltrates, and evidence of hyperinflammation (CRP > 100 mg/L or ferritin > 900 µg/L and any increase in LDH). Patients in the treatment group received a single dose of mavrimumab 6 mg/kg (n=13). A similar cohort managed by the same medical team received no mavrimumab due to lack of consent and lack of access to mavrimumab (n=26). Mortality rates were 0/13 in the mavrimumab group and 7/26 (27%) died in the control group. Median days to clinical improvement (defined as a reduction of two or more points on the seven-point ordinal scale) was 8 (IQR: 5-11) vs. 19 (IQR: 11- > 28), in the mavrimumab vs. control groups, respectively. Mavrimumab was well tolerated in all patients [246]. Randomized controlled trials are underway to investigate the role of GM-CSF inhibitors in the management of COVID-19 [247-249].

Complement inhibitors: In mouse models of both SARS-CoV and MERS-CoV, complement activation has been shown to play a role in the pathogenesis of ARDS. Eculizumab, is a complement inhibitor that is already approved by the FDA for other conditions including myasthenia gravis and paroxysmal nocturnal hemoglobinuria, is currently being studied for the treatment of COVID-19 [250]. Ravulizumab, another complement inhibitor, is also being investigated in randomized trials for COVID-19 [242].

SARS-CoV-2 in children and treatment of multisystem inflammatory syndrome in children (MIS-C)

Last reviewed and updated 9/4/2020

Treatment

Compared with adults, children generally have milder illness from SARS-CoV-2 infection [251, 252]. However, severe illness does occur in children, even those with no predisposing factors [252, 253]. Among children admitted to the hospital for COVID-19, one-third are

admitted to intensive care [252]. Despite this, clinical trials of therapeutic interventions for COVID-19 have almost exclusively focused on adult patients. For example, in the first of two recent studies of the antiviral remdesivir [254, 255], patients younger than 18 years were excluded [256], and the number of children between 12 and 18 years included in the analysis for the second paper was not reported [133]. These studies led to FDA EUA of remdesivir for both adults and children [257], with no published data available on either safety or efficacy in children under 12 years. A phase II/III open label study in this population has started (the “CARAVAN” trial [134]). Future studies of both therapeutics and vaccines will need to include children to assure their safety and efficacy in this population.

Multisystem inflammatory syndrome in children

Multisystem inflammatory syndrome in children (MIS-C) or Pediatric Multisystem Inflammatory Syndrome (PMIS) is a rare acute inflammatory syndrome with some similarities to Kawasaki disease that has recently been reported in children. Reports from Europe and the United States generally describe critically ill children with fever, rash, conjunctivitis, abdominal complaints, shock, and significant cardiac dysfunction [258-270]. Case definitions have been developed to better characterize these patients ([Table 19](#)) [271, 272].

Patients with Kawasaki disease also present with fever and symptoms including rash, conjunctivitis, peripheral extremity changes, lymphadenopathy, and oral mucosal changes such as red, cracked lips and “strawberry tongue.” However, while Kawasaki disease and MIS-C share some similarities, there are also key differences [273]. Both are hyperinflammatory syndromes, both have findings of medium vessel vasculitis and both can present with the signs/symptoms described for Kawasaki disease. MIS-C is more likely to affect older children (average age 8-11 years vs. younger than five years in Kawasaki disease), cause more severe disease (more patients presenting with shock), present frequently with gastrointestinal symptoms, includes some neurologic involvement, and more commonly causes cardiac myocarditis and ventricular dysfunction leading to hypotension or arrhythmias. In contrast, Kawasaki disease more commonly causes coronary artery dilatation. A small study of cytokine profiles in children

distinguished MIS-C from severe COVID-19 based on a higher level of the combination of TNF- α and IL-10 in MIS-C patients [274].

Empiric treatment of MIS-C has generally involved immunomodulatory agents such as high-dose intravenous immunoglobulin (2 g/kg), corticosteroids, aspirin and rarely more targeted anti-inflammatory medications such as anakinra [258-261, 267, 268, 270]. Most of the children with MIS-C have had a history of prior SARS-CoV-2 infection several weeks earlier confirmed by viral detection of antibody testing or have had documented prior exposure to COVID-19, suggesting that this condition is a post-infectious immunologic phenomenon.

Future research should focus on how and why the immune system responds to SARS-CoV-2 causing a spectrum of illness in children, identifying genetic or environmental risk factors for MIS-C, and discovering optimum treatment for children with MIS-C. Multidisciplinary, collaborative approaches to data registries and clinical trials that promote evidence-based care for these children are needed.

Table 19. Case definitions for Multisystem Inflammatory Syndrome in Children (MIS-C) and Paediatric multisystem inflammatory syndrome (PMIS)

	MIS-C (CDC 2020) ¹	PMIS (Royal College of Paediatrics and Child Health 2020) ²
Includes	<p>Age <21 years presenting with:</p> <ul style="list-style-type: none"> • Fever (>38.0°C for ≥24 hours, or report of subjective fever lasting ≥24 hours) • Laboratory evidence of inflammation (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, or interleukin 6, elevated neutrophils, reduced lymphocytes and low albumin), • Evidence of clinically severe illness requiring hospitalization, with multisystem (>2) organ involvement (cardiac, renal, respiratory, hematologic, gastrointestinal, dermatologic or neurological) 	<p>A child presenting with:</p> <ul style="list-style-type: none"> • Persistent fever >38.5°C • Laboratory evidence of inflammation (neutrophilia, elevated CRP and lymphopenia) • Evidence of single or multi-organ dysfunction (shock, cardiac, respiratory, renal, gastrointestinal or neurological disorder) with additional features (listed in Appendix of reference)
Excludes	Patients with alternative plausible diagnoses	Patients with any other microbial cause, including bacterial sepsis, staphylococcal or streptococcal shock syndromes, infections associated with myocarditis such as enterovirus
Other criteria	Positive for current or recent SARS-CoV-2 infection by RT-PCR, serology, or antigen test; OR COVID-19 exposure within the 4 weeks prior to the onset of symptoms	SARS-CoV-2 PCR testing may be positive or negative

References

1. Centers for Disease Control and Prevention. Multisystem Inflammatory Syndrome in Children (MIS-C) Associated with Coronavirus Disease 2019 (COVID-19). Available at: <https://emergency.cdc.gov/han/2020/han00432.asp>. Accessed 24 May 2020.
2. Royal College of Paediatrics and Child Health. Guidance: Paediatric multisystem inflammatory syndrome temporally associated with COVID-19, **2020**.

Discussion

During epidemics like the current COVID-19 pandemic, when there are no clinically proven treatments, the tendency is to use drugs based on *in vitro* antiviral activity, or on anti-inflammatory effects or based on limited observational studies. It is commendable that observational studies are done during an epidemic, but often they do not have concurrent controls, have a significant risk of bias, and use surrogate outcomes like viral clearance rather than patient-important outcomes. Medications that were thought to be effective based on *in vitro* studies and observational studies for other diseases were later proven to be ineffective in clinical trials [275].

Due to the understandable urgency in producing, synthesizing and disseminating data during the current pandemic, there has been a noticeable increase in fast track publication of studies. In addition to well-established concerns that may decrease our certainty in the available evidence, there may be additional issues that will ultimately influence the trustworthiness of that evidence, including: 1) Circumvention of usual research steps (delay of IRB approval [276], inclusion of same patients in several studies); 2) Limited peer-review process (the usual due diligence from editors and reviewers is side-stepped, potentially leading to unnoticed errors in data and calculations, incomplete reporting of methods and results, as well as underestimation of study limitations); 3) Increased potential for publication bias (in the interest of showing promising data and in the race to achieve recognition, there may be added inclination to publish positive results and disregard negative ones). The extent and impact of these considerations remain currently uncertain but were acknowledged in the development of this guideline.

Despite these limitations, the recommendations in this guideline are based on evidence from the best available clinical studies with patient-important endpoints. The panel determined that when an explicit trade-off between the highly uncertain benefits (e.g., the panel was unable to confirm that HCQ increases viral cure or reduces mortality) and the known putative harms (QT prolongation and drug-drug interactions) were considered, a net positive benefit was not reached and could possibly be negative (risk of excess harm). The safety of drugs used

for the treatment of COVID-19, especially in patients with cardiovascular disease, immunosuppressive conditions, or those who are critically ill with multi-organ failure has also not been studied. Drugs like AZ and HCQ can cause QT prolongation and potentially life-threatening arrhythmias. Steroids and IL-6 inhibitors can be immunosuppressive and potentially increase risk of secondary infections. Steroids may produce long term side effect such as osteonecrosis [277]. In instances where the panel could not make a determination whether the benefits outweigh harms, it is be ethical and prudent to enroll patients with COVID-19 in clinical trials, rather than use clinically unproven therapies [278]. There are multiple ongoing trials, some with adaptive designs, which potentially can quickly answer pressing questions on efficacy and safety of drugs in the treatment of patients with COVID-19.

We acknowledge that enrolling patients in RCTs might not be feasible for many frontline providers due to limited access and infrastructure. Should lack of access to clinical trials exist, we encourage setting up local or collaborative registries to systematically evaluate the efficacy and safety of drugs to contribute to the knowledge base. Without such evaluations we often attribute success to drugs and failure to disease (COVID-19) [275]. During such a pandemic, barriers to conducting studies and enrolling patients in trials for already overburdened front line providers should be minimized while ensuring the rights and safety of patients [279].

For clinical trials and observational studies, it is critical to determine *a priori* standardized and practical definitions of patient populations, clinical syndromes, disease severity and outcomes. Observational and non-experimental studies can sometimes answer questions not addressed by trials, but there is still a need for standardized definitions. For clinical syndromes clearly distinguishing between asymptomatic carrier state, upper respiratory tract infection and lower respiratory tract infection is important. Illness severity should be reasonably defined using readily available clinical criteria of end organ failure, like the degree of respiratory failure using SpO₂ (percentage of oxyhemoglobin saturation) or PaO₂:FiO₂ ratios (partial pressure of oxygen in arterial blood: fractional percentage of inspired oxygen) for lower respiratory tract infection, as opposed to location-based severity determinations such as ICU admission, which can lead to bias based on resource limitations (i.e., bed availability) or regional/institutional practice patterns [280]. For outcomes of prophylaxis trials, the primary

endpoint should be prevention of infection and for therapeutic trials patient centered outcomes like reduction of mortality (both short term and long term) [281]. Trials should also study treatments in high risk populations or special populations like immunosuppressed patients, people with HIV, patients with cardiovascular comorbidities and pregnant women. The panel expressed the overarching goal that patients be recruited into ongoing trials, which would provide much needed evidence on the efficacy and safety of various therapies for COVID-19.

This is a living guideline that will be frequently updated as new data emerges. Updates and changes to the guideline will be posted to the IDSA website.

Acknowledgement: The expert panel thanks the Infectious Diseases Society of America for supporting guideline development, and specifically Cindy Sears, Dana Wollins, Genet Demisashi, and Rebecca Goldwater for their continued support throughout the guideline process. The panel would also like to acknowledge Haya Waseem, Kapeena Sivakumaran, and Nicholas J. Newman for supporting the evidence base for this guideline.

Financial Support: This project was funded in part by a cooperative agreement with the Centers for Disease Control and Prevention (CDC) (grant number 6 NU50CK000477-04-01). The CDC is an agency within the Department of Health and Human Services (HHS). The contents of this guideline do not necessarily represent the policy of CDC or HHS and should not be considered an endorsement by the Federal Government.

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has served on a scientific advisory board for Gilead Sciences, Inc., serves on a scientific advisory board for Merck, and receives research funding from the NIH. **J.G.** serves in an advisory role for Qpex and Shionogi; receives research funding from Merck; previously served in an advisory role for Acceletrate, Achaogen, Astellas, Melinta, Nabriva, Paratek, scPharmaceutic, Spero and Tetrphase; and previously served on the speakers bureau for Astellas, Melinta, Merck and Shiongi. **M.H.M** receives research funding from the Agency for Healthcare Research and Quality, the Endocrine Society, the Society for Vascular Surgery and The American Society of Hematology and is a Board member for the Evidence Foundation. **W.J.M.** serves in an advisory role for Seqirus, Inc. and receives research funding from Ansun Biopharma, Astellas Pharma, AstraZeneca, Abbott Laboratories, Enanta Pharmaceuticals, Gilead Sciences, Janssen Pharmaceuticals, Karius, Merck, Melinta Therapeutics, Nabriva Therapeutics, Roche and Tetrphase Pharmaceuticals. **S.S.** serves as an advisory board member for Amplyx Pharmaceuticals, Inc.; as an advisor/consultant to ReViral Ltd.; receives research funding from Ansun BioPharma, F2G, Shire (now Takeda), University of Nebraska, Cidara Therapeutics; and has served as an advisor for Janssen Pharmaceutica and Acidophil. **A.H.S.** receives research funding from the U.S. Department of Veterans Affairs. **Y.F.Y.** receives honoraria for evidence reviews and teaching from the Evidence Foundation, honoraria for evidence reviews for the American Gastroenterological Association, and serves as a Director for the Evidence Foundation and for the U.S. GRADE Network. All other authors: no disclosures reported. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed. All other authors: no disclosures reported.

References

1. Guan WJ, Ni ZY, Hu Y, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med* **2020**.
2. World Health Organization. Coronavirus disease 2019 (COVID-19) Situation Report - 75. Geneva: World Health Organization, **2020** 4 April.
3. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA* **2020**.
4. Morgan RL, Florez I, Falavigna M, et al. Development of rapid guidelines: 3. GIN-McMaster Guideline Development Checklist extension for rapid recommendations. *Health Res Policy Syst* **2018**; 16(1): 63.
5. Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines: 2. Framing the question and deciding on important outcomes. *J Clin Epidemiol* **2011**; 64(4): 395-400.
6. U.S. Food and Drug Administration. What is a Serious Adverse Event? Available at: <https://www.fda.gov/safety/reporting-serious-problems-fda/what-serious-adverse-event>. Accessed 19 June 2020.
7. National Institute for Health and Care Excellence. Scoping. Interim process and methods for developing rapid guidelines on COVID-19 (PMG35). London: National Institute for Health and Care Excellence, **2020**.
8. Wallace BC, Dahabreh IJ, Trikalinos TA, Lau J, Trow P, Schmid CH. Closing the gap between methodologists and end-users: R as a computational back-end. *J Stat Softw* **2012**; 49(5): 1-15.
9. Higgins JPT, Thomas J, Chandler J, et al. *Cochrane Handbook for Systematic Reviews of Interventions*. 2 ed. Chichester (UK): John Wiley & Sons, **2019**.
10. Sterne JA, Hernan MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* **2016**; 355: i4919.
11. Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* **2011**; 64(4): 383-94.
12. GRADEpro GDT. GRADEpro Guideline Development Tool [Software]. McMaster University, 2015 (developed by Evidence Prime, Inc.). Available at: <https://gradepro.org/>.
13. Ben-Zvi I, Kivity S, Langevitz P, Shoenfeld Y. Hydroxychloroquine: from malaria to autoimmunity. *Clin Rev Allergy Immunol* **2012**; 42(2): 145-53.
14. Keyaerts E, Vijgen L, Maes P, Neyts J, Van Ranst M. In vitro inhibition of severe acute respiratory syndrome coronavirus by chloroquine. *Biochem Biophys Res Commun* **2004**; 323(1): 264-8.
15. Dyal J, Coleman CM, Hart BJ, et al. Repurposing of clinically developed drugs for treatment of Middle East respiratory syndrome coronavirus infection. *Antimicrob Agents Chemother* **2014**; 58(8): 4885-93.
16. 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): 269-71.

17. 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**.
18. Vincent MJ, Bergeron E, Benjannet S, et al. Chloroquine is a potent inhibitor of SARS coronavirus infection and spread. *Virology* **2005**; 2: 69.
19. 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.
20. Li C, Zu S, Deng YQ, et al. Azithromycin Protects against Zika virus Infection by Upregulating virus-induced Type I and III Interferon Responses. *Antimicrob Agents Chemother* **2019**.
21. Kouznetsova J, Sun W, Martinez-Romero C, et al. Identification of 53 compounds that block Ebola virus-like particle entry via a repurposing screen of approved drugs. *Emerg Microbes Infect* **2014**; 3(12): e84.
22. Gielen V, Johnston SL, Edwards MR. Azithromycin induces anti-viral responses in bronchial epithelial cells. *Eur Respir J* **2010**; 36(3): 646-54.
23. Tyteca D, Van Der Smissen P, Mettlen M, et al. Azithromycin, a lysosomotropic antibiotic, has distinct effects on fluid-phase and receptor-mediated endocytosis, but does not impair phagocytosis in J774 macrophages. *Exp Cell Res* **2002**; 281(1): 86-100.
24. Menzel M, Akbarshahi H, Bjermer L, Uller L. Azithromycin induces anti-viral effects in cultured bronchial epithelial cells from COPD patients. *Sci Rep* **2016**; 6: 28698.
25. Takizawa H, Desaki M, Ohtoshi T, et al. Erythromycin suppresses interleukin 6 expression by human bronchial epithelial cells: a potential mechanism of its anti-inflammatory action. *Biochem Biophys Res Commun* **1995**; 210(3): 781-6.
26. Schultz MJ. Macrolide activities beyond their antimicrobial effects: macrolides in diffuse panbronchiolitis and cystic fibrosis. *J Antimicrob Chemother* **2004**; 54(1): 21-8.
27. 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.
28. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without Azithromycin in Mild-to-Moderate Covid-19. *N Engl J Med* **2020**.
29. Horby P, Mafham M, Linsell L, et al. Effect of Hydroxychloroquine in Hospitalized Patients with COVID-19: Preliminary results from a multi-centre, randomized, controlled trial. *medRxiv* **2020**.
30. Chen J, LIU D, LIU L, et al. A pilot study of hydroxychloroquine in treatment of patients with moderate COVID-19. *Journal of Zhejiang University (Medical Sciences)* **2020**; 49(1): 0-.
31. Chen Z, Hu J, Zhang Z, et al. Efficacy of hydroxychloroquine in patients with COVID-19: results of a randomized clinical trial. *medRxiv* **2020**.
32. Pan H, Peto R, Karim QA, et al. Repurposed antiviral drugs for COVID-19; interim WHO SOLIDARITY trial results. *MedRxiv* **2020**: Available at: <https://doi.org/10.1101/2020.10.15.20209817> [Preprint 15 October 2020].

33. 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): 2165-76.
34. Ulrich RJ, Troxel AB, Carmody E, et al. Treating COVID-19 With Hydroxychloroquine (TEACH): A Multicenter, Double-Blind Randomized Controlled Trial in Hospitalized Patients. *Open Forum Infect Dis* **2020**; 7(10): ofaa446.
35. 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.
36. Geleris J, Sun Y, Platt J, et al. Observational Study of Hydroxychloroquine in Hospitalized Patients with Covid-19. *N Engl J Med* **2020**.
37. Magagnoli J, Narendran S, Pereira F, et al. Outcomes of hydroxychloroquine usage in United States veterans hospitalized with Covid-19. *Med* **2020**.
38. Mahevas M, Tran V-T, Roumier M, et al. No evidence of clinical efficacy of hydroxychloroquine in patients hospitalized for COVID-19 infection with oxygen requirement: results of a study using routinely collected data to emulate a target trial. *MedRxiv* **2020**.
39. 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**.
40. Yu B, Li C, Chen P, et al. Low dose of hydroxychloroquine reduces fatality of critically ill patients with COVID-19. *Sci China Life Sci* **2020**.
41. Ip A, Berry DA, Hansen E, et al. Hydroxychloroquine and Tocilizumab Therapy in COVID-19 Patients-An Observational Study. *medRxiv* **2020**.
42. Cipriani A, Zorzi A, Ceccato D, et al. Arrhythmic profile and 24-hour QT interval variability in COVID-19 patients treated with hydroxychloroquine and azithromycin. *Int J Cardiol* **2020**.
43. Wang C, Fortin PR, Li Y, Panaritis T, Gans M, Esdaile JM. Discontinuation of antimalarial drugs in systemic lupus erythematosus. *J Rheumatol* **1999**; 26(4): 808-15.
44. Youngster I, Arcavi L, Schechmaster R, et al. Medications and glucose-6-phosphate dehydrogenase deficiency: an evidence-based review. *Drug Saf* **2010**; 33(9): 713-26.
45. Mohammad S, Clowse MEB, Eudy AM, Criscione-Schreiber LG. Examination of Hydroxychloroquine Use and Hemolytic Anemia in G6PDH-Deficient Patients. *Arthritis Care Res (Hoboken)* **2018**; 70(3): 481-5.
46. Beauverd Y, Adam Y, Assouline B, Samii K. COVID-19 infection and treatment with hydroxychloroquine cause severe haemolysis crisis in a patient with glucose-6-phosphate dehydrogenase deficiency. *Eur J Haematol* **2020**.
47. Kuipers MT, van Zwieten R, Heijmans J, et al. G6PD deficiency-associated hemolysis and methemoglobinemia in a COVID-19 patient treated with chloroquine. *Am J Hematol* **2020**.
48. Maillart E, Leemans S, Van Noten H, et al. A case report of serious haemolysis in a glucose-6-phosphate dehydrogenase-deficient COVID-19 patient receiving hydroxychloroquine. *Infect Dis (Lond)* **2020**: 1-3.

49. Rainsford KD, Parke AL, Clifford-Rashotte M, Kean WF. Therapy and pharmacological properties of hydroxychloroquine and chloroquine in treatment of systemic lupus erythematosus, rheumatoid arthritis and related diseases. *Inflammopharmacology* **2015**; 23(5): 231-69.
50. Molina JM, Delaugerre C, 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. *Médecine et Maladies Infectieuses* **2020**.
51. Chorin E, Dai M, Shulman E, et al. The QT Interval in Patients with SARS-CoV-2 Infection Treated with Hydroxychloroquine/Azithromycin. *medRxiv* **2020**.
52. Morgan ND, Patel SV, Dvorkina O. Suspected hydroxychloroquine-associated QT-interval prolongation in a patient with systemic lupus erythematosus. *J Clin Rheumatol* **2013**; 19(5): 286-8.
53. Chen CY, Wang FL, Lin CC. Chronic hydroxychloroquine use associated with QT prolongation and refractory ventricular arrhythmia. *Clin Toxicol (Phila)* **2006**; 44(2): 173-5.
54. Yelve K, Phatak S, Patil MA, Pazare AR. Syncope in a patient being treated for hepatic and intestinal amoebiasis. *BMJ Case Rep* **2012**; 2012.
55. Stas P, Faes D, Noyens P. Conduction disorder and QT prolongation secondary to long-term treatment with chloroquine. *Int J Cardiol* **2008**; 127(2): e80-2.
56. Ray WA, Murray KT, Hall K, Arbogast PG, Stein CM. Azithromycin and the risk of cardiovascular death. *N Engl J Med* **2012**; 366(20): 1881-90.
57. von Rosensteil NA, Adam D. Macrolide antibacterials. Drug interactions of clinical significance. *Drug Saf* **1995**; 13(2): 105-22.
58. Chen F, Chan KH, Jiang Y, et al. In vitro susceptibility of 10 clinical isolates of SARS coronavirus to selected antiviral compounds. *J Clin Virol* **2004**; 31(1): 69-75.
59. Wu CY, Jan JT, Ma SH, et al. Small molecules targeting severe acute respiratory syndrome human coronavirus. *Proc Natl Acad Sci U S A* **2004**; 101(27): 10012-7.
60. Chan JF, Yao Y, Yeung ML, et al. Treatment With Lopinavir/Ritonavir or Interferon-beta1b Improves Outcome of MERS-CoV Infection in a Nonhuman Primate Model of Common Marmoset. *J Infect Dis* **2015**; 212(12): 1904-13.
61. 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): 252-6.
62. Spanakis N, Tsiodras S, Haagmans BL, et al. Virological and serological analysis of a recent Middle East respiratory syndrome coronavirus infection case on a triple combination antiviral regimen. *Int J Antimicrob Agents* **2014**; 44(6): 528-32.
63. Kim UJ, Won EJ, Kee SJ, Jung SI, Jang HC. Combination therapy with lopinavir/ritonavir, ribavirin and interferon-alpha for Middle East respiratory syndrome. *Antivir Ther* **2016**; 21(5): 455-9.
64. 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): 1695-704.
65. 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**.

66. RECOVERY Collaborative Group, Horby PW, Mafham M, et al. Lopinavir–ritonavir in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. *The Lancet* **2020**; 396(10259): 1345-52.
67. World Health Organization. Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected. Available at: <https://apps.who.int/iris/bitstream/handle/10665/331446/WHO-2019-nCoV-clinical-2020.4-eng.pdf>. Accessed 24 June 2020.
68. 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): 757-67.
69. Lee N, Allen Chan KC, Hui DS, et al. Effects of early corticosteroid treatment on plasma SARS-associated Coronavirus RNA concentrations in adult patients. *J Clin Virol* **2004**; 31(4): 304-9.
70. Xiao JZ, Ma L, Gao J, et al. [Glucocorticoid-induced diabetes in severe acute respiratory syndrome: the impact of high dosage and duration of methylprednisolone therapy]. *Zhonghua Nei Ke Za Zhi* **2004**; 43(3): 179-82.
71. Laurent A, Bonnet M, Capellier G, Aslanian P, Hebert P. Emotional Impact of End-of-Life Decisions on Professional Relationships in the ICU: An Obstacle to Collegiality? *Crit Care Med* **2017**; 45(12): 2023-30.
72. 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): 267-76.
73. WHO Rapid Evidence Appraisal for COVID-19 Therapies (REACT) 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**.
74. Horby P, Lim WS, Emberson J, et al. Effect of Dexamethasone in Hospitalized Patients with COVID-19: Preliminary Report. *medRxiv* **2020**: 2020.06.22.20137273.
75. 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**.
76. 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**.
77. 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**.
78. Petersen MW, Meyhoff TS, Helleberg M, et al. Low-dose hydrocortisone in patients with COVID-19 and severe hypoxia (COVID STEROID) trial-Protocol and statistical analysis plan. *Acta Anaesthesiol Scand* **2020**.
79. 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* **2020**.

80. Corral L, Bahamonde A, Arnaiz delas Revillas F, et al. GLUCOCOVID: A controlled trial of methylprednisolone in adults hospitalized with COVID-19 pneumonia. medRxiv **2020**: 2020.06.17.20133579.
81. Salton F, Confalonieri P, Santus P, et al. Prolonged low-dose methylprednisolone in patients with severe COVID-19 pneumonia. medRxiv **2020**: 2020.06.17.20134031.
82. Wang Y, Jiang W, He Q, et al. Early, low-dose and short-term application of corticosteroid treatment in patients with severe COVID-19 pneumonia: single-center experience from Wuhan, China. medRxiv **2020**: 2020.03.06.20032342.
83. 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**.
84. Fernandez-Cruz A, Ruiz-Antoran B, Munoz-Gomez A, et al. Impact of glucocorticoid treatment in SARS-CoV-2 infection mortality: a retrospective controlled cohort study. medRxiv **2020**: 2020.05.22.20110544.
85. Lu X, Chen T, Wang Y, et al. Adjuvant corticosteroid therapy for critically ill patients with COVID-19. medRxiv **2020**: 2020.04.07.20056390.
86. Yuan M, Xu X, Xia D, et al. Effects of Corticosteroid Treatment for Non-Severe COVID-19 Pneumonia: A Propensity Score-Based Analysis. Shock **2020**.
87. Henzen C, Suter A, Lerch E, Urbinelli R, Schorno XH, Briner VA. Suppression and recovery of adrenal response after short-term, high-dose glucocorticoid treatment. Lancet **2000**; 355(9203): 542-5.
88. Siemieniuk RA, Meade MO, Alonso-Coello P, et al. Corticosteroid Therapy for Patients Hospitalized With Community-Acquired Pneumonia: A Systematic Review and Meta-analysis. Ann Intern Med **2015**; 163(7): 519-28.
89. Chen G, Wu D, Guo W, et al. Clinical and immunological features of severe and moderate coronavirus disease 2019. J Clin Invest **2020**; 130(5): 2620-9.
90. Kalikshstein DB, Levantovskaia OM, Vyshenepol'skii I, Ol'shanskii A. [Coagulation and anticoagulation systems of the blood in allergic diseases]. Sov Med **1988**; (9): 104-6.
91. Regeneron Pharmaceuticals, Inc. Evaluation of the Efficacy and Safety of Sarilumab in Hospitalized Patients With COVID-19. Available at: <https://clinicaltrials.gov/ct2/show/NCT04315298>.
92. Assistance Publique - Hôpitaux de Paris. Cohort Multiple Randomized Controlled Trials Open-label of Immune Modulatory Drugs and Other Treatments in COVID-19 Patients - Sarilumab Trial - CORIMUNO-19 - SARI (CORIMUNO-SARI). Available at: <https://clinicaltrials.gov/ct2/show/NCT04324073>.
93. Branch-Elliman W. Sarilumab for Patients With Moderate COVID-19 Disease. Available at: <https://clinicaltrials.gov/ct2/show/NCT04359901>.
94. Della-Torre E, Campochiaro C, Cavalli G, et al. Interleukin-6 blockade with sarilumab in severe COVID-19 pneumonia with systemic hyperinflammation: an open-label cohort study. Ann Rheum Dis **2020**; 79(10): 1277-85.
95. Gremese E, Cingolani A, Bosello SL, et al. Sarilumab use in severe SARS-CoV-2 pneumonia. EClinicalMedicine **2020**; 27: 100553.
96. Gordon AC, Mouncey PR, Al-Beidh F, et al. Interleukin-6 Receptor Antagonists in Critically Ill Patients with Covid-19 – Preliminary report. medRxiv **2021**: Available at:

- <https://www.medrxiv.org/content/10.1101/2021.01.07.21249390v2.full> [Preprint 9 January 2021].
97. 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* **2020**; 181(1): 32-40.
 98. 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**: Available at: <https://doi.org/10.1101/2021.02.11.21249258> [Preprint 11 February 2021].
 99. Rosas I, Bräu N, Waters M, et al. Tocilizumab in hospitalized patients with COVID-19 pneumonia. *MedRxiv* **2020**: Available at: <https://doi.org/10.1101/2020.08.27.20183442> [Preprint 12 September 2020].
 100. 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.
 101. 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* **2020**; 181(1): 24-31.
 102. Stone JH, Frigault MJ, Serling-Boyd NJ, et al. Efficacy of Tocilizumab in Patients Hospitalized with Covid-19. *N Engl J Med* **2020**; 383: 2333-44.
 103. 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.
 104. Rojo M, Cano-Valderrama O, Picazo S, et al. Gastrointestinal Perforation After Treatment With Tocilizumab : An Unexpected Consequence of COVID-19 Pandemic. *Am Surg* **2020**; 86(6): 565-6.
 105. Gonzalez Guardiola P, Diez Ares JA, Peris Tomas N, Sebastian Tomas JC, Navarro Martinez S. Intestinal perforation in patient with COVID-19 infection treated with tocilizumab and corticosteroids. Report of a clinical case. *Cir Esp* **2020**.
 106. Ranchal P, Yates E, Gupta R, Aronow WS. Tocilizumab-Associated Bowel Perforation in SARS-CoV-2 Infection. *Am J Ther* **2020**.
 107. Bruce-Hickman D, Sajeed SM, Pang YH, Seow CS, Chen W, Gulati Kansal M. Bowel ulceration following tocilizumab administration in a COVID-19 patient. *BMJ Open Gastroenterol* **2020**; 7(1).
 108. Guaraldi G, Meschiari M, Cozzi-Lepri A, et al. Tocilizumab in patients with severe COVID-19: a retrospective cohort study. *Lancet Rheumatol* **2020**; 2(8): e474-e84.
 109. Somers EC, Eschenauer GA, Troost JP, et al. Tocilizumab for treatment of mechanically ventilated patients with COVID-19. *Clin Infect Dis* **2020**.
 110. Casadevall A, Scharff MD. Return to the past: the case for antibody-based therapies in infectious diseases. *Clin Infect Dis* **1995**; 21(1): 150-61.
 111. Casadevall A, Dadachova E, Pirofski LA. Passive antibody therapy for infectious diseases. *Nat Rev Microbiol* **2004**; 2(9): 695-703.
 112. Sahr F, Ansumana R, Massaquoi TA, et al. Evaluation of convalescent whole blood for treating Ebola Virus Disease in Freetown, Sierra Leone. *J Infect* **2017**; 74(3): 302-9.

113. Cheng Y, Wong R, Soo YO, et al. Use of convalescent plasma therapy in SARS patients in Hong Kong. *Eur J Clin Microbiol Infect Dis* **2005**; 24(1): 44-6.
114. Ko JH, Seok H, Cho SY, et al. Challenges of convalescent plasma infusion therapy in Middle East respiratory coronavirus infection: a single centre experience. *Antivir Ther* **2018**; 23(7): 617-22.
115. Joyner MJ, Senefeld JW, Klassen SA, et al. Effect of convalescent plasma on mortality among hospitalized patients with COVID-19: initial three-month experience. *medRxiv* **2020**.
116. Wajnberg A, Mansour M, Leven E, et al. Humoral immune response and prolonged PCR positivity in a cohort of 1343 SARS-CoV 2 patients in the New York City region. *medRxiv* **2020**.
117. Salazar E, Kuchipudi SV, Christensen PA, et al. Relationship between Anti-Spike Protein Antibody Titers and SARS-CoV-2 In Vitro Virus Neutralization in Convalescent Plasma. *bioRxiv* **2020**.
118. 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**.
119. Liu ST, Lin H-M, Baine I, et al. Convalescent plasma treatment of severe COVID-19: A matched control study. *medRxiv* **2020**.
120. U.S. Food and Drug Administration. Recommendations for Investigational COVID-19 Convalescent Plasma. 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 28 August 2020.
121. Duan K, Liu B, Li C, et al. Effectiveness of convalescent plasma therapy in severe COVID-19 patients. *Proc Natl Acad Sci U S A* **2020**; 117(17): 9490-6.
122. Gharbharan A, Jordans CC, GeurtsvanKessel C, et al. Convalescent Plasma for COVID-19. A randomized clinical trial. *MEDRxiv* **2020**.
123. Joyner M, Wright RS, Fairweather D, et al. Early Safety Indicators of COVID-19 Convalescent Plasma in 5,000 Patients. *medRxiv* **2020**.
124. Joyner MJ, Bruno KA, Klassen SA, et al. Safety Update: COVID-19 Convalescent Plasma in 20,000 Hospitalized Patients. *Mayo Clin Proc* **2020**; 95(9): 1888-97.
125. Salazar E, Christensen PA, Graviss EA, et al. Treatment of COVID-19 Patients with Convalescent Plasma Reveals a Signal of Significantly Decreased Mortality. *Am J Pathol* **2020**.
126. Lo MK, Jordan R, Arvey A, et al. GS-5734 and its parent nucleoside analog inhibit Filo-, Pneumo-, and Paramyxoviruses. *Sci Rep* **2017**; 7: 43395.
127. Sheahan TP, Sims AC, Graham RL, et al. Broad-spectrum antiviral GS-5734 inhibits both epidemic and zoonotic coronaviruses. *Sci Transl Med* **2017**; 9(396).
128. Warren TK, Jordan R, Lo MK, et al. Therapeutic efficacy of the small molecule GS-5734 against Ebola virus in rhesus monkeys. *Nature* **2016**; 531(7594): 381-5.
129. Williamson BN, Feldmann F, Schwarz B, et al. Clinical benefit of remdesivir in rhesus macaques infected with SARS-CoV-2. *Nature* **2020**.

130. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the Treatment of Covid-19 - Final Report. *N Engl J Med* **2020**.
131. 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): 1048-57.
132. 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): 1569-78.
133. 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**.
134. Gilead Sciences, Inc. Study to Evaluate the Safety, Tolerability, Pharmacokinetics, and Efficacy of Remdesivir (GS-5734™) in Participants From Birth to < 18 Years of Age With Coronavirus Disease 2019 (COVID-19) (CARAVAN). Available at: <https://www.clinicaltrials.gov/ct2/show/NCT04431453>. Accessed 18 November 2020.
135. Borrell B. New York clinical trial quietly tests heartburn remedy against coronavirus. Available at: <https://www.sciencemag.org/news/2020/04/new-york-clinical-trial-quietly-tests-heartburn-remedy-against-coronavirus>.
136. Wu C, Liu Y, Yang Y, et al. Analysis of therapeutic targets for SARS-CoV-2 and discovery of potential drugs by computational methods. *Acta Pharm Sin B* **2020**.
137. 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**.
138. U.S. Food and Drug Administration. Fact Sheet for Health Care Providers: Emergency Use Authorization (EUA) of Bamlanivimab. Available at: <https://www.fda.gov/media/143603/download>. Accessed 15 November 2020.
139. U.S. Food and Drug Administration. Fact Sheet for Health Care Providers: Emergency Use Authorization (EUA) of Casirivimab and Imdevimab. Available at: <https://www.fda.gov/media/143892/download>. Accessed 3 February 2021.
140. Jones BE, Brown-Augsburger PL, Corbett KS, et al. LY-CoV555, a rapidly isolated potent neutralizing antibody, provides protection in a non-human primate model of SARS-CoV-2 infection. *bioRxiv* **2020**.
141. Baum A, Ajithdoss D, Copin R, et al. REGN-COV2 antibodies prevent and treat SARS-CoV-2 infection in rhesus macaques and hamsters. *Science* **2020**.
142. ACTIV-3/TICO LY-CoV555 Study Group, Grund B, Barkauskas CE, et al. A Neutralizing Monoclonal Antibody for Hospitalized Patients with Covid-19. *N Engl J Med* **2020**.
143. Chen P, Nirula A, Heller B, et al. SARS-CoV-2 Neutralizing Antibody LY-CoV555 in Outpatients with Covid-19. *N Engl J Med* **2021**; 384(3): 229-37.
144. Weinreich DM, Sivapalasingam S, Norton T, et al. REGN-COV2, a Neutralizing Antibody Cocktail, in Outpatients with Covid-19. *N Engl J Med* **2021**; 384(3): 238-51.
145. Bekerman E, Neveu G, Shulla A, et al. Anticancer kinase inhibitors impair intracellular viral trafficking and exert broad-spectrum antiviral effects. *J Clin Invest* **2017**; 127(4): 1338-52.
146. Neveu G, Ziv-Av A, Barouch-Bentov R, Berkerman E, Mulholland J, Einav S. AP-2-associated protein kinase 1 and cyclin G-associated kinase regulate hepatitis C virus entry and are potential drug targets. *J Virol* **2015**; 89(8): 4387-404.

147. Richardson P, Griffin I, Tucker C, et al. Baricitinib as potential treatment for 2019-nCoV acute respiratory disease. *Lancet* **2020**; 395(10223): e30-e1.
148. Cantini F, Niccoli L, Matarrese D, Nicastrì E, Stobbione P, Goletti D. Baricitinib therapy in COVID-19: A pilot study on safety and clinical impact. *J Infect* **2020**; 81(2): 318-56.
149. Titanji BK, Farley MM, Mehta A, et al. Use of Baricitinib in Patients with Moderate and Severe COVID-19. *Clin Infect Dis* **2020**.
150. Rodriguez-Garcia JL, Sanchez-Nievas G, Arevalo-Serrano J, Garcia-Gomez C, Jimenez-Vizuetè JM, Martinez-Alfaro E. Baricitinib improves respiratory function in patients treated with corticosteroids for SARS-CoV-2 pneumonia: an observational cohort study. *Rheumatology (Oxford)* **2021**; 60(1): 399-407.
151. Cantini F, Niccoli L, Nannini C, et al. Beneficial impact of Baricitinib in COVID-19 moderate pneumonia; multicentre study. *J Infect* **2020**; 81(4): 647-79.
152. Kalil AC, Patterson TF, Mehta AK, et al. Baricitinib plus Remdesivir for Hospitalized Adults with Covid-19. *N Engl J Med* **2020**.
153. Jorgensen SCJ, Tse CLY, Burry L, Dresser LD. Baricitinib: A Review of Pharmacology, Safety, and Emerging Clinical Experience in COVID-19. *Pharmacotherapy* **2020**; 40(8): 843-56.
154. OLUMIANT (baricitinib) tablet, for oral use (package insert). Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2018/207924s000lbl.pdf. Accessed 23 December 2020.
155. Connors JM, Levy JH. COVID-19 and its implications for thrombosis and anticoagulation. *Blood* **2020**; 135(23): 2033-40.
156. 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.
157. 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.
158. 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: 214-6.
159. Chachar AZK, Khan KA, Asif M, Tanveer K, Khaqan A, Basri R. Effectiveness of Ivermectin in SARS-CoV-2/COVID-19 Patients. *Int J Sci* **2020**; 9(09): 31-5.
160. 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. *EClinicalMedicine* **2020**: [In press] Available at: <https://doi.org/10.1016/j.eclinm.2020.100720>.
161. Gorial FI, Mashhadani S, Sayaly HM, et al. Effectiveness of ivermectin as add-on therapy in COVID-19 management (pilot trial). *medRxiv* **2020**: Available at: <https://doi.org/10.1101/2020.07.07.20145979> [Epub ahead of print 8 July 2020].
162. Hashim HA, Maulood MF, Rasheed AM, Fatak DF, Kabah KK, Abdulmir AS. Controlled randomized clinical trial on using Ivermectin with Doxycycline for treating COVID-19 patients in Baghdad, Iraq. *medRxiv* **2020**: Available at: <https://doi.org/10.1101/2020.10.26.20219345> [Preprint 27 October 2020].

163. Podder CS, Chowdhury N, Sina MI, Ul Haque WMM. Outcome of ivermectin treated mild to moderate COVID-19 cases: a single-centre, open-label, randomised controlled study. *IMC J Med Sci* **2020**; 14(2): 002. [Epub ahead of print 3 September 2020].
164. Rajter JC, Sherman MS, Fattah N, Vogel F, Sacks J, Rajter JJ. Use of Ivermectin Is Associated With Lower Mortality in Hospitalized Patients With Coronavirus Disease 2019: The Ivermectin in COVID Nineteen Study. *Chest* **2021**; 159(1): 85-92.
165. Babalola OE, Bode CO, Ajayi AA, et al. Ivermectin shows clinical benefits in mild to moderate Covid19 disease: A randomised controlled double blind dose response study in Lagos. *medRxiv* **2021**: Available at: <https://doi.org/10.1101/2021.01.05.21249131> [Preprint 6 January 2021].
166. Elgazzar A, Hany B, Youssef SA, Hafez M, Moussa H. Efficacy and Safety of Ivermectin for Treatment and prophylaxis of COVID-19 Pandemic. **2020**: Available at: <https://doi.org/10.21203/rs.3.rs-100956/v1> [Preprint 28 December 2020].
167. 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. **2020**: Available at: <https://doi.org/10.21203/rs.3.rs-109670/v1> [Preprint 24 November 2020].
168. Rezaie S. COVID-19 Update: Ivermectin. Available at: <https://rebelem.com/covid-19-update-ivermectin/>. Accessed 10 February 2021.
169. Shoumann WM, Hegazy AA, Nafae RM, et al. Use of Ivermectin as a Potential Chemoprophylaxis for COVID-19 in Egypt: A Randomized Clinical Trial. *JCDR* **2021**; 15(2): OC27-OC32.
170. Peral de Bruno MdIA, Chala RE. Prophylaxis Covid-19 in Healthcare Agents by Intensive Treatment With Ivermectin and Iota-carrageenan (Ivercar-Tuc). Available at: <https://clinicaltrials.gov/ct2/show/NCT04701710>.
171. Raad H. In vivo use of ivermectin (IVR) for treatment for corona virus infected patients (COVID-19): a randomized controlled trial. Available at: <http://www.chictr.org.cn/showprojen.aspx?proj=54707>.
172. Mahmud R. Clinical Trial of Ivermectin Plus Doxycycline for the Treatment of Confirmed Covid-19 Infection. Available at: <https://clinicaltrials.gov/ct2/show/NCT04523831>.
173. Bukhari SKHS, Asghar A, Perveen N, et al. Efficacy of Ivermectin in COVID-19 Patients with Mild to Moderate Disease. *medRxiv* **2021**: Available at: <https://doi.org/10.1101/2021.02.02.21250840> [Preprint 5 February 2021].
174. Ravikirti, Roy R, Pattadar C, et al. Ivermectin as a potential treatment for mild to moderate COVID-19—A double blind randomized placebo-controlled trial. *medRxiv* **2021**: Available at: <https://doi.org/10.1101/2021.01.05.21249310> [Preprint 9 January 2021].
175. Lu H. Efficacy and Safety of Darunavir and Cobicistat for Treatment of Pneumonia Caused by 2019-nCoV (DACO-nCoV). Available at: <https://clinicaltrials.gov/ct2/show/NCT04252274?id=NCT04252274>.
176. Chan JF, Chan KH, Kao RY, et al. Broad-spectrum antivirals for the emerging Middle East respiratory syndrome coronavirus. *J Infect* **2013**; 67(6): 606-16.
177. Kim JW, Kim EJ, Kwon HH, et al. Lopinavir-ritonavir versus hydroxychloroquine for viral clearance and clinical improvement in patients with mild to moderate coronavirus disease 2019. *Korean J Intern Med* **2020**.

178. Zhu Z, Lu Z, Xu T, et al. Arbidol monotherapy is superior to lopinavir/ritonavir in treating COVID-19. *J Infect* **2020**; 81(1): e21-e3.
179. Davoudi-Monfared E, Rahmani H, Khalili H, et al. Efficacy and safety of interferon beta-1a in treatment of severe COVID-19: A randomized clinical trial. *medRxiv* **2020**.
180. Holland HK, Bashey A, Morris L, E, Solomon S, Solh M. Use of Convalescent Plasma for COVID-19. Available at: <https://clinicaltrials.gov/ct2/show/NCT04408040>.
181. Justman JE, Zech J. Convalescent Plasma for COVID-19 Close Contacts. Available at: <https://clinicaltrials.gov/ct2/show/NCT04390503>.
182. Mohamed MA, El Ekiaby M, Ez-Eldin AM, Hussein AM, Selim AM. Clinical Study for Efficacy of Anti-Corona VS2 Immunoglobulins Prepared From COVID19 Convalescent Plasma Prepared by VIPS Mini-Pool IVIG Medical Devices in Prevention of SARS-CoV-2 Infection in High Risk Groups as Well as Treatment of Early Cases of COVID19 Patients. Available at: <https://clinicaltrials.gov/ct2/show/NCT04383548>.
183. Johns Hopkins University, Jain SK, Gordon O. Human Convalescent Plasma for High Risk Children Exposed or Infected With SARS-CoV-2 (COVID-19). Available at: <https://clinicaltrials.gov/ct2/show/NCT04377672>.
184. Shoham S. Efficacy and Safety Human Coronavirus Immune Plasma (HCIP) vs. Control (SARS-CoV-2 Non-immune Plasma) Among Adults Exposed to COVID-19 (CSSC-001). Available at: <https://clinicaltrials.gov/ct2/show/NCT04323800>.
185. Bloch EM, Shoham S, Casadevall A, et al. Deployment of convalescent plasma for the prevention and treatment of COVID-19. *J Clin Invest* **2020**; 130(6): 2757-65.
186. The IMPact-RSV Study Group. Palivizumab, a Humanized Respiratory Syncytial Virus Monoclonal Antibody, Reduces Hospitalization From Respiratory Syncytial Virus Infection in High-risk Infants. *Pediatrics* **1998**; 102(3): 531-7.
187. Feltes TF, Cabalka AK, Meissner HC, et al. Palivizumab prophylaxis reduces hospitalization due to respiratory syncytial virus in young children with hemodynamically significant congenital heart disease. *J Pediatr* **2003**; 143(4): 532-40.
188. ter Meulen J, Bakker AB, van den Brink EN, et al. Human monoclonal antibody as prophylaxis for SARS coronavirus infection in ferrets. *Lancet* **2004**; 363(9427): 2139-41.
189. Stockman LJ, Bellamy R, Garner P. SARS: systematic review of treatment effects. *PLoS Med* **2006**; 3(9): e343.
190. 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* **2019**.
191. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* **2020**; 395(10223): 507-13.
192. Ning Q, Han M. A Prospective/Retrospective, Randomized Controlled Clinical Study of Antiviral Therapy in the 2019-nCoV Pneumonia. Available at: <https://clinicaltrials.gov/ct2/show/NCT04255017>.
193. Ning Q, Han M. A Randomized, Open, Controlled Clinical Study to Evaluate the Efficacy of ASC09F and Ritonavir for 2019-nCoV Pneumonia. Available at: <https://clinicaltrials.gov/ct2/show/NCT04261270>.

194. Kongsangdao S, Sawanpanyalert N. Various Combination of Protease Inhibitors, Oseltamivir, Favipiravir, and Hydroxychloroquine for Treatment of COVID19 : A Randomized Control Trial (THDMS-COVID19). Available at: <https://clinicaltrials.gov/ct2/show/NCT04303299>.
195. Cao W, Liu X, Bai T, et al. High-Dose Intravenous Immunoglobulin as a Therapeutic Option for Deteriorating Patients With Coronavirus Disease 2019. *Open Forum Infect Dis* **2020**; 7(3): ofaa102.
196. Sakoulas G, Geriak M, Kullar R, et al. Intravenous Immunoglobulin (IVIG) Significantly Reduces Respiratory Morbidity in COVID-19 Pneumonia: A Prospective Randomized Trial. *medRxiv* **2020**.
197. Xie Y, Cao S, Dong H, et al. Effect of regular intravenous immunoglobulin therapy on prognosis of severe pneumonia in patients with COVID-19. *J Infect* **2020**; 81(2): 318-56.
198. Mohtadi N, Ghaysouri A, Shirazi S, et al. Recovery of severely ill COVID-19 patients by intravenous immunoglobulin (IVIG) treatment: A case series. *Virology* **2020**; 548: 1-5.
199. Hoffmann M, Kleine-Weber H, Schroeder S, et al. SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor. *Cell* **2020**; 181(2): 271-80 e8.
200. Coxib, traditional NTC, Bhala N, et al. Vascular and upper gastrointestinal effects of non-steroidal anti-inflammatory drugs: meta-analyses of individual participant data from randomised trials. *Lancet* **2013**; 382(9894): 769-79.
201. Zhang X, Donnan PT, Bell S, Guthrie B. Non-steroidal anti-inflammatory drug induced acute kidney injury in the community dwelling general population and people with chronic kidney disease: systematic review and meta-analysis. *BMC Nephrol* **2017**; 18(1): 256.
202. Voiriot G, Dury S, Parrot A, Mayaud C, Fartoukh M. Nonsteroidal antiinflammatory drugs may affect the presentation and course of community-acquired pneumonia. *Chest* **2011**; 139(2): 387-94.
203. Voiriot G, Philippot Q, Elabbadi A, Elbim C, Chalumeau M, Fartoukh M. Risks Related to the Use of Non-Steroidal Anti-Inflammatory Drugs in Community-Acquired Pneumonia in Adult and Pediatric Patients. *J Clin Med* **2019**; 8(6).
204. Mancía G, Rea F, Ludergnani M, Apolone G, Corrao G. Renin-Angiotensin-Aldosterone System Blockers and the Risk of Covid-19. *N Engl J Med* **2020**; 382(25): 2431-40.
205. World Health Organization. The use of non-steroidal anti-inflammatory drugs (NSAIDs) in patients with COVID-19. Available at: [https://www.who.int/news-room/commentaries/detail/the-use-of-non-steroidal-anti-inflammatory-drugs-\(nsaids\)-in-patients-with-covid-19](https://www.who.int/news-room/commentaries/detail/the-use-of-non-steroidal-anti-inflammatory-drugs-(nsaids)-in-patients-with-covid-19). Accessed 18 June 2020.
206. Castro VM, Ross RA, McBride SM, Perlis RH. Identifying common pharmacotherapies associated with reduced COVID-19 morbidity using electronic health records. *medRxiv* **2020**.
207. Adnet F, Slama Schwok A. Efficacy of Addition of Naproxen in the Treatment of Critically Ill Patients Hospitalized for COVID-19 Infection (ENACOVID). Available at: <https://clinicaltrials.gov/ct2/show/NCT04325633>.
208. Beale R, Mazibuko N, Farrell C, King's College London. LIBERATE Trial in COVID-19 (LIBERATE). Available at: <https://clinicaltrials.gov/ct2/show/NCT04334629>.

209. Vaduganathan M, Vardeny O, Michel T, McMurray JJV, Pfeffer MA, Solomon SD. Renin-Angiotensin-Aldosterone System Inhibitors in Patients with Covid-19. *N Engl J Med* **2020**; 382(17): 1653-9.
210. Ferrario CM, Jessup J, Chappell MC, et al. Effect of angiotensin-converting enzyme inhibition and angiotensin II receptor blockers on cardiac angiotensin-converting enzyme 2. *Circulation* **2005**; 111(20): 2605-10.
211. Ishiyama Y, Gallagher PE, Averill DB, Tallant EA, Brosnihan KB, Ferrario CM. Upregulation of angiotensin-converting enzyme 2 after myocardial infarction by blockade of angiotensin II receptors. *Hypertension* **2004**; 43(5): 970-6.
212. Dijkman R, Jebbink MF, Deijs M, et al. Replication-dependent downregulation of cellular angiotensin-converting enzyme 2 protein expression by human coronavirus NL63. *J Gen Virol* **2012**; 93(Pt 9): 1924-9.
213. Sodhi CP, Wohlford-Lenane C, Yamaguchi Y, et al. Attenuation of pulmonary ACE2 activity impairs inactivation of des-Arg(9) bradykinin/BKB1R axis and facilitates LPS-induced neutrophil infiltration. *Am J Physiol Lung Cell Mol Physiol* **2018**; 314(1): L17-L31.
214. Zhang P, Zhu L, Cai J, et al. Association of Inpatient Use of Angiotensin-Converting Enzyme Inhibitors and Angiotensin II Receptor Blockers With Mortality Among Patients With Hypertension Hospitalized With COVID-19. *Circ Res* **2020**; 126(12): 1671-81.
215. Li J, Wang X, Chen J, Zhang H, Deng A. Association of Renin-Angiotensin System Inhibitors With Severity or Risk of Death in Patients With Hypertension Hospitalized for Coronavirus Disease 2019 (COVID-19) Infection in Wuhan, China. *JAMA Cardiol* **2020**.
216. Bean DM, Kraljevic Z, Searle T, et al. Angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers are not associated with severe COVID-19 infection in a multi-site UK acute hospital trust. *Eur J Heart Fail* **2020**; 22(6): 967-74.
217. Tedeschi S, Giannella M, Bartoletti M, et al. Clinical Impact of Renin-angiotensin System Inhibitors on In-hospital Mortality of Patients With Hypertension Hospitalized for Coronavirus Disease 2019. *Clin Infect Dis* **2020**; 71(15): 899-901.
218. Reynolds HR, Adhikari S, Pulgarin C, et al. Renin-Angiotensin-Aldosterone System Inhibitors and Risk of Covid-19. *N Engl J Med* **2020**; 382(25): 2441-8.
219. Fosbol EL, Butt JH, Ostergaard L, et al. Association of Angiotensin-Converting Enzyme Inhibitor or Angiotensin Receptor Blocker Use With COVID-19 Diagnosis and Mortality. *JAMA* **2020**.
220. Oussalah A, Gleye S, Clerc Urmes I, et al. Long-Term ACE Inhibitor/ARB Use Is Associated with Severe Renal Dysfunction and Acute Kidney Injury in Patients with severe COVID-19: Results from a Referral Center Cohort in the North East of France. *Clin Infect Dis* **2020**.
221. European Society of Cardiology. Position Statement of the ESC Council on Hypertension on ACE-Inhibitors and Angiotensin Receptor Blockers. Available at: [https://www.escardio.org/Councils/Council-on-Hypertension-\(CHT\)/News/position-statement-of-the-esc-council-on-hypertension-on-ace-inhibitors-and-ang](https://www.escardio.org/Councils/Council-on-Hypertension-(CHT)/News/position-statement-of-the-esc-council-on-hypertension-on-ace-inhibitors-and-ang). Accessed 3 August 2020.
222. Association AH. Patients taking ACE-i and ARBs who contract COVID-19 should continue treatment, unless otherwise advised by their physician. Available at: <https://newsroom.heart.org/news/patients-taking-ace-i-and-arbs-who-contrast-covid->

- [19-should-continue-treatment-unless-otherwise-advised-by-their-physician](#). Accessed 3 August 2020.
223. International Society of Hypertension. A statement from the International Society of Hypertension on COVID-19. Available at: <https://ish-world.com/news/a/A-statement-from-the-International-Society-of-Hypertension-on-COVID-19>. Accessed 3 August 2020.
224. 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): 1054-62.
225. Rojo JMC, Santos JMA, Núñez-Cortés JM, et al. Clinical characteristics of patients hospitalized with COVID-19 in Spain: results from the SEMI-COVID-19 Network. *medRxiv* **2020**.
226. Argenziano MG, Bruce SL, Slater CL, et al. Characterization and clinical course of 1000 Patients with COVID-19 in New York: retrospective case series. *medRxiv* **2020**.
227. Rawson TM, Moore LSP, Zhu N, et al. Bacterial and fungal co-infection in individuals with coronavirus: A rapid review to support COVID-19 antimicrobial prescribing. *Clin Infect Dis* **2020**.
228. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical Characteristics of Covid-19 in New York City. *N Engl J Med* **2020**; 382(24): 2372-4.
229. Sepulveda J, Westblade LF, Whittier S, et al. Bacteremia and Blood Culture Utilization during COVID-19 Surge in New York City. *J Clin Microbiol* **2020**; 58(8).
230. Wei W, Ortwine JK, Mang NS, Joseph C, Hall BC, Prokesch BC. Limited Role for Antibiotics in COVID-19: Scarce Evidence of Bacterial Coinfection. Available at SSRN 3622388 **2020**.
231. McCreary EK, Pogue JM. Coronavirus Disease 2019 Treatment: A Review of Early and Emerging Options. *Open Forum Infect Dis* **2020**; 7(4): ofaa105.
232. Clancy CJ, Nguyen MH. COVID-19, superinfections and antimicrobial development: What can we expect? *Clin Infect Dis* **2020**.
233. Furuta Y, Gowen BB, Takahashi K, Shiraki K, Smee DF, Barnard DL. Favipiravir (T-705), a novel viral RNA polymerase inhibitor. *Antiviral Res* **2013**; 100(2): 446-54.
234. Cai Q, Yang M, Liu D, et al. Experimental Treatment with Favipiravir for COVID-19: An Open-Label Control Study. *Engineering (Beijing)* **2020**.
235. Chen C, Huang J, Cheng Z, et al. Favipiravir versus arbidol for COVID-19: a randomized clinical trial. *MedRxiv* **2020**.
236. Lou Y, Liu L, Qiu Y. Clinical Outcomes and Plasma Concentrations of Baloxavir Marboxil and Favipiravir in COVID-19 Patients: an Exploratory Randomized, Controlled Trial. *medRxiv* **2020**.
237. 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 Rheumatol* **2020**; 2(6): e325-e31.
238. Chatham WW, Kendrach A, University of Alabama at Birmingham. Early Identification and Treatment of Cytokine Storm Syndrome in Covid-19. Available at: <https://www.clinicaltrials.gov/ct2/show/NCT04362111>.

239. Ucciferri C, Auricchio A, Di Nicola M, et al. Canakinumab in a subgroup of patients with COVID-19. *Lancet Rheumatol* **2020**; 2(8): e457-ee8.
240. Novartis Pharmaceuticals. Study of Efficacy and Safety of Canakinumab Treatment for CRS in Participants With COVID-19-induced Pneumonia (CAN-COVID). Available at: <https://clinicaltrials.gov/ct2/show/NCT04362813>.
241. National Institute of Allergy and Infectious Diseases (NIAID). Adaptive COVID-19 Treatment Trial 2 (ACTT-2). Available at: <https://clinicaltrials.gov/ct2/show/NCT04401579>.
242. Hall F. mulTi-Arm Therapeutic Study in Pre-ICu Patients Admitted With Covid-19 - Repurposed Drugs (TACTIC-R) (TACTIC-R). Available at: <https://clinicaltrials.gov/ct2/show/NCT04390464>.
243. Eli Lilly and Company. A Study of Baricitinib (LY3009104) in Participants With COVID-19 (COV-BARRIER). Available at: <https://clinicaltrials.gov/ct2/show/NCT04421027>.
244. Lenz H-J, University of Southern California. Baricitinib, Placebo and Antiviral Therapy for the Treatment of Patients With Moderate and Severe COVID-19. Available at: <https://clinicaltrials.gov/ct2/show/NCT04373044>.
245. Menichetti F, Ospedaliero A. Baricitinib Compared to Standard Therapy in Patients With COVID-19 (BARICIVID-19). Available at: <https://clinicaltrials.gov/ct2/show/NCT04393051>.
246. 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-e73.
247. Durrant C, Ahmed O, Humanigen, Inc. Phase 3 Study to Evaluate Efficacy and Safety of Lenzilumab in Patients With COVID-19. Available at: <https://clinicaltrials.gov/ct2/show/NCT04351152>.
248. Xu C, Kumar P, Siegel M, et al. Study of TJ003234 (Anti-GM-CSF Monoclonal Antibody) in Subjects With Severe Coronavirus Disease 2019 (COVID-19). Available at: <https://www.clinicaltrials.gov/ct2/show/NCT04341116>.
249. Dagna L, De Luca G, Ospedale San Raffaele. Mavrilimumab in Severe COVID-19 Pneumonia and Hyper-inflammation (COMBAT-19) (COMBAT-19). Available at: <https://clinicaltrials.gov/ct2/show/NCT04397497>.
250. Bergeron-Lafaurie A, Azoulay E, Peffault de Latour R, Assistance Publique - Hôpitaux de Paris. CORIMUNO19-ECU: Trial Evaluating Efficacy and Safety of Eculizumab (Soliris) in Patients With COVID-19 Infection, Nested in the CORIMUNO-19 Cohort (CORIMUNO19-ECU). Available at: <https://clinicaltrials.gov/ct2/show/NCT04346797>.
251. Dong Y, Mo X, Hu Y, et al. Epidemiology of COVID-19 Among Children in China. *Pediatrics* **2020**; 145(6).
252. 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): 1081-8.
253. 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**.

254. National Institute of Allergy and Infectious Diseases (NIAID). Adaptive COVID-19 Treatment Trial (ACTT). Available at: <https://clinicaltrials.gov/ct2/show/NCT04280705>.
255. Gilead Sciences, Inc. Study to Evaluate the Safety and Antiviral Activity of Remdesivir (GS-5734™) in Participants With Severe Coronavirus Disease (COVID-19). Available at: <https://clinicaltrials.gov/ct2/show/NCT04292899>.
256. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the Treatment of Covid-19 - Preliminary Report. *N Engl J Med* **2020**.
257. U.S. Food and Drug Administration. Letter of FDA Emergency Use Authorization to Ashley Rhodes dated May 1, 2020. In: Rhoades A, Gilead Sciences, Inc., **2020**.
258. Belhadjer Z, Méot 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): 429-36.
259. Deza Leon MP, Redzepi A, McGrath E, et al. COVID-19-Associated Pediatric Multisystem Inflammatory Syndrome. *J Pediatric Infect Dis Soc* **2020**; 9(3): 407-8.
260. Riphagen S, Gomez X, Gonzalez-Martinez C, Wilkinson N, Theocharis P. Hyperinflammatory shock in children during COVID-19 pandemic. *Lancet (London, England)* **2020**; 395(10237): 1607-8.
261. 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. *The Lancet* **2020**; 395(10239): 1771-8.
262. Blondiaux E, Parisot P, Redheuil A, et al. Cardiac MRI of Children with Multisystem Inflammatory Syndrome (MIS-C) Associated with COVID-19: Case Series. *Radiology* **2020**: 202288.
263. Greene AG, Saleh M, Roseman E, Sinert R. Toxic shock-like syndrome and COVID-19: A case report of multisystem inflammatory syndrome in children (MIS-C). *Am J Emerg Med* **2020**.
264. Pouletty M, Borocco C, Ouldali N, et al. Paediatric multisystem inflammatory syndrome temporally associated with SARS-CoV-2 mimicking Kawasaki disease (Kawa-COVID-19): a multicentre cohort. *Ann Rheum Dis* **2020**; 79(8): 999-1006.
265. 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): 393-8.
266. Cabrero-Hernandez M, Garcia-Salido A, Leoz-Gordillo I, et al. Severe SARS-CoV-2 Infection in Children With Suspected Acute Abdomen: A Case Series From a Tertiary Hospital in Spain. *Pediatr Infect Dis J* **2020**; 39(8): e195-e8.
267. Feldstein LR, Rose EB, Horwitz SM, et al. Multisystem Inflammatory Syndrome in U.S. Children and Adolescents. *N Engl J Med* **2020**; 383(4): 334-46.
268. Dufort EM, Koumans EH, Chow EJ, et al. Multisystem Inflammatory Syndrome in Children in New York State. *New England Journal of Medicine* **2020**.
269. 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): 259-69.

270. 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): 1074-80.
271. Centers for Disease Control and Prevention. Multisystem Inflammatory Syndrome in Children (MIS-C) Associated with Coronavirus Disease 2019 (COVID-19). Available at: <https://emergency.cdc.gov/han/2020/han00432.asp>. Accessed 24 May 2020.
272. Royal College of Paediatrics and Child Health. Guidance: Paediatric multisystem inflammatory syndrome temporally associated with COVID-19, **2020**.
273. Rowley AH. Understanding SARS-CoV-2-related multisystem inflammatory syndrome in children. *Nat Rev Immunol* **2020**; 20(8): 453-4.
274. 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**.
275. Kalil AC. Treating COVID-19-Off-Label Drug Use, Compassionate Use, and Randomized Clinical Trials During Pandemics. *JAMA* **2020**.
276. Bauchner H, Golub RM, Zylke J. Editorial Concern-Possible Reporting of the Same Patients With COVID-19 in Different Reports. *JAMA* **2020**.
277. Zhao R, Wang H, Wang X, Feng F. Steroid therapy and the risk of osteonecrosis in SARS patients: a dose-response meta-analysis. *Osteoporos Int* **2017**; 28(3): 1027-34.
278. Calain P. The Ebola clinical trials: a precedent for research ethics in disasters. *J Med Ethics* **2018**; 44(1): 3-8.
279. Cook D, Burns K, Finfer S, et al. Clinical research ethics for critically ill patients: a pandemic proposal. *Crit Care Med* **2010**; 38(4 Suppl): e138-42.
280. Fowler RA, Webb SA, Rowan KM, et al. Early observational research and registries during the 2009-2010 influenza A pandemic. *Crit Care Med* **2010**; 38(4 Suppl): e120-32.
281. Iwashyna TJ, McPeake J. Choosing outcomes for clinical trials: a pragmatic perspective. *Curr Opin Crit Care* **2018**; 24(5): 428-33.