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Special Article

Therapeutic options for the management of severe COVID-19: A rheumatology perspective

Claudia Mendoza-Pinto, a,b Mario García-Carrasco, a,b,c Pamela Munguía Realpozo, b Socorro Méndez-Martínez c

a Unidad de Investigación de Enfermedades Autoinmunes Sistémicas, Hospital de Especialidades, UMAE-Centro de Investigación Biomédica de Oriente, Instituto Mexicano del Seguro Social, Puebla, Mexico
b Departamento de Reumatología e Inmunología, Facultad de Medicina, Benemérita Universidad Autónoma de Puebla, Puebla, Mexico
c Coordinación de Investigación en Salud, Delegación Puebla, Instituto Mexicano del Seguro Social, Puebla, Mexico

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ABSTRACT

The novel SARS-CoV-2 human coronavirus in Wuhan, China, has triggered a worldwide respiratory disease outbreak (COVID-19). Acute respiratory distress syndrome (ARDS), multiorgan dysfunction and thrombotic events are among the leading causes of death in critically ill patients with COVID-19. The elevated inflammatory cytokines suggest that a "cytokine storm", also known as cytokine release syndrome (CRS), may play a major role in the pathology of COVID-19. In addition to anti-viral therapy and supportive treatment in critically ill patients, unique medications for this condition are also under investigation. Here we reviewed therapeutic options, including the antibody therapy that might be an immediate strategy for SARS-CoV-2 therapy.

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Opciones terapéuticas en el manejo de la COVID-19 grave: una perspectiva de Reumatología

RESUMEN

El inicio del nuevo coronavirus humano del síndrome respiratorio agudo grave (SARS-CoV-2) en Wuhan, China, ha desencadenado un brote respiratorio mundial (COVID-19). El síndrome de insuficiencia respiratoria aguda (SIRA), el fallo multiorgánico y eventos trombóticos están entre las causas que llevan a la muerte en pacientes críticamente enfermos con COVID-19. Las citocinas inflamatorias elevadas sugieren que una “tormenta de citocinas”, también conocida como síndrome de liberación de citocinas (SLC), puede jugar un papel principal en la patología de COVID-19. Adicionalmente al tratamiento anti-viral y la terapia de apoyo respiratorio en pacientes críticamente enfermos, están en investigación medicamentos únicos para esta condición. En esta revisión sintetizamos la evidencia más actual de opciones terapéuticas, incluyendo anticuerpos anti-citocinas como una estrategia intermedia para la terapia de SARS-CoV-2.

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Introduction

The degree of disease severity with COVID-19 varies and can become fulminant or fatal. The World Health Organization (WHO) estimates that severe disease can occur in about 13.8% of cases and 6.1% are critical. When cases are fulminant, patients may develop sepsis, acute respiratory failure syndrome (ARDS) or multiple organ failure, which are not exclusive to coronaviruses. Cytokine...
release syndrome (CRS) refers to an uncontrolled and exaggerated release of pro-inflammatory mediators into the activated immune system. This disturbance may be present in various clinical entities, including the rheumatology setting, Still’s disease, systemic juvenile idiopathic arthritis, systemic lupus erythematosus and catastrophic antiphospholipid syndrome (APS). CRS is involved in the immunopathogenesis of many pathological processes, such as ARDS, sepsis, Macrophage activation syndrome (MAS), etc., several of which are described in severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and also in the new COVID-19 infection. While treatment directed against the virus is desired, treatment of the systemic response is possibly the most important aspect of patient care and should be viewed aggressively. Finally, patients with COVID-19 who develop a severe condition may have a procoagulant pattern. Therefore, this review synthesizes the evidence related to therapies with an anti-inflammatory role that can play a relevant role in the management of patients with severe COVID-19, briefly mentioning the role of antithrombotic therapy in the treatment of complicated patients.

**Glucocorticoids**

Glucocorticoids (GC) are some of the most widely used anti-inflammatory agents; they are commonly prescribed in the treatment of patients with COVID-19 (72% in the ICU). However, as mentioned in the Chinese COVID-19 guidelines, physicians must be careful in the use of GCs because of their uncertain benefits in the context of viral respiratory infection. Several studies have reported inferior results in SARS patients treated with GC, due to delayed purging of the virus. Other concerns with GCs are short-term and long-term adverse effects.

**Antimalarials (chloroquine and hydroxychloroquine)**

Recent publications have drawn attention to the possible beneficial effect of hydroxychloroquine (HCQ) and chloroquine (CLQ) in the treatment of patients infected with the new SARS-CoV-2 coronavirus. It has been observed that the growth of several different viruses (including SARS coronavirus) can be inhibited in cell cultures by both CLQ and HCQ. In addition, these drugs are weak bases that can affect acidic vesicles and inhibit several enzymes. This characteristic enables inhibiting of viral entry into cells when endocytosis is pH dependent. They also inhibit the enzyme glycosyltransferase (inhibition of virus glycosylation), post-transcriptional viral modifications and replication of some viral families. As it is known that COVID-19 infection can on occasion lead to severe pictures with SARS, which can be due in part to the increase of proinflammatory cytokines such as interleukin 6 (IL-6) and tumour necrosis factor–alpha (TNF-α). CLQ is highly effective in combination with remdesivir in controlling SARS-CoV-2 in vitro. There is now already some evidence in humans. In an open observational study conducted in France, they evaluated the role of HCQ in combination with azithromycin on respiratory viral load in 20 patients with COVID-19 compared with 16 controls. A significant reduction in viral load was shown (70% at day 7) compared to the controls. When azithromycin was added, more efficient elimination of the virus was found (100% reduction). Gao et al. described results in 100 patients in China where they demonstrated the superiority of CLQ over the control treatment in inhibiting exacerbation of pneumonia, improving lung imaging findings, promoting negative virus conversion, and shortening the course of the disease. However, the details of this study are not known in depth. A recent study reported the results of a retrospective analysis of 368 hospitalized patients with confirmed SARS-CoV-2 infection (U.S. Veterans Health Administration) of evaluation of exposure to HCQ alone or in combination with azithromycin. The mortality rates in the HCQ alone, combined HCQ, and no HCQ groups were 27.8%, 22.1%, and 11.4%, respectively. Ventilation rates in the HCQ, combined HCQ and no HCQ groups were 13.3%, 6.9% and 14.1%, respectively. In this study, no evidence was found that the use of HCQ alone or combined reduces the risk of mechanical ventilation in hospitalized patients with COVID-19 and that patients receiving HCQ alone had the highest mortality rate. These findings highlight the importance of waiting for the results of the prospective randomized studies that are underway before widely adopting these drugs. There are currently about 14 clinical trials registered to prove the benefit of antimalarials. Although antimalarials are relatively safe drugs, it should be remembered that their most frequent effects are gastrointestinal, pruritus, and dermal changes in 10% of patients. The most serious effects are of low incidence, such as cardiomyotoxicity, neuromyopathy, and irreversible retinopathy (large doses and long term).

**Tocilizumab, interleukin-6 inhibitor**

There has recently been much interest in the possibility of using tocilizumab, a humanized antibody targeting the IL-6 receptor, on the grounds of preventing or treating the cytokine storm that has been observed in patients that progress to cardiovascular collapse, multiorgan dysfunction, and death. Inflammatory cytokines and chemokines, including IL-6, IL-1β, induced protein 10, and monocyte chemotactic protein-1, have been found to be significantly elevated in COVID-19 patients, and are more often elevated in severe patients than in non-severe patients. In patients with COVID-19, with elevated inflammatory cytokines, post mortem pathology revealed tissue necrosis and infiltrations of macrophages and monocytes in the lung, heart and gastrointestinal mucosa, which suggests an uncontrolled immune response.

Studies have shown that ARDS occurs in some SARS patients despite a reduced viral load, suggesting that an exuberant immune response rather than viral virulence is possibly responsible for the pathology at tissue level. Therefore, antiviral therapy alone may not be sufficient. As previously mentioned, IL-6 is one of the cytokines that plays a role in the pathogenesis in patients with severe COVID-19; it has also been suggested as a biomarker of severe disease, and therefore blockade may be a promising strategy for COVID-19-induced CRS.

IL-6 is essential for the generation of T-helper 17 (Th17) lymphocytes in the interaction between T-lymphocytes and dendritic cells. Therefore elevated IL-6 may explain the excessive Th17 activation observed in patients with COVID-19, as reported by Xu et al. Although no data are available on IL-6 blockade in CRS induced by viral infection, animal studies of SARS-CoV have shown that they inhibit nuclear factor kappa-B, an essential transcription factor of IL-6, increasing animal survival with reduced levels of IL-6. Tocilizumab, which blocks IL-6, binds to the IL-6 receptor in both soluble and membrane-bound forms to inhibit IL-6-mediated signals. This drug has been approved by the Food and Drug Administration for the treatment of CRS associated with CAR T-cell therapy.

Data on the use of this molecule in the treatment of SARS-CoV-2 infection are still preliminary but promising results have prompted the Chinese Health Commission to update its national guidelines, which include tocilizumab for the treatment of severe COVID-19. The Italian guidelines also support the use of tocilizumab (at a dose of 8 mg/kg, with a second dose 12 h after the first and a possible third after 24–36 h, depending on the clinical response), in the event of rapid clinical or radiological worsening, after excluding contraindications to its use (levels of transaminases >5 times the upper limit of normal, neutrophil count <50,000 cells/μL, presence of doc-
Interleukin 1b inhibitors and protein kinase inhibitors  
JAK1/2 (ruxolitinib)

Several laboratory markers related to MAS/haemaphagocytic lymphohistiocytosis (HLH) are elevated in severe COVID-19. Therefore, treatments aimed at controlling MAS/HLH have been suggested for the management of severe COVID-19. The recombinant human IL-1 receptor antagonist, anakinra, has been used for the treatment of MAS/HLH associated with autoimmune rheumatic diseases. Data from a reanalysis of a phase III controlled trial found that anakinra was associated with significant improvement in the survival of patients with sepsis with concurrent MAS/HLH.

Small molecule inhibiting Janus kinases, such as the JAK1/2 inhibitor ruxolitinib, are capable of blocking signals from IL-6, interferon γ (IFN-γ) and other cytokines involved in MAS/HLH. Therefore, this drug could have potential in the treatment of serious complications in patients with COVID-19. More recently, the use of anti-IFN-γ antibodies has been contemplated in the management of this serious complication.

Intravenous immunoglobulin and plasma from recovered patients ("convalescent plasma")

Individuals with a weakened immune system appear to be at greater risk of developing complications associated with COVID-19. Immunotherapy using IgG in combination with antiviral drugs could be used to treat or prevent SARS-CoV-2 infection and strengthen our immune system against this virus. They have also been administered as anti-infective agents against viruses, bacteria and fungi in experimental models and in humans. IVIGs can modulate the immune response by several mechanisms, including blocking various pro-inflammatory cytokines, Fc receptors, and leukocyte adhesion molecules, suppressing Th1 and Th17 cell subtypes, and neutralizing pathogenic autoantibodies. IVIGs can also expand regulatory T lymphocytes. However, IVIGs have adverse reactions. During the SARS outbreak in 2003, IVIG was used extensively in Singapore. However, some critically ill patients developed venous thromboembolism (VTE) including pulmonary embolism despite the use of prophylactic low molecular weight heparin. This is due to the increased viscosity in hypercoagulable states of SARS patients.

Convalescent plasma samples have been used to treat SARS in Hong Kong and China and may be valuable because, unlike standard IVIG preparations, they have high levels of anti-SARS-CoV antibodies. Pyrc et al. showed that human serum from adult humans inhibited infection by HCoV-NL63. Furthermore, they described that IVIGs can also neutralize HCoV-NL63. Boukhvalova et al. demonstrated that, in contrast, the commercially available therapeutic polyclonal IgG products, IVIG obtained from donors with antibodies at high titres against respiratory syncytial virus (RSV), have great potential in improving RSV outcomes in immunocompromised subjects, not only controlling viral replication, but also reducing damage to the lung parenchyma and the epithelial lining of the respiratory tract. The use of convalescent plasma or serum was also suggested by the WHO under the Blood Regulators Network should vaccines and antiviral drugs not be available in an emerging virus. In the current pandemic, there are reports that convalescent plasma has been used in China to treat patients with COVID-19. In a pilot study of 10 patients with severe COVID-19, investigators collected convalescent plasma with neutralizing antibody titres at a dilution of 1:640 or more. The convalescent plasma transfusion resulted in no serious adverse events in the receivers. All 10 patients had improvement of symptoms (e.g., fever, cough, shortness of breath, and precordial pain) within 1–3 days of the transfusion; they also showed radiological improvement in lung lesions. Similarly, an undetectable viral load was found in most of them.

IgG immunotherapy could be used to neutralize the virus causing COVID-19. The efficiency of IgG could be improved if these immune IgG antibodies were collected from patients who had recovered from COVID-19 in the same city, or surrounding areas, as donor subjects who have dealt with the virus.

Plasma interchage

Therapeutic apheresis encompasses a large number of techniques the main basis of which is to process a patient’s blood through an extracorporeal device with the aim of eliminating antibodies and preformed immunocomplexes to prevent tissue damage, eliminating inflammation mediators as a complement and cytokines that could contribute to damage, and providing deficiency factors. Among the different types of apheresis, some of the most used are therapeutic plasma exchange (PE) and immunoadsorption. Therapeutic PE is a technique for purifying extracorporeal blood, through which plasma is removed. A variable volume of plasma is removed from the patient and replaced with replacement solutions that maintain volume and oncotic pressure. The term plasmapheresis should be reserved for situations in which only plasma removal without replenishment is performed, such as plasma donation by apheresis for transfusion or subsequent industrial plasma fractionation. This procedure extracts less plasma (around 600 ml), without replenishment solution, in less time and with simpler separation techniques than those used in PE. The host response to infection has been described and involves a complex interaction of cytokine storm, inflammation, endothelial dysfunction, and pathological coagulation. Plasma exchange is a pathway that offers benefit at multiple levels by removing inflammatory cytokines, stabilizing endothelial membranes, and restarting the hypercoagulable state.

Busund et al. showed a trend towards improving mortality with therapeutic PE as an adjuvant treatment in adults with sepsis and multiple organ failure in a controlled clinical trial, while a meta-analysis by Rimmer also showed benefit in adult patient mortality. Addressing this information, Patel et al. used therapeutic PE during the 2009 A (H1N1) influenza epidemic in 3 paediatric patients with a fulminant condition similar to the current pandemic. All 3 patients developed ARDS with haemodynamic compromise that continued to deteriorate despite rescue treatment for ARDS including inhaled nitric oxide and extracorporeal venous membrane oxygenation. All 3 patients made a full recovery from their disease after receiving rescue PE. Recently, 3 patients were described with COVID-19 in Wuhan, China characterized by deep inflammation and treated with blood purification therapies, including PE and adsorption. A potent effect on cytokine storm management and pathogenic antibodies was shown. Of these 3 patients, 2 maintained a stable state and could be discharged from the Intensive Care Unit, while one developed disseminated intravascular coagulation (DIC) and died.

Antithrombotic therapy

Severe COVID-19 can often present a marked elevation of D-dimer, thrombocytopenia and coagulation disturbances that are considered to be regulated by various inflammatory cytokines and that correlate with mortality. Another biomarker that has been
found to be elevated in patients with severe COVID-19 is ferritin, which is also impaired in other severe conditions, including APS in its most severe form, catastrophic APS. Recently, a group from China described 3 cases with COVID-19 and antiphospholipid antibodies. Recent statements by the International Society on Thrombosis and Haemostasis (ISTH) and the American Society of Hematology (ASH) suggest that all patients hospitalized with COVID-19 should receive thromboprophylaxis or full-dose therapeutic anticoagulation. The efficacy of anticoagulation therapy in patients with COVID-19 was recently evaluated retrospectively. Lower mortality at 28 days was found in patients who used heparin (40%) compared to those who did not (64.2%), mainly in those with sepsis-induced coagulopathy or with markedly elevated D-dimer. Table 1 summarizes the antithrombotic recommendations for patients with COVID-19.

### Conclusions

COVID-19 is a viral infection with potentially serious complications that can increase the risk of death in infected patients. Several of these disturbances are secondary to an uncontrolled immune response where a cytokine storm plays a similarly important role in preventing the thrombotic complications to which these patients are exposed. Although antiviral treatment and respiratory support therapies are essential in the treatment of severe cases, it is necessary to assess the risk-benefit of therapies aimed at controlling the immune response to decrease the mortality rate.

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### Conflict of interests

The authors have no conflict of interests to declare.

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Conclusions: The study provides evidence of a deleterious role of IL-6 in COVID-19-induced severe respiratory distress syndrome, suggesting that IL-6-targeted therapies might be a promising treatment option for COVID-19 patients.