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Heparin treatment in COVID-19: Where are we?

Manuela Rizzo Antonio Pisani*

Department of Public Health, University of Naples, Naples, Italy

Abstract

Coronavirus disease 2019 (COVID-19) is a severe acute respiratory syndrome with a high mortality rate; it is caused by SARS-CoV-2, a new virus of the Corona viridae family that emerged in Wuhan, Hubei, China, in December 2019 and rapidly spread worldwide until declared by the World Health Organization a global pandemic on March. The race for an effective drug to prevent or treat SARS-CoV-2 infection is the highest priority among health care providers, government officials, and the pharmaceutical industry. Despite scientific effort, no pharmacological intervention has proven definitively beneficial, and care is primarily supportive.

Keywords: SARS-CoV-2, COVID-19, Heparin, Acute respiratory syndrome.

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Introduction

Heparin role in COVID-19 management is currently under debate. Heparin (in the form of unfractionated heparin UFH or low-molecular-weight heparin LMWH, comprising several chemically distinct compounds) is mainstay treatment in thrombotic disorders. LMWH is increasingly supplanting UFH owing to a number of advantages, including a more predictable pharmacokinetic profile with increased bioavailability and the need for less frequent administration and decreased risk of bleeding. Moreover, in contrast to UFH, anticoagulant monitoring with partial thromboplastin time is not usually required with LMWH [1].

Heparin has been extensively used in COVID-19 management due to its anticoagulant properties, mostly as LMWH at prophylactic dose in complicated patients with increased thrombotic risk. Hypercoagulable state in COVID-19 patients is associated with both venous and arterial thrombosis, with pulmonary embolism, stroke, acute limb ischemia, acute coronary syndromes, and recurrent clotting of dialysis filters or oxygenators of extracorporeal membrane oxygenation.

COVID-19 coagulopathy typically presents in critically ill patients with thrombocytopenia, prolongation of prothrombin time, prolongation of partial thromboplastin time, elevated serum D-dimer and elevated fibrinogen. In these patients, anticoagulation benefits are well-established. A retrospective analysis conducted in Tongji hospital showed that LMWH use is associated with better outcomes in severe COVID-19 patients meeting sepsis-induced coagulopathy criteria or with markedly elevated D-dimer.

As revealed by autopsy studies, coagulopathy represents a common complication in patients with severe COVID-19, for surprisingly high incidence of deep venous thrombosis and pulmonary embolism was observed at post-mortem examination. It's interesting to note that thromboembolic events were sometimes clinically overlooked, and sudden and unexplained deaths in critically ill patients correlated with suggestive autopsy findings. In addition, microthrombi were found in the pulmonary microvasculature, possibly explaining ventilation-perfusion mismatch and subsequent refractory hypoxemia in these patients. Anatomic location of capillary obstruction also matches the predominantly distal and patchy distribution of the radiological infiltrates [2].

Thus, coagulopathy may play an important part in COVID-19 natural history. Several pathogenetic mechanisms are involved in COVID-19 coagulopathy, which can be classified as a consumptive coagulopathy. Those include direct viral damage and inflammatory effect by cytokine storm on the endothelium or coagulation cascade. It is likely that additional mechanisms may also contribute to the pathogenesis of hemostatic imbalance, such as immune-mediated damage by antiphospholipid antibodies. Moreover, hypoxia itself, long-term bed rest and possible hormone treatment increase thromboembolic risk. Eventually, free thrombin activates platelets and stimulates fibrinolysis with elevated levels of D-dimer and fibrinogen degradation products.

The largest available study evaluating anticoagulation in COVID-19 is an analysis of 2,773 patients in the Mount Sinai Health System in New York City. Results proved that systemic treatment-dose anticoagulation in COVID-19 patients is associated with reduced in-hospital mortality and longer median survival. In addition, though patients who received treatment-dose anticoagulation were more likely to require invasive mechanical ventilation, probably reflecting reservation of treatment-dose anticoagulation for more severe clinical presentations, they showed better outcomes than mechanical ventilation-treated patients not receiving treatment-dose anticoagulation [3].

Treatment-dose heparin tailored to clinical severity were also associated with significant improvement observed in oxygen exchange and clinical symptoms in 27 consecutive COVID-19 patients admitted to Sirio Libanes Hospital in São Paulo-Brazil.

Another retrospective clinical study evaluating 44 COVID-19 patients, showed significant increase in percentage of lymphocytes and reduction of D-dimer, FDP and IL-6 levels in

COVID-19 patients treated with LMWH compared to control subjects.

Initial observations also address the possible differences between UFH and LMWH in COVID-19 patients. Though UFH should be preferred in marked renal impairment, heparin resistance caused by markedly increased acute phase reactants including fibrinogen could limit its use. Other than systemic heparin, nebulised UFH was also proposed for COVID-19 pneumonia and ARDS.

Note that, in addition to anticoagulation, heparin rationale against COVID-19 seem to be supported at least by two additional modes of activity: anti-inflammatory and antiviral. In particular, heparin may exhibit antiviral properties against SARS-CoV-2, inhibiting initial infection or spread from infected to non-infected cells. Heparin antiviral properties against several viral pathogens are known, including hepatitis C virus and herpesvirus family [4].

Antiviral efficacy against Coronaviridae family was first revealed in a 2011 experiment in which heparin prevented SARS-CoV pseudovirus entry into host cells.

According to this model, cell surface heparan sulfate interacts with SARS-CoV spike protein as an adhesion molecule coreceptor, as the bond facilitates SARS-CoV interaction with ACE2 receptor and subsequent cell entry. Specifically, heparin acts as a decoy receptor for SARS-CoV spike protein, diverting virus from cell surface. Based on these premises, heparin ability to bind SARS-CoV-2 was tested. It was demonstrated that heparin effectively binds to SARS-CoV-2 spike protein and induces a significant structural change. A recent *in vitro* experiment also confirmed that heparin *in vitro* prevents SARS-CoV-2 infection. Apparently, antiviral activity through competitive spike protein binding is less evident with LMWH than UFH [5].

Conclusion

In conclusion, though heparin benefits are well-established in severe COVID-19 patients with increased thromboembolic risk, its additional theoretic properties (anti-inflammatory and antiviral) taken together with growing clinical data seem to suggest a broader use. Multicentre, randomized controlled trials are mandatory to answer unresolved questions, including optimal anticoagulant dose with possible utilization of therapeutic anticoagulation before the development of thrombosis, potential differences between UFH and LMWH and patient characteristics to balance benefits and risks (above all hemorrhagic risks).

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*Correspondence to

Dr. Manuela Rizzo Antonio Pisani

Department of Public Health

University Naples

Naples

Italy

E-mail: manuelarizzo@live.it

antonio.pisani13@gmail.com