Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

The role of vascular surgeons in the treatment of COVID-19-associated pulmonary embolism

As the world is currently going through a pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-COVID-2), the international medical community is collecting data on coronavirus disease (COVID-19). In this battle, vascular surgeons are not directly involved in the diagnosis and/or treatment of COVID-19. Their role is still to be determined, mainly by examining whether they could intervene in cases of pulmonary embolism (PE) caused by severe SARS-COVID-2 infection. This is exactly the point that a vascular surgeon should join efforts to combat this infection and possibly save patients in a dire situation.

PE is a potentially lethal form of venous thromboembolism with a nonspecific clinical presentation and a rather challenging diagnosis. The number of diagnosed PE cases have been continually increasing, mainly owing to the introduction improved diagnostic workup and increased awareness from medical personnel. Septic PE (SPE) is a form of secondary PE and alike PE its diagnosis is challenging.

It is already described that disseminated intravascular coagulation can occur in patients with severe COVID-19 leading to SPE.[1-3] COVID-19-related SPE is already described as a lethal complication and a negative prognostic factor.[4] Published data on COVID-19-related SPE remains limited to a small number of case reports.

Besides anticoagulation, PE treatment consists of systemic fibrinolysis (SF), catheter-directed thrombolysis (CDT), and surgical thrombectomy (STE).[5] SF shows both a high survival rate and significant bleeding risk for stable PE patients. SF is recommended in high-risk patients and in deteriorating patients. STE is recommended in high-risk PE patients with contraindications for SF or when SF has already failed. CDT (including aspirational thrombectomy) seems to have more benefits than risks for the patient compared to STE and it is considered an alternative to STE when there is contraindication for SF or when SF has failed.

Very limited data exist regarding SPE treatment. Therefore, it should not come to our surprise that SPE is not part of any society's guidelines and any treatment is based on PE data.

Anticoagulation and SF can be performed by physicians other than vascular surgeons. On the other hand, the two methods used in PE patients who saw little or no benefit from anticoagulation—STE and CDT—could be performed by vascular surgeons. In patients with COVID-19, any CDT technique could be of great clinical benefit because it improves pulmonary circulation without the risks of SF or STE. Most CDT techniques are performed in existing setups of specialized centers by multidisciplinary PE response teams consisting of cardiologists, interventional radiologists, vascular surgeons, intensive care physicians, and pulmonary specialists. These teams rapidly evaluate the frail or quickly deteriorating patient, then choose the optimal technique for maximum patient benefit and finally execute the plan.

Despite a lack of solid evidence regarding SARS-COVID-2, COVID-19 patients presenting with SPE should receive life-saving pulmonary reperfusion performed by an experienced vascular surgeon as a member of a multidisciplinary team.

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COVID-19 and SIC (!)

Accurate risk stratification tools are paramount for optimal disease management. Patients with cardiovascular conditions, diabetes, and cancer are most susceptible to coronavirus disease-2019 (COVID-19) complications, leading to poor outcomes.[1] These systemic diseases relate to enhanced fibrin formation and thromboinflammation. Indeed, the severity of peripheral occlusive arterial disease correlates with the levels of both fibrinogen and its turnover measure D-dimer.[2] In severe COVID-19 infection, elevation of D-dimer and sepsis-induced coagulopathy (SIC) predicts a poor prognosis. The incidence of venous thromboembolism in patients with severe COVID-19 pneumonia is 25% (!).[3] Furthermore, endothelial injury inherent to vascular procedures may predispose to coagulopathy in COVID-19. The

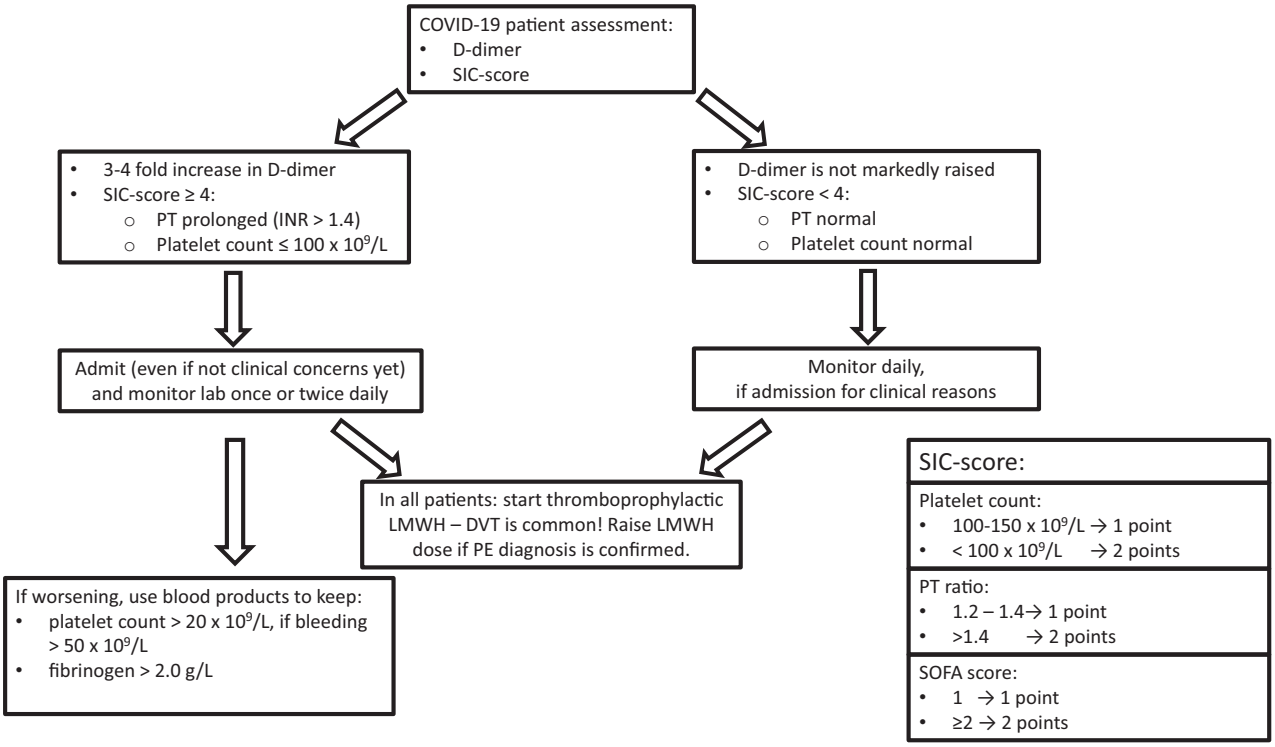

Fig. Outline of the algorithm for the management of coagulopathy in COVID-19 based on D-dimer and SIC-score. *DVT,* Deep vein thrombosis; *INR,* international normalized ratio; *LMWH,* low-molecular-weight heparin; *PE,* pulmonary embolism; *PT,* prothrombin time; *SIC,* sepsis-induced coagulopathy; *SOFA,* sequential organ function assessment.

benefit of low-molecular-weight heparin therapy is the protection of critically ill patients against venous thromboembolism, as well as its putative anti-inflammatory properties. Pulmonary embolism, triggered by severe infection, may be masked by the symptoms and signs of hypoxia in COVID-19. We advocate these considerations for vascular specialists.

A large retrospective Chinese cohort study[1] demonstrated that the fibrin turnover-measure D-dimer exceeding 1 μg/mL on admission was associated with an increased risk of in-hospital death (odds ratio, 20; 95% confidence interval, 6.50-61.56; $P < .0001$) in patients with COVID-19. Another retrospective study[4] assessed the benefits of anticoagulation on 28-day mortality, which does not seem to differ between heparin users (22%) and nonusers (mortality rates of 30.3% vs 29.7%, respectively). However, patients with six-fold higher than normal D-dimer levels (3 μg/mL) clearly benefited from anticoagulation, translating to lower mortality (32.8% vs 52.4%; $P = .017$). Therefore, D-dimer levels on admission are particularly useful for risk stratification in patients with COVID-19 (Fig).

Another important predictor of mortality is the International Society of Thrombosis and Haemostasis (ISTH) SIC-score,[5] which includes prothrombin time (ratio >1.5), platelet count ($<100 \times 10^9$/L), and the sequential organ function assessment score. In this study,[3] patients with an ISTH SIC-score of 4 or greater treated with anticoagulation showed again lower 28-day mortality rates than the untreated ones (40% vs 64%; $P = .029$).

To guarantee the best outcomes for patients we suggest that all medical professionals, including vascular specialists, adhere to ISTH guidelines on recognition and management of coagulopathy in COVID-19 based on D-dimer and SIC-scores as major prognostic factors (Fig).[6]

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A proposed scoring system for triage of patients who require vascular access creation in times of COVID-19

In response to the COVID-19 pandemic, many institutions have suspended elective procedures to preserve resources, such as personal protective equipment and bed space. Inevitably, many patients with chronic kidney disease cannot receive timely arteriovenous access surgery. A global survey revealed that >90% of vascular surgeons have reduced or ceased performing elective procedures such as vascular access creation.[1] The Society for Vascular Surgery Clinical Practice Council has also released guidelines recommending deferment of elective vascular access creation.[2]

We foresee a large backlog of patients who require vascular access creation when COVID-19 starts to be curtailed. Once elective procedures are permitted, it is important that these patients be triaged to minimize the risks of potential catheter-related complications. We propose the ABCDE score, a simple five-component scoring system that will allow clinicians to triage patients who require vascular access creation. Each component of the scoring system is represented by a corresponding character in ABCDE (Fig). Patients with temporary access concerns, such as frequent catheter malfunction or limited catheter options, will be allocated 2 points. Patients with a history of catheter-related bloodstream infection will be allocated 3 points. Patients will be allocated points based on their current chronic kidney disease stage per Kidney Disease: Improving Global Outcomes guidelines.[3] Last, patients who are currently dialysis dependent or have had a central venous catheter for >6 months will be allocated 1 point, respectively. The scoring system allows a minimum score of 4 points and a maximum score of 12 points. We recommend that patients with a total of >9 points be given priority and scheduled for vascular access creation earliest. Patients who score 5 to 8 points should be scheduled next, and patients who score 4 points should be scheduled last.

Access concerns Frequent catheter malfunction, limited catheter options (existing pacemaker or central vein stenosis)	**2**
Bloodstream infection History of catheter-related bloodstream infection	**3**
Chronic kidney disease stage Current chronic kidney disease stage (KDIGO)	**4 or 5**
Dialysis dependent Patients already on dialysis	**1**
Extended period of dialysis catheter Dialysis catheter in-situ for more than 6 months	**1**
ABCDE score ≥ 9	Priority access creation
ABCDE score 5 to 8	Early access creation
ABCDE score 4	Non-urgent access creation

Fig. The ABCDE score for triage of patients who require dialysis access creation. *KDIGO,* Kidney Disease: Improving Global Outcomes.

In conclusion, we propose a simple scoring system that can be used to triage patients who require vascular access creation in times of COVID-19. Although future studies are required to validate this scoring system, we firmly believe that appropriate prioritization of these patients is imperative to reducing adverse events, such as catheter-related bloodstream infections, in these challenging times.

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