The novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is infecting hundreds of thousands of humans around the globe. The coronavirus disease 2019 (COVID-19) is known to generate mild as well as critical courses. Complications on the intensive care units include acute respiratory distress syndrome, acute cardiac, and kidney injury as well as shock. Here, we present the first case report of a successful treatment of a COVID-19 patient presenting with adult respiratory distress syndrome plus refractory combined cardiogenic and vasoplegic shock, which could be successfully stabilized after implantation of a percutaneous ventricular assist device plus an extracorporeal membrane oxygenation. Although such intense treatment might not be feasible in case of a health care disaster as described for the hot spots of the COVID-19 pandemic, it might encourage treatment of younger patients on intensive care units not overcrowded by critically ill patients. ASAIO Journal 2020; 66:607–609.

Key Words: coronavirus disease 2019, extracorporeal membrane oxygenation, Impella, percutaneous ventricular assist device, shock

The novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is infecting hundreds of thousands of humans around the globe and represents one of the mayor health care disasters as defined by the world health organization WHO. A recent meta-analysis reports mortality to be as high as 13.9% in all patients with highest mortality in older patients. Although the development of the acute respiratory distress syndrome (ARDS) is the most common trigger for intensive care unit (ICU) admission (incidence 32.8%), cardiac injury and shock are frequent (incidence 13.0% and 6.2%, respectively). Although these numbers derive from an all-comer coronavirus disease 2019 (COVID-19) collective, hemodynamic complications might be far more frequent in COVID-19 patients requiring ICU admission. To this date, there is insufficient data in order to comment on the prognosis of COVID-19 patients with hemodynamic complication like shock.

Patient Information

We report the case of a 52-year-old man (79 kg and 176 cm) with known history of dilated cardiomyopathy, who presented in the emergency department with dyspnea and fever. As for his medical history, he was recently dismissed from our cardiology ward after suffering from an acute myocardial infarction and implantation of an implantable cardioverter-defibrillator with New York Heart Association Functional Classification heart failure class II and was scheduled for cardiac rehabilitation. Apart from the heart failure, the patient had no significant comorbidities (Figure 1A).

Clinical Findings

At the emergency department (day 0), the initial clinical presentation was interpreted as acute on chronic heart failure with pulmonary congestion (Figure 1B) and the patient was transferred to our cardiology ward after suffering from an acute myocardial infarction and implantation of an implantable cardioverter-defibrillator. The patient was transferred to our ICU for noninvasive ventilation for pulmonary congestion in the early morning hours. The chest x-ray on ICU showed a significant increase of the bilateral infiltrates (Figure 1C). A SARS-CoV-2 polymerase chain reaction test returned positive that day.

Beside the moderate ARDS (as graded by the Berlin classification), the patient developed a combined cardiogenic and vasoplegic shock. Advanced hemodynamic monitoring using the Pulse Contour Cardiac Output device (PICCO; Pulson Medical Systems SE, Feldkirchen, Germany) showed a reduced cardiac output with 1.8 L/min/m² in addition to a severe vasoplegia. We started levosimendan and norepinephrine, but the combined shock persisted. An empiric
SARS-CoV-2 therapy was initiated with a combination of lopinavir and ritonavir plus chloroquine. The shock, however, could not be resolved through day 2 and was complicated by an acute kidney failure. For details on the clinical course see Table 1 and Figure 2.

**Percutaneous Ventricular Assist Device**

To counteract the cardiogenic shock, we implanted a peripherally ventricular assist device (Impella CP Smart Assist; Abiomed, Aachen, Germany) at day 3. Implantation was performed in the catheterization laboratory and did achieve a stable blood flow of 3.5 L/min. Left ventricular end-diastolic diameter (as determined by bedside ultrasound studies) and the left ventricular end-diastolic diameter (as determined by the Impella CP Smart Assist) decreased and lactate levels returned to normal. However, the vasoplegic shock persisted, requiring continuous maximum vasopressor therapy.

**Extracorporeal Membrane Oxygenation**

For the profound vasoplegic shock, a venoarterial extracorporeal membrane oxygenation (ECMO) (Stöckert centrifugal pump console, SCPC; Sorin Group, Munich, Germany) was added at day 4 using a bifemoral cannulation, initially running at a blood flow of 4.5 L/min and a sweep gas flow of 1.5 L/min at 100% oxygen. Vasopressor doses could be significantly reduced at day 7 as the vasoplegic shock resolved. We switched the venoarterial ECMO to venovenous using a femoro-jugular configuration. During this switch procedure, the percutaneous ventricular assist device (pVAD) offered a sufficient hemodynamic support and unloading.
COVID-19 COMBINATION OF PVAD AND ECMO

The first week on ICU was dominated by the combined shock, whereas the respiratory situation was well controlled. The course, however, was complicated by a severe COVID-19 associated ARDS. Sequential chest x-rays showed a rapid progression of bilateral opacities (Figure 1D). The Impella CP was weaned at day 19. The venovenous ECMO, however, is still running (blood flow 2.0 L/min, sweep gas flow 1.5 L/min at 60% oxygen). The therapy of our patients is still ongoing (day 24).

Discussion

We report a case of COVID-19 complicated by severe mixed, cardiogenic, and vasoplegic shock. Shock might be an uncommon but life threatening complication of a SARS-CoV-2 infection. Giving the high number of infections, however, an incidence of shock in 6.0% of all COVID-19 patients1 translates in a significant number of patients.

As reported here, the combined shock necessitated 17 days of mechanical circulatory support but could be overcome. This might be important for other patients presenting in shock complicating COVID-19 since, at least in our patient, the ARDS is the long-lasting, persistent complication and not the shock. Although such intense treatment might not be feasible in case of a health case disaster as described for the hot spots of the COVID-19 pandemic, it might encourage treatment of younger patients on ICUs not overcrowded by critically ill patients.

There have been reports on a cytokine storm syndrome in COVID-19 patients which we believe was responsible for the vasoplegic shock.2 Unlike the hyperinflammatory state in most venoarterial ECMO patients, which results in capillary leakage and high volume therapy to these patients,3 our patient discussed here presented with a fluid lung without leakage to the rest of the body. This made our patient a good candidate for mechanical support devices which are dependent on venous or ventilrual drainage. Importantly, as the ARDS still persists, the prognosis is now driven by the potential pulmonary recovery. We do not have sufficient data on this very sick patient collective in order safely estimate prognosis. At least in our patient, the shock could be overcome using a combination of two mechanical support devices. This case might encourage the community in preparing for extracorporeal treatment in COVID-19 patients4 as well as sharing all data, for example, in the registry of the Extracorporeal Life Support Organization.

Conclusions

This is the first published case report of a COVID-19 patient presenting with a combined cardiogenic and vasoplegic shock which could be hurdled by a combination of pVAD and ECMO. Cardiac support was needed for 17 days, while ARDS persisted longer. This might suggest that prognosis of COVID-19 is driven by ARDS.

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