CASE REPORTS

VENTILATORY FAILURE AND PULMONARY EMBOLISM IN COVID-19 REQUIRING ENHANCED VENOUS DRAINAGE FOR EXTRACORPOREAL MEMBRANE OXYGENATION

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Abstract

Introduction: *COVID-19 infection manifests as a spectrum of respiratory and vascular complications, including acute respiratory distress syndrome (ARDS) and pulmonary embolism. Herein, we describe a case of a healthy young male who presented with ARDS refractory to mechanical ventilation and concomitant bilateral pulmonary emboli managed with extracorporeal membrane oxygenation (ECMO) and embolectomy. The embolectomy and initial veno-venous ECMO configuration failed to correct the patient's hypoxemia despite maximal flows. This was thought to be due to a high-output state secondary to vasodilatory shock preventing adequate drainage from the existing single drainage ECMO cannulation, following which a second venous cannula was placed to form a unique veno-veno-venous ECMO circuit that resolved the persistent hypoxemia. The case underscores the importance of identifying embolic events and vasodilatory shock in COVID-19 patients, both of which need to be addressed simultaneously to avoid worsening right ventricular failure (via both mechanical and hypoxia-driven pathways) and the resulting veno-arterial ECMO along with its associated complications.*

Keywords: *extracorporeal membrane oxygenation; pulmonary embolism; COVID-19; thrombectomy*

INTRODUCTION

SARS-CoV-2 infection, also known as COVID-19, has emerged as a devastating respiratory viral infection over the past 2 years[1]. Infection can produce variable respiratory symptoms from a mild cough to acute respiratory distress syndrome (ARDS)[2]. Extracorporeal membrane oxygenation (ECMO) remains a crucial therapy for patients that develop severe respiratory failure refractory to conventional mechanical ventilation and has survival to hospital discharge rate up to ~60%[3]. We describe a case of a young, healthy male who developed severe COVID-19 infection with progression to ARDS and bilateral pulmonary embolism requiring ECMO.

CASE PRESENTATION

A 31-year-old previously healthy male was transferred from another facility with acute hypoxic respiratory failure requiring mechanical ventilation secondary to COVID-19 ARDS. On arrival, the patient was intubated and sedated and was hemodynamically unstable. He was started on broad-spectrum antibiotics and vasopressors, but he remained hypoxemic with a PaO_2/FiO_2 ratio (partial pressure of oxygen in arterial blood/fraction of inspired

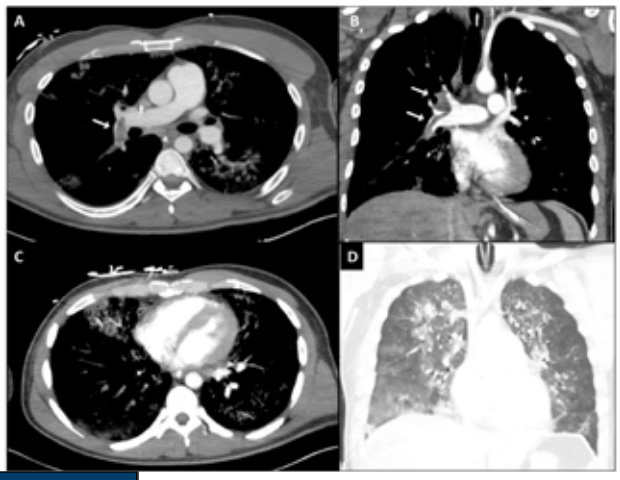

Figure 1

Coronal view of a computed tomography angiography study of the chest. Panel A and B show embolus in the right distal pulmonary artery (white arrow). Panel C shows an enlarged right ventricle with a left to right ventricular ratio of 1:1. Panel D shows diffuse bilateral ground glass and consolidative opacities secondary to severe COVID-19 Pneumonia.

Figure 2

Transthoracic echocardiogram showing an enlarged right ventricle with flattening of the interventricular septum.

oxygen) of 70 mmHg, acidotic with pH 7.31 and hypercarbic with a $PaCO_2$ (partial pressure of carbon dioxide) of 110 mmHg. A pulmonary CT-angiogram revealed acute, bilateral pulmonary emboli (Figure 1A and B) with an increased right-to-left ventricle ratio (Figure 1C) and bilateral diffuse ground glass opacities with widespread consolidations (Figure 1D). A transthoracic echocardiogram revealed septal flattening and RV enlargement (Figure 2).

He continued to be hypoxic on maximal safe mechanical ventilator settings requiring deployment of veno-venous (V-V) ECMO. The patient was cannulated with a femoro-jugular approach using a 25 French (Fr) cannula draining the inferior vena cava and a 21 Fr cannula returning to the right internal jugular vein. The patient remained hypoxemic with SpO_2 below 90% and PaO_2/FiO_2 ratio <50 on a FiO_2 of 100% with positive end-expiratory pressure (PEEP) of 10 cm H_2O and V-V ECMO support with a flow rate of 4.2 Liters/minute (Lpm) at 3395 revolutions/minute (rpm) and 100% O_2 return cannula saturation. An increase in ECMO flow was attempted but was limited by line chatter and frequent vacuum alarms. A right heart catheterization revealed elevated pulmonary artery pressure of 65/23 mmHg (mean 39 mmHg) with a right atrial pressure of 15 mmHg and pulmonary capillary wedge pressure of 15 mmHg (Ratio of 1), pulmonary artery pulsatility index (PAPi) of 2.8 and pulmonary artery O_2 saturation of 77%, while aortic SaO_2 was 80%. Findings from the pulmonary angiogram are shown in Figure 3. Given the risk of bleeding with thrombolytic therapy with ECMO, it was decided to perform an embolectomy. A 16 Fr DrySeal Flex sheath (Gore Medical, Flagstaff, AZ) was placed in the left femoral vein and a Lightning-12 Indigo aspiration catheter (Penumbra, Alameda, CA) was passed along the femoral venous return cannula into the pulmonary circulation. A significant amount of clot was retrieved with an improvement in SpO_2 saturation to 87%. Given residual hypoxemia, improving ECMO drainage by exchanging the current drainage cannula with a 29 Fr was considered; however, with the patient's tenuous hemodynamic status, it was decided to avoid transiently taking the patient off the circuit and additional venous cannula placement was planned. The 16 Fr DrySeal Flex sheath was exchanged for a 17 Fr Bio-Medicus NextGen Adult Arterial/Jugular Cannula (Medtronic, Minneapolis, MN, Cat. # 96530-117) for additional drainage of the inferior vena cava, which was connected to the ECMO circuit using a Y connector (Figure 4). Following the re-initiation of veno-veno-venous ECMO (VV-V ECMO), pump flows increased to 5.2 Lpm at 3395 rpm and the patient's SpO_2 improved rapidly from 80% to 94%. The patient's pre- and post-procedural PaO2/FiO2 ratios were 55 and 103, respectively. The patient's ventilatory requirements started to decrease, with gradual weaning of FiO2 while maintaining SpO_2 >90%.

The patient underwent a prolonged hospital stay. He developed bilateral pneumothoraxes and gram-negative empyema treated with chest tube placement and broad-spectrum antibiotics. He was successfully decannulated from VV-V ECMO after 28 days of the VV-V ECMO configuration. The patient continued to be ventilator-dependent through a tracheostomy for the remainder of his hospitalization and was subsequently discharged to a long-term acute care facility for rehabilitation and prolonged ventilator weaning. He is currently alive one year out of the hospital not requiring supplemental oxygen.

DISCUSSION

This was a unique case of COVID-19 ARDS requiring pulmonary embolectomy and VV-V ECMO. The RHC was

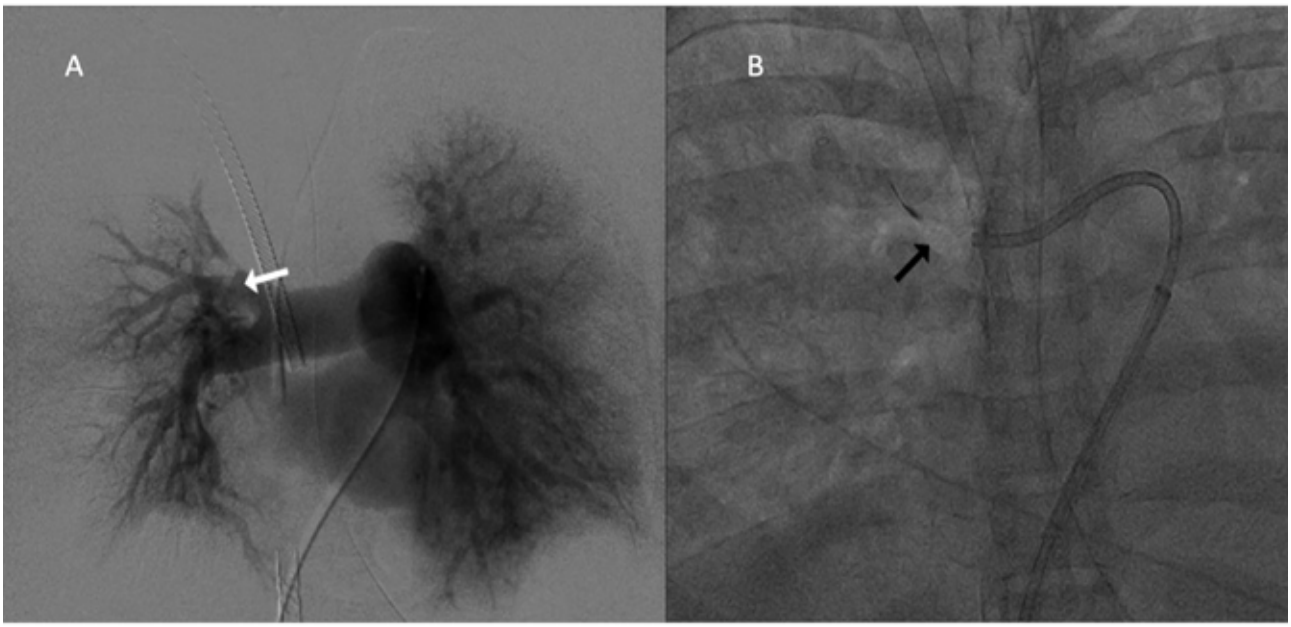

Figure 3

Still images obtained from a right heart catheterization procedure performed with contrast. Panel A shows the pulmonary angiography with digital subtraction showing poor perfusion of the right lung field. Still image obtained at the beginning of the levophase. Filling defects were noticed in the right pulmonary artery (white arrow). Panel B shows the Lightning-12 indigo catheter in the right pulmonary artery with the separator (black arrow).

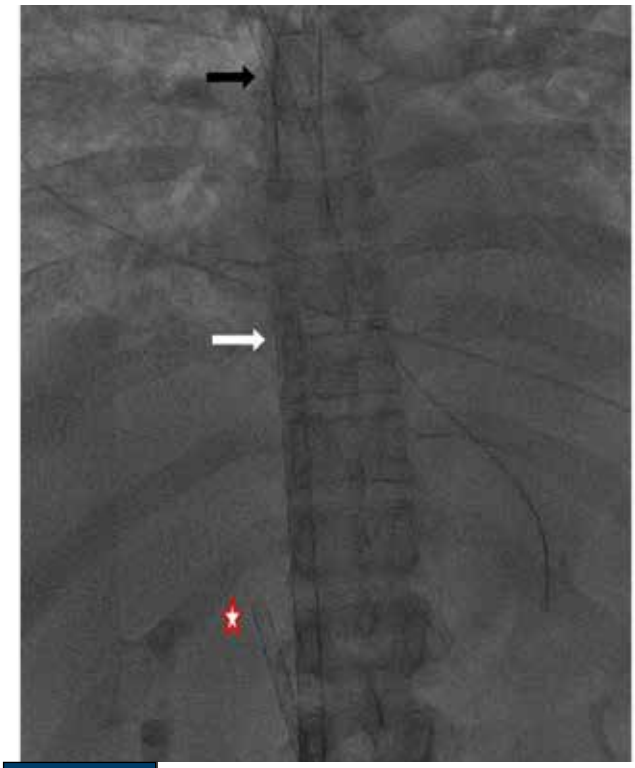

Figure 4

Fluoroscopy showing the original venovenous ECMO (extracorporeal membrane oxygenation) drainage (white arrow) and return (black arrow) cannulas, along with the additional 17 French sheath drainage (star).

the pivotal study where we anticipated high right-sided filling pressures. It was unlikely that the pulmonary embolism was the predominant cause of refractory ventilatory failure; however, imaging and RHC findings were suggestive of progressive RV failure with an elevated right atrium to wedge ratio despite a preserved PAPi. Given the active drainage of the RA, we felt that PAPi was underestimated during VV ECMO support. Conversion to veno-arterial ECMO could have helped unload the RV, but it was feared to cause differential hypoxia[7], leading to myocardial and cerebral ischemia. A decision was made to perform a pulmonary embolectomy to address RV afterload. Following the procedure, an RHC revealed a suboptimal pulmonary SaO_2 which indicated insufficient peripheral oxygenation. This was thought to be due to 1) inadequate matching of the patient's high cardiac output state secondary to vasodilatory shock and 2) current ECMO flows which were limited by small venous cannula diameter. Therefore, a decision was made to upgrade to a triple venous ECMO cannulation. Triple cannulation is traditionally performed when V-V/V-A ECMO approaches fail to improve oxygenation and/or hemodynamic status[4], as additional arterial cannulation (veno-arteriovenous [V-AV] ECMO) provides further circulatory pressure to prevent cardiopulmonary collapse. In this case, however, the configuration was converted into a unique VV-V ECMO approach af-

ter thrombectomy as the single venous drainage cannula did not seem to drain an adequate proportion of blood volume resulting in poor oxygenation. This low-pressure circulation system resulted in spontaneous improvement, thereby requiring lower FiO_2 to maintain reasonable oxygen saturation and allowing the patient to be weaned off VV-V ECMO.

CONCLUSION

Respiratory failure, refractory to correction by ECMO, may occur with inadequate venous drainage in the setting of a high-output state. An RHC can help determine adequate ECMO output as a decreased pulmonary SaO_2 may represent insufficient drainage of de-oxygenated blood that may be corrected by additional venous cannulation.

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