Hypoxemia in a Patient Receiving Venovenous Extracorporeal Membrane Oxygenation

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A 64-year-old woman with a medical history of stage IV COPD who was receiving 4 L of supplemental oxygen during the day and bilevel positive airway pressure at night presented to the hospital with acute COPD exacerbation and acute on chronic hypercapnic respiratory failure. Five days into her hospitalization, the patient’s condition decompensated to acute hypercarbic and hypoxemic respiratory failure, and the decision was made to place patient on venovenous extracorporeal membrane oxygenation (VV-ECMO) via right internal jugular Avalon catheterization as a bridge to lung transplantation. Intraoperatively, the cannula was placed under fluoroscopy; there were no intraoperative complications. Patient was extubated to non-rebreather on no vasoactive drips and was taken to the cardiothoracic ICU. Shortly after arriving in the ICU, the patient’s condition acutely decompensated, becoming hypotensive with increased oxygen requirements.

Question: After Videos 1 and 2 have been viewed, what is the most likely cause for the decompensation?
Answer: Migration of the ECMO cannula into the right atrium

Discussion

After bedside point-of-care ultrasound (POCUS) was performed, we discovered that the bicaval dual lumen ECMO cannula migrated into the right atrium (Fig 1). The patient was reintubated, given her decompensation, and was immediately taken back to the OR; the catheter was repositioned successfully under fluoroscopic guidance.

On postoperative day (POD) 1, the patient was extubated to a 2-L nasal cannula and walked with physical therapy. The patient’s postoperative course was complicated by spontaneous abdominal bleeding on POD 8 that required transfusion, discontinuation of anticoagulation, and embolization of her left internal iliac artery. Unfortunately, 3 days after embolization, the patient again had abdominal bleeding and underwent a repeat embolization. Her VV-ECMO oxygenator required exchange because of fibrin buildup. On POD 17, 6 days after her repeat embolization, the patient again had an acute drop in her hemoglobin, and CT imaging showed multifocal bleed. She was no longer deemed a transplantation candidate; patient and her family decided to pursue comfort care.

VV-ECMO has become a successful intervention in many patients with severe respiratory failure as a bridge to recovery or transplantation.

Dual-lumen single-site insertion VV ECMO catheters provide several advantages over dual-site cannulation, such as decreased blood recirculation, increased patient mobility, and a potentially decreased risk of infection. The dual lumen VV-ECMO catheters provide bicaval drainage of blood into the ECMO circuit and a second lumen for return of oxygenated blood to the patient.

For insertion of a bicaval dual-lumen catheter, the use of fluoroscopy or transesophageal echocardiogram is required. A guidewire is placed into the right internal jugular vein and guided across the cavoatrial junction and into the inferior vena cava (IVC). The Seldinger technique is used to position the distal lumen into the IVC. Once ECMO flow is initiated, the cannula is further manipulated under imaging guidance to direct the oxygenated return blood flow into the right atrium and towards the tricuspid valve (Video 3).

Causes of acute hypoxia in patients with VV-ECMO immediately after insertion include hemothorax, pneumothorax, catheter migration, and insufficient flow. POCUS can be used to diagnose some of these causes quickly. Chest radiography and transesophageal echocardiography traditionally have been methods to diagnose these causes of hypoxia; however, these imaging modalities would have delayed the diagnosis in our patient’s acutely decompensating condition.

Catheter migration is a known complication of VV-ECMO that required cannula manipulation in 47% of cases in a retrospective review. One of the most common findings is that the return blood flow is no longer directed toward the tricuspid valve. The cannula may have rotated towards in the interatrial septum and away from the tricuspid valve. Additionally, the cannula may have migrated superiorly or inferiorly so that the return blood goes into the vena cava. In our circumstance, the catheter migrated into the right atrium, which was quickly diagnosed by visualization of the cannula in the chamber. In normal circumstances, the catheter cannot be visualized in the heart but can be visualized in the IVC with the use of the subxiphoid view (Video 4).

The of incidence of pneumothorax caused by cannulation in a single center study was 2.7%. Ultrasound imaging can be used to rule out a pneumothorax with the presence of lung sliding, with a sensitivity of 95.3% and specificity of 91.1%. However, the positive predictive value is limited for multiple causes of absent lung sliding that include pneumonia, lung injury, and adhesions (Video 5).
A hemothorax can cause hypoxia and hypotension, which can be diagnosed quickly on ultrasound imaging by looking at the costophrenic angle or the posterolateral alveolar syndrome and/or pleural syndrome point. The estimated volume varies by the formula used; however, ultrasound imaging is more sensitive than radiography for the detection of a pleural effusion (Video 6).

Pericardial effusion that leads to cardiac tamponade is a rare complication that can be diagnosed quickly with transthoracic echocardiography or transesophageal echocardiography. Tamponade most likely occurs during the placement of the catheter with rupture of the right ventricle. In two small retrospective studies, the incidence of a pericardial effusion without tamponade was 2% in one study; in the other study, the incidences of tamponade was 2.7% (Video 7).

The differential diagnosis of hypoxia in patients on VV-ECMO can be broad; however, POCUS ultrasound imaging can be performed quickly to diagnose complications in patients on ECMO whose condition is acutely decompensating.

Reverberations

1. The differential diagnosis for hypoxia in patients who are cannulated for VV-ECMO is broad.
2. The bicaval dual lumen ECMO cannula should be visualized in the IVC.

3. Visualizing the bicaval dual lumen ECMO cannula in the right atrium and not in the IVC is an emergency and requires immediate repositioning.

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Additional information: To analyze this case with the Videos, see the online version of this article.

References