Complication of venovenous extracorporeal membrane oxygenation cannulation – the significance of an inferior vena cava anomaly

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Key Clinical Message
Physicians should be aware of possible anatomical variants during cannulation for extracorporeal membrane oxygenation (ECMO). Particular attention to ensure continual visualization of the guidewire before proceeding to final positioning of the ECMO cannulae should be paid. Alternative imaging modalities should be contemplated when uncertainties arise to minimize the risk of inadvertent vascular injuries.

Keywords
Cannulation complication, double inferior vena cava, extracorporeal membrane oxygenation, inferior vena cava anomaly.

Introduction
Venovenous extracorporeal membrane oxygenation (V-V ECMO) is a form of organ support for patients with severe respiratory failure. Improvements in ECMO circuitry and machine technology have led to a drop in treatment-related complications. Percutaneous vascular cannulation is commonly performed for initiation of ECMO, and vascular injuries remain as an important cause of ECMO-related morbidity and mortality. We report a complication arising from cannulation in a patient with undetected anatomical variant.

Case History
A 56-year-old man was diagnosed to have dermatomyositis complicated by interstitial lung disease. Despite standard medical treatment (methylprednisolone, cyclophosphamide, and intravenous immunoglobulin) and noninvasive mechanical ventilator support, he deteriorated and necessitated invasive mechanical ventilation. He had refractory hypoxemia which was further complicated by barotrauma. V-V ECMO was initiated.

As a result of hypoxia, insertion of another drainage cannula was planned to convert the existing circuit into a high-flow venovenous ECMO circuit. Upon bedside
ultrasound assessment, the right femoral vein was deemed unsuitable due to the presence of deep vein thrombosis. Vascular puncture of left femoral vein was performed under ultrasound guidance, and a multistage cannula (Maquet Fr 21) was advanced with the Seldinger technique, aiming for a final position in the inferior vena cava (IVC). Unfortunately, since we were unable to obtain a good subcostal view by transthoracic ultrasound to guide the position of the cannula, it was positioned by crude estimation of the distance between xiphisternum and left groin. After reconfiguring the circuit to a high-flow setup with the additional cannula, ECMO blood flow was increased to 3.8 L/min and SpO2 levels above 90% were achieved. The patient remained hemodynamically stable throughout the procedure.

Routine chest and abdominal radiographs taken after cannulation showed the startling finding of an abnormal position of the new venous drainage cannula (Fig. 1). Computer tomography (CT) showed the cannula was traversing the left side of the aorta, suspicious of a left-sided or double inferior vena cava (Fig. 2). There was evidence of venous perforation at the junction between the left inferior vena cava and left renal vein. Emergency operation was undertaken for cannula removal and vascular repair. The findings on CT and the presence of a double inferior vena cava were confirmed upon laparotomy.

Figure 1. An abnormal position of the drainage cannula was detected upon routine abdominal radiograph taken after cannulation.

Figure 2. Abdominal CT film (left) with 3D reconstruction (right) showing the course of the drainage cannula travelling along the left side of the aorta, with venous perforation likely occurring at the junction of the left-side IVC and left renal vein. Some of the side holes of the multistage cannula remained in the left-side IVC, accounting for the additional blood flow achieved after reconfiguration to high-flow V-V ECMO setup.
The right femoral vein was subsequently cannulated to set up the high-flow V-V ECMO circuit in spite of the presence of thrombus and satisfactory oxygenation was achieved. However, the patient ran a progressive downhill clinical course, with nosocomial pneumonia and septic shock, and finally died of multiple organ failure.

Discussion

The purpose of this case report is to report the significance of anatomical variants in the cannulation process for ECMO, in particular the potential complications arising therein.

The patient had an existing V-V ECMO circuit via a dual lumen cannula inserted in the internal jugular vein. Often, the need to reconfigure to a high-flow V-V ECMO setup involves vascular puncture of alternative sites such as the left femoral vein in our patient. The presence of a double inferior vena cava was unexpected. During cannulation, there was little evidence of the vascular anomaly as the passing of the guidewire was smooth and there was venous backflow from the new cannula. The patient did not exhibit signs of hypotension or peritonism, and the ECMO machine functioned normally. The complication was not detected until a routine radiograph.

Upon reviewing the CT images and existing literature, the cannulation team concluded that the complication had occurred because the guidewire failed to advance past the relatively acute angle formed when the left-side IVC joined the left renal vein (Fig. 3). This was not realized because the hepatic IVC was not well visualized by transthoracic ultrasound. Subsequent advancement of the ECMO cannula resulted in perforation of the venous vasculature. A small increase in ECMO blood flow (an additional 0.8 L per min) was achieved nonetheless because the side holes of the multistage cannula were within the left-side IVC.

Although uncommon, the incidence of the double IVC phenomenon is not rare, with a reported incidence of 0.2–3% in the normal population upon autopsy [1]. Reported after CT imaging became accessible in the late 1970s, patients with a duplication of the IVC have a normal IVC along the right side of the spine; in addition, a left-side IVC ascends along the left side and is joined by the left renal vein before crossing anterior to the aorta to join the right-side IVC [2, 3].

As ECMO is increasingly utilized in various clinical scenarios, the probability of encountering vascular anomalies will invariably increase. It is difficult to predict anatomical variants by bedside observation, and routine preprocedural imaging is neither cost effective nor without risks in this group of critically ill patients. In retrospect, the complication in our patient could only be avoided had we employed fluoroscopy during cannulation or we abandoned the procedure upon the inability to visualize the guidewire in the hepatic IVC. In most ECMO centers, real-time bedside ultrasonography remains the mainstay of image-guided percutaneous vascular cannulation. This case raises the need to be aware of and equipped with alternative or supplemental imaging techniques. In particular, the urgency of the cannulation is crucial in deciding which imaging modality is most appropriate, for example, fluoroscopy would be the best option in a semi-elective procedure while ultrasonography can be used during clinical emergencies.

Conflict of Interest

None of the author has a real or perceived conflict of interest or a disclosure of any personal or financial support.

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