Vascular Complications in Extracoporeal Membrane Oxygenation

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KEYWORDS

• Limb salvage • Venoarterial extracorporeal membrane oxygenation
• Vascular complications • Arterial dissection • Pseudoaneurysm
• Thromboembolic complications • Infectious arterial complications

KEY POINTS

- Limb ischemia is one of the most common complications of venoarterial extracorporeal membrane oxygenation (VA ECMO) via femoral cannulation.
- Use of ultrasound guidance at time of cannula placement, near infrared spectroscopy monitoring with trained intensive care unit staff during ECMO support, and placement of a distal perfusion catheter can prevent and detect early signs of limb ischemia, allowing prompt intervention.
- Other vascular complications include infection, pseudoaneurysm, dissection, retroperitoneal hematoma, and need for amputation.

INTRODUCTION

Venoarterial extracorporeal membrane oxygenation (VA ECMO) is a rescue therapy in patients with severe cardiac failure. Most patients on ECMO are cannulated via femoral artery and vein given the ready accessibility of the vessels and the emergent nature leading to need for cannulation.[1] Accessing the femoral vessels can potentially lead to significant vascular complications including limb ischemia from lack of perfusion distal to the arterial cannula, thromboembolic complications, retroperitoneal bleeding, dissection, pseudoaneurysm, and groin infection.[2–11] This article describes femoral vessel cannulation, selecting appropriate cannulas for vessel size, vascular complications associated with cannulation, and associated management strategies.

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We also briefly discuss venovenous ECMO (VV ECMO), which is used for respiratory support.

PATIENT EVALUATION

Vascular Access for Venoarterial Extracorporeal Membrane Oxygenation

There are 2 main cannulation strategies for patients requiring VA ECMO: central cannulation and peripheral (femoral) cannulation. VA ECMO using central cannulation is reserved for patients who are postcardiotomy with cardiac or respiratory failure. The advantage of this cannulation is simplicity of cannulation from the consequence of cardiopulmonary bypass during cardiac surgery.[12,13] The cannula size is usually larger than peripheral cannulation to provide sufficient flow to the systemic circulation. Another advantage of the central cannulation is antegrade flow to brain, compared with retrograde flow of peripheral cannulation. Cannulas are placed in direct vision of the vessels during cardiac surgery and secured with a tourniquet. Because these cannulas are a continuation of cardiopulmonary bypass, the sternum is typically kept open and packed. During an ECMO run, additional attention should be paid for cannula dislodging, mediastinal bleeding, and infections related to the open sternum.

Central cannulation is an appropriate option for patients after pericardotomy while in the operating room. Unfortunately, many of patients requiring VA ECMO present in less controlled environments than the operating room, including catherization laboratory, emergency room, intensive care unit, or the wards. In these patients, peripheral cannulation is the most appropriate option, as it can be done bedside.[1] A femoral arterial line, distal limb perfusion line, and venous line are required, and placement can be enhanced with the use of a bedside ultrasound and fluoroscopy if available. Vessel size cannot typically be assessed before the procedure with contrast imaging studies, so ultrasound findings and clinical judgment are used to estimate vessel size and guide cannula selection.[1] Small vessel size and difficulty with cannulation, including large pannus covering groin, are risk factors leading to vascular complications while placing patients on VA ECMO.[3,4,8] Distal perfusion catheters should be placed with ultrasound guidance to provide antegrade flow to the distal superficial femoral artery (SFA) and distal leg. If a vascular stent is present, cannulation from the contralateral femoral vessel is recommended to avoid damage to the stent or stent thrombosis. A previously placed inferior vena cava (IVC) filter may cause venous injury at the time of venous cannulation; thus, fluoroscopy is necessary and removal of the filter may be necessary to place the venous cannula.

Although vessels are often easily accessible, they are usually not directly visualized during cannulation, as most cannulation is done percutaneously. As such, vascular access can often be difficult, particularly in morbidly obese patients or patients with peripheral vascular disease. Given these factors, vascular complications related to VA ECMO tend to be related to peripheral femoral cannulation.[2–4] Vascular complications related to femoral cannulation are the focus of this article.

Cannula Size Selection

Each arterial and venous cannula has a flow pressure curve based on the company's package inserts. The larger cannula promises larger flow rates in the in vitro situation. For example, a 17-Fr arterial cannula is able to provide only 4 to 5 L/min, whereas a 21-Fr arterial cannula can provide 6 L/min without adding extreme pressure on the cannula, which may later lead to hemolysis. VA ECMO flow is set to achieve a goal cardiac index greater than 2.2 L/min/m^2.[14] If the cardiac distension is expected from the cardiac arrest, 1 L may be added in addition to the optimum calculated ECMO flow to