Methods for bedside assessment of venoarterial extracorporeal membrane oxygenation distal perfusion cannula positioning

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Video clip is available online.

A 43-year-old woman with a history of multivessel coronary artery stenting presented with an anterior wall myocardial infarction and acute left ventricular dysfunction. She subsequently experienced a sudden cardiac arrest where return of spontaneous circulation was not achieved, and emergent bedside initiation of venoarterial extracorporeal membrane oxygenation (VA-ECMO) was performed.

**TECHNIQUE**

The right common femoral artery and left common femoral vein were accessed percutaneously under ultrasound guidance. Each vessel was serially dilated, and a 17-French (Fr) arterial cannula and 25-Fr multistage venous cannula were inserted. The cannulas were connected to the ECMO circuit, ECMO support was initiated, and appropriate flows were obtained. The right superficial femoral artery (SFA) was then identified under ultrasound guidance. Due to the patient’s cardiogenic shock and subsequent cardiac arrest, her SFA was small, measuring approximately 2 mm. Access to the right SFA was obtained with a micropuncture needle, and a micropuncture wire was inserted followed by a 5-Fr micropuncture sheath. The micropuncture sheath was exchanged for a 6-Fr, 11-cm arterial sheath (Telereg Medical) that was used as the distal perfusion cannula (DPC) for the lower extremity. Concerningly, yet not atypically for small patients who postarrest with a caudal cannula in the common femoral artery, the DPC did not yield robust blood return. We used an agitated saline injection and confirmed appropriate placement of the DPC on bedside ultrasound (Video 1). The DPC was then connected to the side-port of the arterial cannula via extension tubing with intervening three-way stopcock. To further assure proper positioning of the DPC in the SFA and adequate lower-limb perfusion, angiography with low volume, dilute, intra-arterial contrast directly through the DPC was performed.

**DPC Confirmatory Tests**

*Agitated saline injection through DPC.* The SFA was visualized with color Doppler ultrasound (FUJIFILM Sonosite Inc). The SFA cannula distal stopcock was turned off to the circuit (Figure 1, A), a 60-mL syringe filled with agitated saline was connected to the proximal SFA cannula.
stopcock, and a rapid continuous injection of agitated saline through the SFA cannula was performed (Figure 1, B). Color flow isolated to the SFA, and not extravasating in the perivascular space, suggested that the cannula was appropriately placed within the SFA.

**Angiography through DPC.** The SFA cannula distal stopcock was turned off to the circuit, a 30-mL syringe filled with dilute contrast (10 cc saline, 20 cc contrast) agent was connected to the proximal SFA cannula stopcock, and 10 cc of contrast was injected through the SFA cannula. Real-time bedside radiograph of the right leg was simultaneously obtained, to ensure that both the SFA (Figure 2, A) and popliteal artery (Figure 2, B) were adequately filling.

Institutional review board approval was granted by our institution (institutional review board #18120143, approved February 3, 2022), and the patient provided written informed consent. She was supported on VA-ECMO for a total of 54 days, during which no lower-extremity ischemia was encountered.

**DISCUSSION**

Lower-limb ischemia is a common and catastrophic complication of femorally cannulated VA-ECMO.\(^1\) The incidence of limb ischemia has been shown to be partially mitigated by placement of an ipsilateral DPC,\(^2\) most commonly in the SFA. Percutaneous SFA cannulation may be preferable to open cannulation due to the ability to avoid patient transport to the operating room, more expeditiously initiate support, and avoid an incision, which may be associated with infection and bleeding risks. However, unlike with open cannulation, confirmation of appropriate SFA cannula positioning is significantly more challenging when performed percutaneously and can often be difficult to determine by use of standard ultrasound alone. In this regard, percutaneous SFA cannulation without definitive angiographic confirmation of positioning has been associated with high limb ischemia rates (26\%) in at least one series.\(^3\)

While ultrasound visualization of sulfur hexafluoride microbubble ultrasound enhancing agent (SonoVue; Bracco) in the popliteal artery after injection through a DPC has been previously described,\(^4\) we demonstrate that rapid injection of agitated saline alone provides adequate echogenicity to confirm DPC positioning. This confers several advantages, including lower cost, more ready availability, and no risk of intolerance reactions. However, the agitated saline test does also have some risk of misinterpretation; extremely rapid injection can result in an ambiguous result secondary to a diffuse color Doppler signal. For this reason, we recommend complimentary angiography through the DPC.

**FIGURE 1.** Color Doppler ultrasound demonstrating (A) the absence of detectable flow through superficial femoral artery with distal perfusion cannula stopcock turned off to extracorporeal membrane oxygenation circuit and (B) flow that is isolated to the superficial femoral artery and not extravasating in the perivascular space during active injection of agitated saline through distal perfusion cannula.
Lower-extremity computed tomography angiography is typically reserved for ECMO patients already demonstrating clinical signs of limb malperfusion, as the contrast dye requirement can be prohibitive in patients with renal insufficiency. Direct contrast dye injection through the DPC itself enables the use of lower contrast volumes, enabling bedside angiography in most patients. While we do not do so routinely, if there is any uncertainty about DPC position, we recommend additional views that include the knee and possibly lower leg; visualization of contrast in the genicular arteries and/or trifurcation below the knee can help provide further confirmation of positioning.

The two techniques for confirmation of DPC positioning described herein are simple, inexpensive, and able to be rapidly performed at the bedside at time of ECMO cannulation. They have become standard of practice at our institution, and we strongly advocate for their use during all percutaneous femoral VA-ECMO cannulations.

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FIGURE 2. Radiograph of right leg demonstrating (A) flow of contrast from distal perfusion cannula to superficial femoral artery and (B) flow of contrast from distal superficial femoral artery to popliteal artery.