

Variability in End-Organ Perfusion with Femoral-Femoral Venoarterial Extracorporeal Membrane Oxygenation: Aortographic Evidence

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Abstract: In femoral-femoral venoarterial extracorporeal membrane oxygenation (VA-ECMO), the outflow of oxygenated blood from the circuit enters the aorta in retrograde fashion. As a result, variability in end-organ oxygenation (e.g., cerebral vs. splanchnic) may arise—particularly, when the heart is unable to contribute forward flow. We present the case of a 74-year-old man supported by femoral-femoral VA-ECMO in whom aortography was used to visualize the retrograde distri-

bution of arterial ECMO flow that can produce such differences in end-organ perfusion. We do this by describing a series of still images captured during the aortography; we then discuss the importance of monitoring end-organ oxygenation in this setting and outline several interventions that can ameliorate this flow phenomenon. **Keywords:** ECMO, extracorporeal membrane oxygenation, imaging, perfusion, physiology. *JECT. 2015;47:48–51*

Venoarterial extracorporeal membrane oxygenation (VA-ECMO) can provide lifesaving, full cardiopulmonary support to patients with refractory cardiogenic shock. Although various cannulation strategies exist for VA-ECMO (including central access via the cavae and ascending aorta) in emergent settings, the quickest access is typically gained via percutaneous cannulation of the femoral vessels. In so-called “femoral-femoral” VA-ECMO, the outflow of oxygenated (i.e., arterial) blood from the circuit enters the aorta in retrograde fashion. As a result, the cerebral circulation and coronary arteries “see” this oxygen-rich blood much later in its course of flow than they would if they were to be perfused by a centrally located arterial cannula providing antegrade flow. End-organ (e.g., brain and heart) oxygen saturations therefore are of particular concern with this cannulation scheme, especially when the native heart is sick to the point of contributing little or no forward flow.

In fact, our group previously demonstrated that femoral-femoral VA-ECMO generates regional variability in the

delivery of oxygen (1). For instance, radial artery oxygen saturations were significantly lower in patients with femoral arterial cannulae than in those with central, aortic cannulation (1). The present case serves as an adjunct to our earlier work; herein, we report on an elderly man supported by femoral-femoral VA-ECMO in whom we demonstrate similarly diminished ECMO perfusion using aortography.

DESCRIPTION

A 74-year-old, 1.93 m² male with a 2-month history of worsening chest pain and exertional dyspnea was admitted to the cardiology service for workup. The patient’s complex medical history was notable for congestive heart failure (23% ejection fraction), multiple episodes of ventricular fibrillation (for which he received an automatic implantable cardioverter defibrillator), coronary artery disease (status post [s/p] three-vessel coronary artery bypass grafting 12 years earlier), aortic valve disease (s/p replacement with a mechanical valve necessitating warfarin), hypertension, hyperlipidemia, gout, and idiopathic thrombocytopenic purpura. While awaiting left heart catheterization on hospital day (HD) 2, the patient suddenly developed ventricular fibrillation; a code was called and advanced cardiovascular life support was initiated. Despite repeated internal and external defibrillations as well as numerous pharmacological interventions, the patient’s

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arrhythmia proved intractable. Fortunately, adequate perfusion could be maintained with chest compressions as the patient was noted to be intermittently arousable during the prolonged resuscitation (e.g., moaning prior to intubation, moving arms toward person doing compressions) and as evidenced by arterial pressure waveforms. Bedside ultrasonography revealed extremely poor intrinsic left ventricular contractility; external cardiac compressions were continued and an intra-aortic balloon pump (IABP) was emergently placed.

The cardiac surgery team was called to the bedside and the IABP was then exchanged for femoral-femoral VA-ECMO with lower extremity perfusion after the patient had been heparinized. Written informed consent was obtained from the patient's wife. In brief, using the Seldinger technique, the left femoral artery and vein were percutaneously wired and serially dilated; a 19-French Bio-Medicus cannula (Medtronic, Inc., Minneapolis, MN) was placed in the left femoral artery and a 21-French Bio-Medicus multistage cannula (Medtronic, Inc.) was inserted into the left femoral vein with the tip at approximately the level of the right atrium. A 5-French Pinnacle sheath (Terumo Medical Corp., Somerset, NJ) was used for left lower extremity perfusion. The ECMO circuit consisted of a CentriMag pump (Thoratec Corp., Pleasanton, CA), a Quadrox oxygenator (Maquet Corp., Rastatt, Germany), and coated tubing (Terumo Medical Corp.). ECMO flows were increased to 4.5 L/min (2.3 L/min/m²) with good oxygenation; left lower extremity perfusion was confirmed by Doppler. The patient, now stabilized, was then brought to the cardiac catheterization laboratory for further evaluation. The patient was found to have severe left main and three-vessel coronary artery disease; only two of three bypass grafts were patent.

In an attempt to visualize the ECMO flow within the aorta, an arterial pigtail catheter inserted via the left brachial artery was then positioned in the aortic bifurcation just beyond the tip of the arterial ECMO cannula (Figure 1). As is illustrated in the figure, after instillation via the arterial catheter, contrast was seen flowing proximally in the aorta—i.e., along the path of travel of the arterial ECMO jet (figure legend provides detailed description). Although a splanchnic artery was visualized, relatively little contrast was noted in the proximal aorta. No contrast could be seen entering the coronary arteries. Of note, the patient had minimal native heart ejection during this time and his pulse pressure, measured via a left axillary arterial line, was 9 mmHg. Near-infrared spectroscopy (NIRS) monitoring was not available prior to, or during, the cardiac catheterization.

The patient was subsequently transferred to the cardiothoracic surgery intensive care unit. The patient's chances for meaningful recovery were deemed to be exceedingly small and given his age, he was not a candidate for cardiac

transplantation. As such, his family elected to withdraw care on HD 3; the patient expired shortly thereafter.

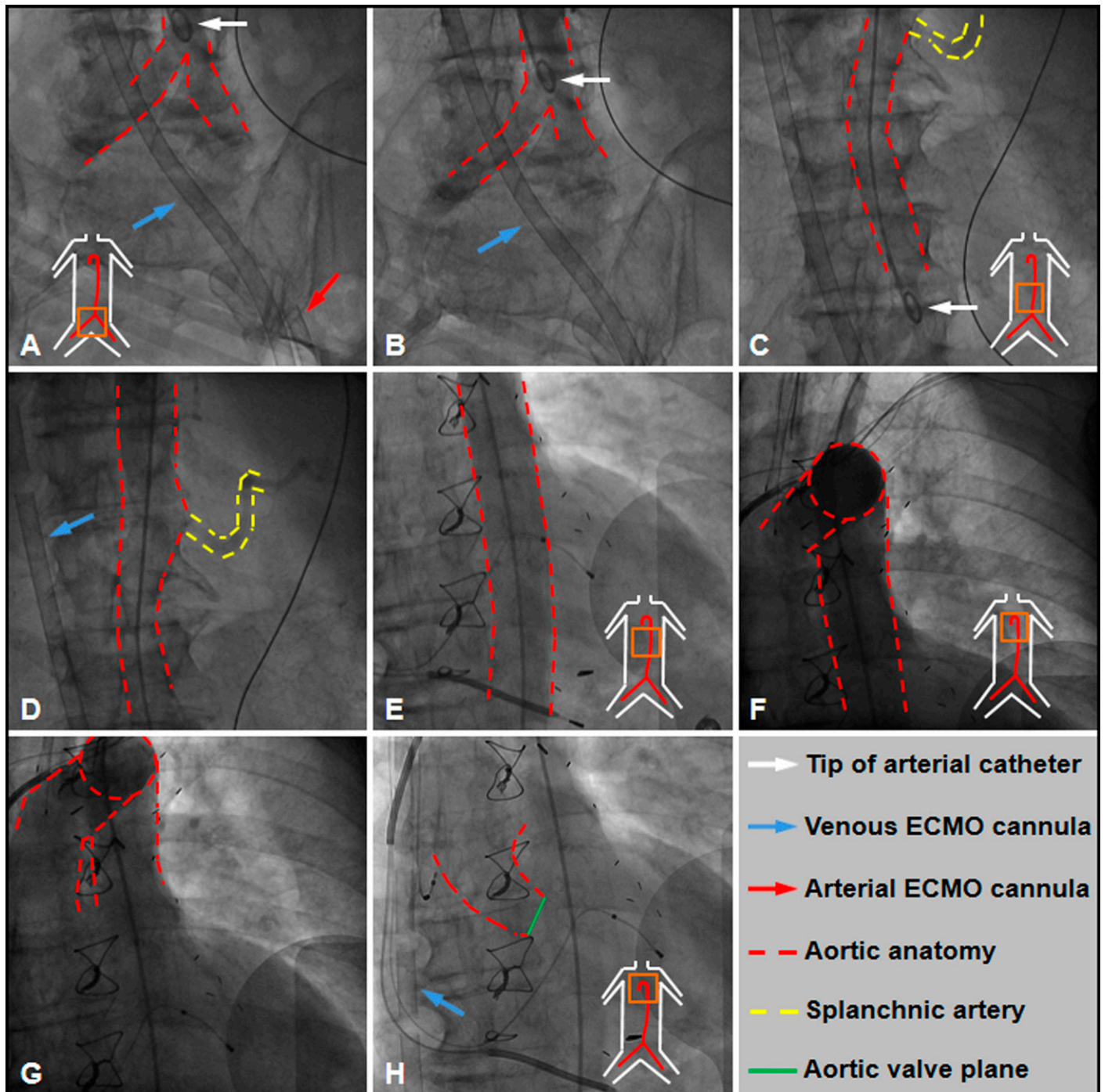
COMMENT

To the best of our knowledge, this is the first aortographic demonstration of the variability in end-organ perfusion provided by femoral-femoral VA-ECMO. Although we were able to visualize arterial ECMO flow perfusing some of the splanchnic bed, we saw only limited proximal (i.e., nearer the heart) perfusion and could not appreciate ECMO-propelled contrast within the coronary arterial tree. In situations such as this, considerable coronary and cerebral oxygenation must therefore be supplied by blood ejected from the patient's left ventricle—assuming the heart is strong enough to deliver this degree of intrinsic support.

We used aortography to visualize end-organ perfusion under ECMO support; technologies exist that allow for analogous real-time monitoring of end-organ oxygenation at the bedside. For example, NIRS can be used to monitor regional oxygenation and to detect hypoxemia in the brain (via forehead oximeters) and lower extremities (2). Another option involves monitoring arterial blood gases drawn from multiple peripheral sources, as described by Alwardt et al. (3). Regardless of the technique used, such monitoring is especially important for patients receiving retrograde ECMO perfusion in whom native cardiopulmonary circulation is dramatically impaired (as it was in our patient). With little oxygenated blood being ejected from these patients' hearts, their brains, and other superiorly located end organs thus depend overwhelming on ECMO flow for perfusion.

Recognition of this local hypoperfusion is vital in that it affords the clinician an opportunity to intervene: various combinations of increasing ECMO flow, ventilator adjustments, and inotropic support can be made to ultimately improve end-organ oxygenation. Alterations to the ECMO circuit can further promote oxygenation of "distal" tissues (i.e., distal relative to the arterial cannula). Although a longer femoral artery cannula may deliver oxygenated blood further up the aorta, a second arterial cannula can be placed in the axillary artery to provide additional antegrade flow.

We demonstrate aortographically that the potential for malperfusion exists with femoral-femoral VA-ECMO when retrograde (ECMO) flow occurs in the absence of meaningful oxygenated, antegrade flow from the native heart. We must point out, however, since we did not have the resources in place to use NIRS during the aortography, we cannot definitively illustrate that this flow phenomenon correlated with insufficient end-organ oxygenation at the time that these images were captured. The present case therefore further exemplifies the variability in perfusion that can result from VA-ECMO using retrograde



femoral artery cannulation and, in turn, reiterates the importance of monitoring end-organ oxygenation.

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