To Pulse or Not to Pulse, That Is the Question

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We read with interest this succinct review by Keller (1), published in the recent issue of Critical Care Medicine, on the application of peripheral venoarterial extracorporeal membrane oxygenation (ECMO) in cardiogenic shock, the intricate physiologic challenges which arise with its institution, and its lack of definitive guidelines. We note that areas of concern include how to "dose" mechanical circulatory support appropriately, and agree that its titration is difficult. Each patient with cardiogenic shock being supported with venoarterial ECMO is unique, which is why an individualized, patient-centered approach is inev-itable, and guidelines are difficult to prescribe.

One area that we are investigating is how to better corre-late the degree of venoarterial ECMO support with end-organ function. A robust animal model is essential to carry this out effectively. As Keller (1) has stated, serial markers of end-organ perfusion, such as lactate and urine output, will only partially help delineate a clinical trajectory.

The sublingual microcirculation, and its perfused vessel den-sity, has been identified as a novel potential marker for identi- fying successful weaning from venoarterial ECMO for patients with refractory cardiogenic shock (2). At Critical Care Research Group, we directly study these phenomena in our animal facility using novel techniques, such as sidestream dark-field imaging. This provides real time assessment of end-organ perfusion at the bedside, is repeatable, simple, and validated, and can therefore assist in guiding titration of mechanical support.

A second area of interest is the role of pulsatile flow venoarterial ECMO. We believe that pulsatility remains of paramount physiologic importance. Although there are limited data, pre-vious authors have shown that pulsatile flow improves micro- circulation and end-organ function (3).

We believe that the increase in afterload that is associated with retrograde venoarterial ECMO flow can be countered by augmenting pulsatility and synchronizing its amplitude with diastole. In a similar fashion to the intra-aortic balloon pump, whereby mechanical pulses are coupled with diastole, a pulsatile ECMO device has the potential to raise diastolic blood pressure and promote systolic ejection.

Furthermore, Ostadal et al (4) showed that afterload-dependent variables such as cardiac output and left ventricular (LV) volumes are lowered using a pulsatile, electrocardiogram- synchronized Extracorporeal Life Support device (i-cor; Xenios, Heilbronn, Germany). Therefore, the focus should be on removing unphysiological, retrograde, continuous flow to transform ECMO from a circulatory support device into a ventricular assist device.

Currently, we are conducting optimization studies for an upcoming in vivo animal study integrating pulsatile venoarterial ECMO. Our group has developed a sustainable, repeatable, and clinically translatable ovine model of cardiogenic shock. Variables studied by Ostadal et al (4) (such as ejection fraction, cardiac output, or LV volumes) are afterload-dependent and may therefore not represent true contractility (5). Instead, our study focuses on end-systolic elastance, the reference variable of myocardial contractility. Downstream effects of pulsatile venoarterial ECMO, such as by neurohormonal mechanisms, will be of additional interest in this study.

With a large, multicenter, retrospective study also being formed by our institution, in addition to our animal studies, we look forward to the opportunity to contribute data supporting the next chapter of venoarterial ECMO, and potentially pulsatile venoarterial ECMO, in the management of cardiogenic shock.

References

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