Emergency Parallel Mechanical Circulatory Support for Ventricular Fibrillation

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Extracorporeal and implantable mechanical circulatory support devices are increasingly used for refractory cardiogenic shock. We describe a patient with a continuous-flow left ventricular assist device (LVAD) who developed refractory ventricular fibrillation (VF) and deteriorating right ventricular function, requiring emergency implantation of venoarterial extracorporeal membrane oxygenation (ECMO), which supported the patient for 23 days of continuous VF until urgent transplantation. We illustrate challenges in managing parallel competing flows in the 2 circuits (Figure).

The patient is a 45-year-old man with dilated cardiomyopathy and a HeartMate II (Thoratec, Pleasanton, CA) as a bridge to heart transplantation. Over 1 year post LVAD, the patient’s clinical status and conditioning improved dramatically but he had increasing ventricular tachycardia and implantable cardioverter-defibrillator discharges, despite fluid and LVAD optimization to avoid suction.

Now he presented with repetitive implantable cardioverter-defibrillator discharges. He was in sinus rhythm and awake but anxious. HeartMate II rpm was 9400, providing a calculated flow of 4.5 to 5.5 L/min, with left ventricular ejection fraction of 10%, left ventricular end-diastolic diameter of 85 mm, and dilated right ventricle with poor function. He developed intractable VF and incessant implantable cardioverter-defibrillator discharges, despite intravenous amiodarone, lidocaine and magnesium, and sedation and intubation. The implantable cardioverter-defibrillator was turned off and the patient was initially stable in VF, but calculated LVAD flow declined from 5.5 to 4.0 L/min, sign of increasing right ventricular failure developed, mean blood pressure fell to 30 mmHg, and peripheral venoarterial ECMO (Centrimag, Levitronix, USA and Quadrox oxygenator, Maquet, Germany) was urgently implanted.

ECMO was gradually uptitrated to 4300 rpm, yielding 5.1 L/min flow, whereas HeartMate II rpm was downtitrated to 7400 rpm, where calculated flow is unreliable and displayed as “— — —”. Continuous low-flow alarms suggested a flow <2.5 L/min. The anticoagulation regimen was changed from warfarin to heparin. Because of competitive and thus reduced flows in the 2 circuits, activated partial thromboplastin time was kept at 90 to 130 seconds and antithrombin >1.0 kIU/L.

On LVAD+ECMO, the patient was extubated without supplemental oxygen, awake, and neurologically intact and without distress. Echo revealed immobile and dilated left and right ventricles and moderate aortic regurgitation. Chest radiograph revealed diffuse congestion and atelectasis and arterial saturation in the right arm was 96%. Pulmonary flow was 0.5 to 1.0 L/min measured noninvasively (Innocor, Innovation, Denmark).

During uptitration to 7800 rpm, LVAD inflow cannula flow and aortic regurgitation increased by echocardiography, whereas left ventricular end-diastolic diameter and pulmonary flow by Innocor were unchanged (Figure). External cardioversion was attempted repeatedly without success and the patient remains stable and awake in VF for 23 days until transplantation.

This case illustrates several things. First, the natural history of VF is thought to include inevitable progression to asystole, but as this and other reports illustrate, VF may be sustained if cardiac and systemic perfusion is secured. Second, perfusion may be secured by, for example, a pulsatile-flow LVAD and a resulting Fontan-like circulation, but continuous-flow LVADs provide less unloading and indeed our patient’s right ventricular function deteriorated rapidly. Third, despite concerns about competing flows, blood stagnation, and thrombosis, LVAD and venoarterial ECMO can be sustained in parallel, in particular, in the presence of aortic regurgitation. Interestingly, progressively aortic regurgitation frequently occurs over time with continuous-flow LVADs and was serendipitous in this case. The aortic regurgitation permitted adequate flow through the LVAD and the LVAD accommodated the regurgitant flow that otherwise would cause high left ventricular loads during ECMO.

Disclosures
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References
Figure. Schematic illustration of parallel extracorporeal membrane oxygenation (ECMO) and left ventricular assist device (LVAD). The ECMO flow bypasses the lungs and LVAD. The LVAD flow consists of pulmonary venous return and aortic regurgitant flow (illustration AB Typofom).
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