A hybrid configuration of a left ventricular assist device and venovenous extracorporeal membrane oxygenation

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One method of managing acute cardiopulmonary failure is with venoarterial extracorporeal membrane oxygenation (ECMO). An alternative to venoarterial ECMO that uses a hybrid system of venovenous ECMO with an Impella left ventricular assist device (LVAD; Abiomed, Inc, Danvers, Mass) is described.

CLINICAL SUMMARY

A 37-year-old man with nonischemic cardiomyopathy—baseline ejection fraction 20%—was seen with progressive dyspnea and rapid atrial fibrillation for electrical cardioversion. His condition deteriorated, necessitating intubation and resuscitation with multiple vasopressors. Echocardiography demonstrated worsened left ventricular function (ejection fraction 10%) with moderate right ventricular dysfunction. An Impella 5.0 LVAD was implanted through a right transaxillary approach with a 10-mm graft under echocardiographic and fluoroscopic guidance. The mean arterial pressure ranged between 60 and 80 mm Hg, with LVAD flows of 4.5 to 5.0 L/min. A heparin infusion was initiated with an activated partial thromboplastin time anticoagulation parameter of 45 to 55 seconds.

During the next 72 hours, the arterial blood gas profile demonstrated progressive hypoxia and hypercapnia. The chest radiograph showed opacification of the left lung, and bronchoscopy demonstrated heavy secretions. Sputum cultures were positive for *Achromobacter* species, *Staphylococcus aureus*, and *Klebsiella pneumoniae*. Despite antibiotics and maximal ventilator management, venovenous ECMO was initiated. Cannulation was performed with a 25F left femoral venous cannula (inflow) and a 19F right internal jugular cannula (outflow)—both inserted percutaneously. ECMO flow was 4.5 L/min (Figure 1).

Although echocardiography continued to demonstrate persistent severe LV dysfunction, other parameters

Venovenous extracorporeal membrane oxygenation combined with microaxial LVAD.

Central Message

The combination of venovenous ECMO and the microaxial LVAD is a novel therapy for acute cardiorespiratory failure.

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stabilized and improved: (1) stability of blood pressure and heart rate; (2) maintenance of adequate urinary output and renal function; (3) normal cerebral oximetry; and (4) reduction in vasopressors. The LVAD was removed after 13 days of support—it was withdrawn from the graft, and the graft was oversewn. Pulmonary function improved a week later, allowing bedside ECMO cannula removal. A tracheostomy was required but removed before discharge on hospital day 44. There were no neurologic complications.

DISCUSSION

In 2015, a clinical expert consensus statement was reported advocating the role of percutaneous circulatory support devices in cardiovascular care.¹ The traditional mechanical support therapy, venoarterial ECMO, has some disadvantages: (1) it does not unload the left ventricle; (2) retrograde arterial flow carries the potential for cerebral hypoxemia; and (3) mechanical linkage of the cardiac and respiratory systems requires both organs to recover before considering support removal.

The configuration described in this case was chosen because it was our intent to support the heart with an access that would permit mobility. Unfortunately, respiratory failure subsequently developed, necessitating mechanical pulmonary support. We chose to add venovenous ECMO to the existing LVAD.

FIGURE 1. Hybrid Impella 5.0 left ventricular assist device and venovenous extracorporeal membrane oxygenation.

The concept of combining the Impella with ECMO has been previously described.^{2,3} These previous reports, however, referred to using the Impella 2.5 LVAD with venoarterial ECMO. To our knowledge, this is the first report of using an Impella 5.0 in combination with venovenous ECMO.

Some important clinical aspects of the case require mentioning: (1) the combination of multiple high-dose vasopressors with low cardiac output is associated with a high mortality,⁴ necessitating more than intraaortic balloon pump support; (2) adequate right ventricular function is necessary for optimal LVAD performance, the current configuration notwithstanding; (3) the transaxillary Impella implantation has a short distance from the inflow tip to the insertion site, thereby reducing malposition issues (admittedly, the transaxillary approach takes more time—on average 30 to 45 minutes—and may not be advisable in cases where this time frame is not available); (4) although the capital costs of venoarterial ECMO is lower than that of the hybrid configuration described, the hybrid configuration has clinical advantages (as described) and financial value, because the ECMO and the LVAD can be billed as two independent entities; (5) although the Impella is US Food and Drug Administration approved for only 6 hours of support, its use beyond this interval is not uncommon; (6) whether the respiratory failure is truly pulmonary in origin or secondary to cardiac failure may not always be apparent initially and therapies need to be dynamic and

tailored accordingly; (7) and finally, an alternative strategy for venovenous ECMO would include the percutaneous double-lumen transjugular Avalon cannula (Avalon Laboratories, LLC, Rancho Dominguez, Calif).

In summary, the hybrid Impella LVAD combined with venovenous ECMO is a useful configuration for acute cardiorespiratory failure. The ability to uncouple the two therapies as each organ system recovers proved beneficial in this case. Further experience with hybrid venovenous ECMO and LVAD devices for acute cardiopulmonary support in extreme cases appears worthwhile.

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