Ambulatory simultaneous venoarterial extracorporeal membrane oxygenation and temporary percutaneous left ventricular assist device bridge to heart transplantation

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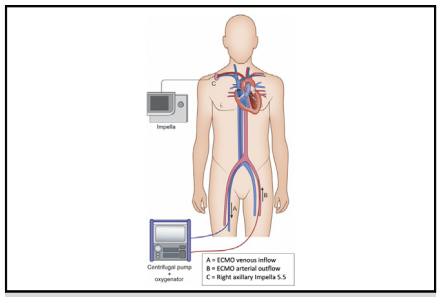


Simultaneous peripheral VA-ECMO cannulation with axillary Impella 5.5 placement.

CENTRAL MESSAGE

Combined peripheral VA-ECMO and axillary inserted Impella left ventricular unloading allows for adequate hemodynamic support and early ambulation while awaiting cardiac transplantation.

See Commentary on page 135.

Video clip is available online.

Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is a proven method for rapid restoration of end-organ perfusion in patients with cardiogenic shock, and it has become an increasingly used bridging strategy to heart transplantation (HT).[1] However, reluctance to ambulate these patients may subject candidates to physical deconditioning, especially those with longer waiting times. In this report, we present a 45-year-old male patient in cardiogenic shock who was successfully rescued and bridged to HT using a peripherally inserted configuration of simultaneous VA-ECMO and Impella 5.5 (Abiomed) temporary left ventricular (LV) unloading.

This study was approved by our institutional review board (MOD18120143-003, approved March 9, 2020), and written consent was obtained from the patient for the publication of this report.

CLINICAL SUMMARY

A 45-year-old man with nonischemic cardiomyopathy presented with multiple episodes of ventricular tachycardia and was found to be in acute decompensated heart failure. His LV ejection fraction was 12% with a cardiac index of 1.5 (L/min/m^2). He was supported on intravenous milrinone and listed for HT. He subsequently experienced an episode of ventricular fibrillation arrest requiring a few minutes of cardiopulmonary resuscitation and external defibrillation. Following this event, he experienced right ventricular (RV) stunning with worsening renal and hepatic function. Over the ensuing hours, the patient experienced a doubling in his central venous pressure and evidence of worsening pulmonary edema on chest roentgenography despite increasing inotropic therapy. After medical management was deemed inadequate, the decision was made to pursue mechanical circulatory support, and he was taken to the operating room approximately 13 hours following this arrest.

The patient underwent simultaneous cannulation for VA-ECMO and Impella 5.5 temporary LV assist device placement. ECMO was established via a percutaneous, bifemoral approach (25-F right femoral vein multi-stage venous drainage cannula, 17-F left femoral arterial cannula). An Impella 5.5 was inserted via a right axillary artery cutdown using a 10-mm Gelweave graft (Figures 1 and 2) for LV unloading. A 6-F distal perfusion catheter was placed into the

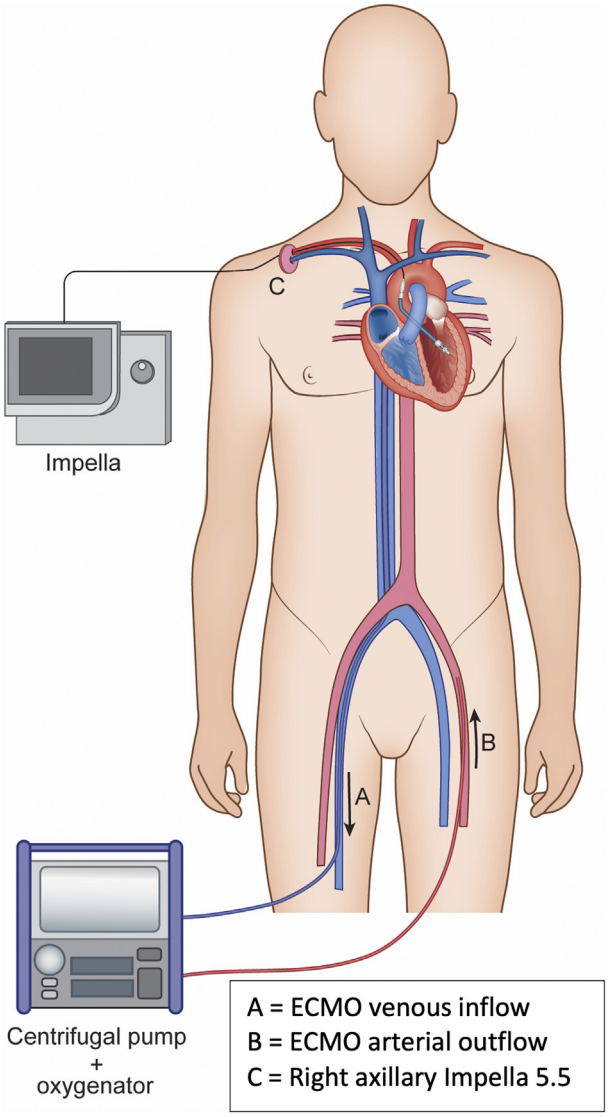


FIGURE 1. Schematic of anatomic layout of simultaneous peripheral venoarterial extracorporeal membrane oxygenation cannulation and axillary Impella 5.5. *ECMO*, Extracorporeal membrane oxygenation.

left superficial femoral artery. The Impella catheter was affixed to the axillary graft with silk ties and ECMO cannulas were secured to the patient's skin and soft tissues with multiple silk sutures.

Immediately following the operation, the patient was downgraded to a status 7 for HT due to acute renal and hepatic injury (Kidney Disease: Improving Global Outcomes stage 2 renal injury, Model for End-Stage Liver Disease score 31 on postcannulation day 1). The patient's resultant Sequential Organ Failure Assessment and Acute Physiology and Chronic Health Evaluation scores on postcannulation day were 9 and 14, respectively. These issues resolved without intervention or need for renal-replacement therapy, and he was reactivated as a status 1

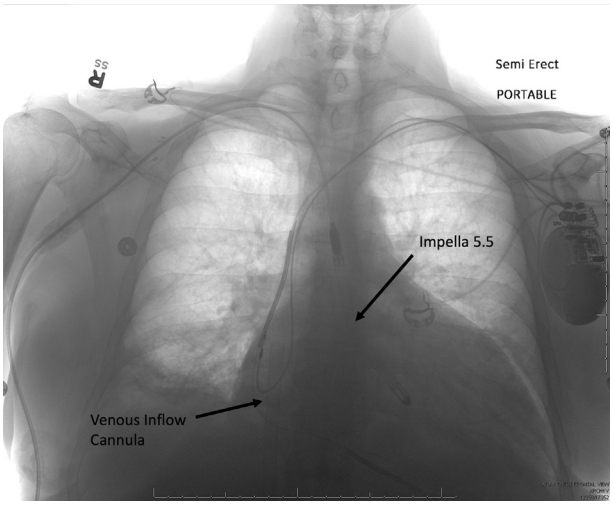
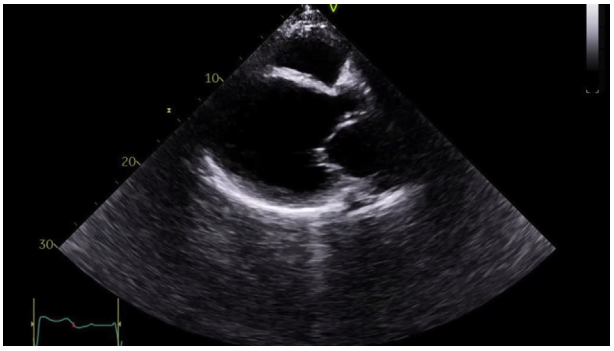


FIGURE 2. Chest roentgenogram following cannulation for peripheral venoarterial extracorporeal membrane oxygenation and axillary Impella 5.5.

on postcannulation day 7. While awaiting a heart offer, he was able to participate in physical therapy and ambulate (Video 1). Attempts to wean VA-ECMO support were unsuccessful while awaiting a heart offer due to ongoing RV dysfunction. Similarly, due to ongoing RV dysfunction, the patient was not considered for durable LV assist device placement. The VA-ECMO circuit was maintained at a speed of 3000 RPMs with a flow of 3 L/min and a sweep of 0.5-1.0 L/min. The Impella was maintained on P-7 setting with a flow of 4.0 L/min. While cannulated, the patient's peak lactate dehydrogenase peaked at 640 U/L and hemoglobin concentrations remained stable; thus, no transfusions were required. There were no issues with access bleeding or need for device repositioning. On postcannulation day 13, he received an acceptable offer and was transplanted.



VIDEO 1. Patient with biventricular failure supported with combination of peripheral VA-ECMO and Impella 5.5 while awaiting heart transplantation. Bifemoral VA-ECMO cannulation and right axillary placement of Impella allow for the patient to ambulate and participate in physical therapy. Video available at: https://www.jtcvs.org/article/S2666-2507(22)00110-9/fulltext.

The patient's posttransplant course was notable for acute kidney injury that once again resolved without renal replacement. He also was treated for *Escherichia coli* bacteremia with a 2-week course of meropenem. He was discharged to an inpatient rehabilitation facility on posttransplant day 19, and then discharged home 1 week later.

DISCUSSION

In light of the 2018 allocation system change, temporary, nondischargable support devices have experienced widespread increased usage as a means of bridging to HT. In certain patients with LV dysfunction, percutaneous temporary ventricular assist devices such as the Impella may provide adequate support and allow for a status 2 listing. However, as in this case, those with fulminant biventricular failure may require additional support.

Peripheral, femorally inserted VA-ECMO cannulation provides a rapid method for the restoration of end-organ perfusion. While previous reports have demonstrated that patients can ambulate while on VA-ECMO,[2-4] it is also clear peripherally inserted VA-ECMO increases afterload, which may have adverse consequences. Specifically in the severely impaired heart, elevated LV pressures may lead to pulmonary edema, ventricular overdistention, and myocardial ischemia, further propagating cardiac injury. Further, if aortic valve opening is absent, stasis and thrombus formation may occur. Central ECMO cannulation strategies provide easy access for a vent to be placed for LV unloading. However, this strategy is typically achieved via median sternotomy and thus places the patient at greater risk of significant blood loss, transfusion, and possibly the development of unwanted sensitization. Furthermore, when the sternum cannot be reapproximated, the patient must remain bedbound and often mechanically ventilated. A previous report by Singh and colleagues[5] described a minimally invasive central ECMO cannulation strategy that obviates the need of sternotomy, although the left ventricle was not vented.

In this case, we used a strategy that combines the minimally invasive benefits of peripheral ECMO cannulation and adequate LV unloading. A previous report described the use of peripheral VA-ECMO, combined with a femorally inserted Impella for ventricular unloading.[6] However, in this case, the femoral Impella was removed due to hemolysis and the ECMO cannulation was converted to a central configuration. Use of an Impella 5.5, inserted via the axillary artery, can provide excellent LV unloading, achieve good positional stability, and promote early ambulation. Furthermore, if RV function improves, the patient may be weaned from ECMO to Impella 5.5 alone for LV support. In patients presenting with predominantly LV dysfunction (RV dysfunction is less than severe), Impella alone may be considered, barring the presence of malignant arrhythmias. In those presenting with cardiogenic shock with severe RV dysfunction, VA-ECMO is usually pursued first to provide right-sided support. If LV dysfunction is also present, an Impella 5.5 may be added later if there are concerns for inadequate LV unloading. In patients with LV failure who are on VA-ECMO, LV venting is used selectively at our program. Specifically, if patients develop pulmonary edema, have evidence of LV distention on echocardiography, or have severely elevated LV diastolic pressures, an LV vent is employed. Further, if patients with LV failure have echocardiographic evidence of blood stasis within the aortic root or LV while on VA-ECMO support, we will also consider LV venting. We generally favor an Impella 5.5 as a first-line strategy over other models such as the CP as we have observed a lower incidence of hemolysis and better positional stability with the 5.5 in our practice. Furthermore, if the patient can be weaned from VA-ECMO and supported with Impella alone, we feel the higher flows afforded by the Impella 5.5 compared with other models may be advantageous. In the presented case, the patient's RV and LV function were both very poor, and therefore, VA-ECMO cannulation and Impella insertion were performed simultaneously to provide hemodynamic support and prevent later LV distention and pulmonary edema that would have likely resulted. Contraindications to this approach are similar to the use of an axillary-inserted Impella and peripherally inserted VA-ECMO, which include heavily diseased/calcified vessels or those too small to permit cannulation. Furthermore, the presence of significant LV thrombus may preclude Impella placement, and another form of venting may be preferred.

The combination of Impella 5.5 and peripheral VA-ECMO has been described by Ramzy and colleagues,[7] who described a series of 11 patients with this combined therapy. In this series, 8 patients were successfully weaned to Impella support alone, with 5 patients eventually weaned to no long-term mechanical support and 3 patients to transplantation (3 patients died). However, no mention was made on the mobility of patients while on full support. In patients with isolated, axillary inserted Impella 5.5, we strive for early ambulation in nearly all patients while they await transplantation or other definitive therapy. In those with peripheral VA-ECMO cannulation, ambulation is achieved in a much smaller subset of patients but is encouraged if possible. To achieve this, the patient much be neurologically intact, hemodynamically stable on support with no concerns for bleeding, and liberated from mechanical ventilation. Before ambulation, ECMO cannula positioning is confirmed using chest and abdominal roentgenography, and a visual inspection of external sutures is conducted to confirm secure attachment of cannulas and prevent dislodgement. Of note, caution must be taken in patients with obesity, as cannulas that are affixed to the soft tissues may be at a greater risk of migration and dislodgement. Before ambulation, we typically first trial mobilizing the patient from the hospital bed to sitting in a chair and then later

standing while taking steps in place. Although likely to be achieved only in select subset of patients, in this case we show that this strategy of axillary-inserted Impella 5.5, paired with peripheral VA-ECMO can provide maximal hemodynamic support and allow for participation in physical therapy, which may prevent deconditioning while awaiting transplantation and improve posttransplant outcomes.

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