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CASE REPORT

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Ambulatory central VA-ECMO with biventricular decompression for acute cardiogenic shock

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Abstract

We describe the off-pump insertion of a biventricular assist device with extra-corporeal membrane oxygenation (ECMO): a novel technique that allows for ambulatory central veno-arterial (VA) ECMO with direct biventricular decompression.

KEYWORDS

cardiovascular intervention, extra-corporeal membrane oxygenation, mechanical circulatory support, ventricular assist device

1 | INTRODUCTION

Surgical implantation of a left ventricular assist device (LVAD) may be an option for patients in cardiogenic shock who do not respond to conventional therapies. Nonetheless, it requires an invasive surgical procedure associated with a high risk of bleeding that is commonly inappropriate for patients with hemodynamic instability who often have coagulopathy. Alternatively, veno-arterial extracorporeal membrane oxygenation (VA-ECMO) is beneficial in the setting of respiratory and circulatory compromise, and it can be established outside of the operating room [1]. Complications of VA-ECMO include left ventricular distention and pulmonary edema that result from an increased afterload and retrograde flow support. We describe the off-pump insertion of a partial right ventricular assist device (RVAD) and a LVAD with ECMO: a novel technique that allows for ambulatory central VA-ECMO.

2 | CASE REPORT

A 44-year-old male with a history of non-ischemic cardiomyopathy and paroxysmal atrial fibrillation presented with decompensated heart failure and rapid atrial fibrillation. Investigations revealed mild acute kidney injury (AKI) (SCr 1.9 mg/dL), a left ventricular ejection fraction of 10%, severely reduced right ventricular systolic function, and severe biventricular dilatation. We optimized his medical therapy, inotropic support, and performed a successful cardioversion. Despite these interventions, the patient's clinical status continued to decline with worsening fluid retention, progressive AKI (SCr 3.8 mg/dL), and multiple episodes of ventricular tachycardia and ventricular fibrillation terminated by his implantable cardiac defibrillator (SAVE score-2) [2]. We made the decision to insert a partial RVAD and a LVAD with ECMO for biventricular support and oxygenation. The patient underwent a left mini-thoracotomy, with off-pump trans-apical placement of a 31 Fr ProtekDuo® cannula. Prior to cannulation, we administered 15,000 U of heparin without a gainful increase in activated clotting time (ACT). Subsequently, a target ACT of >180–220s was achieved with 1,166 U of antithrombin III & further 15,000 U of heparin. We secured the device using 3.0 Prolene purse-string sutures. The cannula provided a route for blood exchange with the inflow port located in the left ventricle and the outflow port and cannula tips situated 2–3 cm above the aortic valve. The blood circulated by the cannula passed through a pump (TandemHeart®) followed by the extra-corporeal membrane oxygenator (TandemLung®). We also placed a 21-Fr inferior vena cava (IVC)–superior vena cava (SVC) venous cannula via the femoral vein, connecting the tubing to the inflow of the trans-apical ProtekDuo®

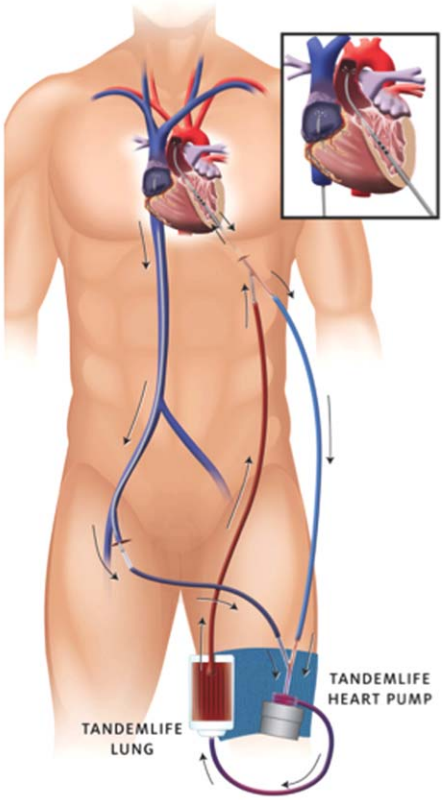

FIGURE 1 Central VA-ECMO—A trans-apical dual lumen cannula spliced with femoral venous cannula connected to an ECMO circuit with blood ejected into the ascending aorta [Color figure can be viewed at wileyonlinelibrary.com]

cannula (Figure 1). right atrium (RA)-IVC venous and left ventricle (LV) inflow cannula flow differentials were 1.5 and 3.5 L/min, respectively. The patient received one unit of packed red blood cells and two units

TABLE 1 Perioperative medication management

Date	2017 Day 0	2017 Day 0	2017 Day 1	2017 Day 16
Time	1600	2000	1115	0800
Event	Preop	Intraop	Postop	Pre HVAD
Dobutamine (mcg/kg/min)	5	10	5 mcg stopped	
			Day 1 1115	
Heparin (units/hr)	1300 U	30,000 U Bolus	1000 U	1500 U
Milrinone (mcg/kg/min)	0.375	0.56	0.5	0.25
Norepinephrine (mcg/kg/min)	15	5–15	16 mcg stopped	
			Day 1 1700	
Vasopressin (Units/min)	0.04	0.04	0.04 stopped	
			Day 4 1245	

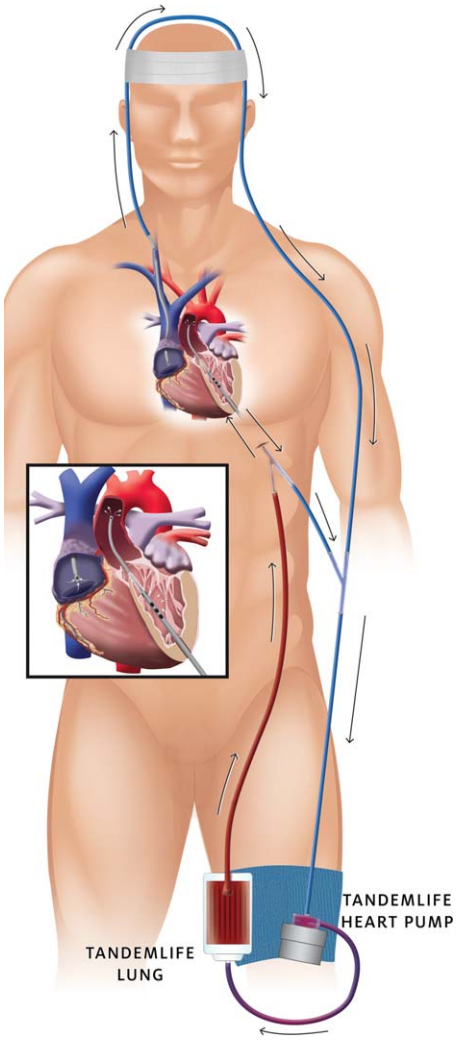

FIGURE 2 Diagrammatic representation of Ambulatory Central VA-ECMO [Color figure can be viewed at wileyonlinelibrary.com]

of platelets during the operative period, yielding a final hematocrit of 38.3% and platelet count of 140,000 per mcL.

Within 24 hr after the procedure the patient required less inotropic support and was successfully extubated after we observed a vastly improved response to diuretics and the AKI started to resolve (Table 1). Within 48 hr, the pulmonary artery diastolic pressure decreased from 25 to 15 mm Hg and the mean arterial pressure increased from 80 to 92 mm Hg. On post-operative day 2, we exchanged the right femoral venous cannula for a 19-Fr venous cannula via the right internal jugular vein and connected the tubing to the inflow of the ProtekDuo cannula (Figure 2). We confirmed placement in the right atrium using transesophageal echocardiography. Following the procedure, the patient worked with physiotherapy and he walked around the unit (Figure 3). On the fourth day of central VA-ECMO, we removed the right internal jugular venous cannula and the TandemLung. Over the following fortnight, the patient continued to work with physical therapy and our team discussed options for durable mechanical circulatory support. Over a period of three consecutive days, he remained asymptomatic while walking around the unit, and he maintained pump flows greater

FIGURE 3 Patient ambulating with Central VA-ECMO [Color figure can be viewed at wileyonlinelibrary.com]

than 4.5 LPM without inotropic support. Sixteen days after its initial insertion, we explanted the trans-apical extra-corporeal LVAD (TandemHeart) and placed an intra-corporeal LVAD (HVAD, Heartware) as a bridge to transplant. During placement of the HVAD, we observed no necrosis, damage, or fibrotic scar deforming the left ventricular apex.

3 | DISCUSSION

National trends have shown an increase in peripheral VA-ECMO for refractory cardiogenic shock [1] often coupled with a left ventricular vent such as an Impella 3.5CP®. Femorofemoral VA-ECMO restricts patient mobility which may lead to critical illness myopathy. Bachetta and coworkers have previously described a "Sport Model" of VA-ECMO using the right internal jugular and axillary or subclavian artery cannulation [3] as well as a "Central Sport Model" using the Innominate artery [4]. These techniques allow for ambulatory VA-ECMO, however, they do not provide direct left ventricular decompression, create the potential for right upper limb ischemia as well as preferential blood flow down the right subclavian and carotid arteries. A minimally invasive off-pump biventricular assist device insertion technique has been reported [5]. Building upon this technique for LVAD insertion, we have created an ambulatory VA-ECMO system with direct biventricular decompression, physiologic flow support, and avoids the potential for limb ischemia.

4 | CONCLUSION

Our method for off-pump insertion of a partial RVAD and LVAD with extracorporeal membrane oxygenation offers a novel option for ambulatory central VA-ECMO.

CONFLICT OF INTEREST

No conflicts of interest or funding sources exist

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