CASE REPORT
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Apical approach with double-lumen cannula for extracorporeal membrane oxygenation as a bridge to ventricular assist device. Alea Iacta est

Abordaje apical con cánula de doble lumen para oxigenación por membrana extracorpórea como puente a dispositivo de asistencia ventricular. Alea Iacta est

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ABSTRACT

Temporary mechanical circulatory support (MCS) is used in the treatment of cardiogenic shock. options for temporary MCS typically include intra-aortic balloon pump placement (IABP), impella, left ventricular assist device (LVAD) placement, and veno-arterial extracorporeal membrane oxygenation (VA-ECMO). Cannulation for VA-ECMO can be done either peripherally, or centrally. Central cannulation allows for antegrade arterial return and can be used when adequate flow cannot be achieved via peripheral cannulation, but it must be performed surgically. However, minimally-invasive techniques, such as transapical placement under the guidance of transesophageal echocardiography, have been described using the dual lumen cannula ProtekDuo®. This approach may be associated with decreased hemolysis, improved mobility, and early extubation. This technique has been used as a bridge to LVAD, as well as bridge to recovery, IABPs and Impella® both require access via either axillary or femoral artery. Our case describes the successful

RESUMEN

El soporte circulatorio mecánico temporal (SCM) se utiliza en el tratamiento del choque cardiogénico. Las opciones para el SCM temporal incluyen comúnmente el balón de contrapulsación intra-aórtico (BCIA), el Impella®, el dispositivo de asistencia ventricular izquierda (LVAD) y la oxigenación por membrana extracorpórea venoarterial (VA-ECMO). La canulación para VA-ECMO puede realizarse de manera periférica o central. La canulación central permite el retorno arterial en sentido anterógrado y puede emplearse cuando no se logra un flujo adecuado por vía periférica, aunque su colocación requiere intervención quirúrgica. Sin embargo, se han descrito técnicas mínimamente invasivas, como el abordaje transapical guiado por ecocardiografía transesofágica, utilizando la cánula de doble lumen ProtekDuo®. Este enfoque puede asociarse con menor hemólisis, mayor movilidad y extubación temprana. La técnica se ha utilizado como puente hacia el implante de un VAD, así como puente a la recuperación. Tanto el BCIA como el

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minimally invasive placement and use of a Spectrum® cannula for central VA-ECMO in a patient who did not have adequate arterial access, as a bridge to LVAD, after which the patient achieved cardiac recovery.

Keywords: cardiogenic shock, dual lumen cannula, extracorporeal membrane oxygenation, heart failure.

Impella® requieren acceso por la arteria axilar o femoral. Nuestro caso describe la colocación exitosa y mínimamente invasiva de una cánula Spectrum® para VA-ECMO central en una persona que no tenía acceso arterial adecuado, utilizándolo como puente hacia LVAD, tras lo cual se logró la recuperación cardiaca.

Palabras clave: *choque cardiogénico, cánula de doble lumen, oxigenación por membrana extracorpórea, insuficiencia cardiaca.*

Abbreviations:
CPB = cardiopulmonary bypass
IABP = intra-aortic balloon pump placement
LVAD = left ventricular assist device
MCS = mechanical circulatory support
TEE = transesophageal echocardiography
VA-ECMO = veno-arterial extracorporeal membrane oxygenation

Use of mechanical circulatory support (MCS) for cardiogenic shock has rapidly increased.[1] Most common initial MCS strategies entail institution of veno-arterial extracorporeal membrane oxygenation (VA-ECMO). For patients with anatomically small peripheral arteries or insufficient circulatory support, central cannulation techniques may be necessary. These invasive approaches are associated with increased risk of bleeding and other significant complications.[2] To minimize complications, many different techniques have been described including a mini left thoracotomy and direct apical cannulation for VA-ECMO using a ProtekDuo Cannula (Cardiac Assist Inc., LivaNova). This technique allows early ambulation and avoids peripheral artery access complications but has only been described in small case series.[3] However, to our knowledge, this is the first case describing the use of the Spectrum® cannula (Spectrum Medical) for apical central ECMO as bridge to left ventricular assist device (LVAD).

CASE DESCRIPTION

A 27-year-old female with a history of dilated cardiomyopathy, peripartum cardiomyopathy resulting in heart failure with reduced ejection fraction, hypertension, and obesity with Body Mass Index (BMI) 40, presented with pneumonia and acute on chronic systolic heart failure. She experienced dyspnea, rapid labored breathing, and hypoxia. She was placed on nasal cannula. Chest X-ray showed bilateral infiltrates and pulmonary edema. The patient was intubated due to worsening respiratory distress and started on intravenous Lasix, milrinone, heparin infusion, propofol, and fentanyl. An arterial line connected to a FloTrac device recorded a cardiac output of 6.0 l/min, cardiac index of 3.3 l/min/m^2 and central venous pressure of 12 mmHg. Fevers developed, vancomycin and piperacillin/tazobactam were initiated. The patient was transferred for further management.

Upon arrival, the patient was in cardiogenic shock and maintained on propofol and milrinone. Temperature was 38.4 °C, blood pressure 122/80 mmHg, with low ventilator settings and no acidosis and/or hypoxemia. Laboratory studies showed total bilirubin 7.4 mg/dl, direct bilirubin 4.3 mg/dl, ALT 74, LDH 356, BNP 135, troponin 67, WBC 14.4, PLT 134, D-dimer 2362, fibrinogen 575, and urinalysis negative for infection.

The patient initially declined transplant consideration due to negative family experience. Barriers included BMI. severity of illness with multi-organ dysfunction with possible pneumonia, and segmental/subsegmental pulmonary thromboembolism. In subsequent days, multiple vasopressors were required. Diminished lower extremity pulses bilaterally raised concern for acute limb ischemia. Echocardiography revealed marked stasis in the left ventricle "smoke" *(Fig. 1)* and femoral and axillary vessels measuring less than 5 mm. Given the lack of suitable peripheral cannulation sites, including axillary Impella® (Abiomed, Johnson & Johnson. Massachusetts, United States America), and in order to avoid sternotomy, the decision was made to transition the patient to apical central ECMO.

SURGICAL TECHNIQUE

The apex of the heart was identified. A small left anterior thoracotomy was performed. The pericardium was incised. A 14 mm Dacron Graft® (Maquet. New Jersey, United States America) was anastomosed with several mattress full thickness 4-0 Pledgeted Prolene® suture (Ethicon, Johnson & Johnson, New Jersey, United States America) at the apex. Heparin was administered, an 8 mm Dacron Graft® (Maquet, New Jersey, United States America) was anastomosed to the small right axillary artery, simultaneously, the right femoral vein was cannulated with Seldinger Technique with a 25 Fr long venous cannula Multihole® (Medtronic, Minneapolis, United States America) in preparation for cardiopulmonary bypass (CPB). Under transesophageal echocardiography (TEE) guidance, the apical myocardium inside the graft was accessed with a needle. Using the Seldinger technique, a 0.035" Glidewire® (Terumo Cardiovascular Systems Corp., Colorado, United States America) was placed into the left

ventricle and passed antegrade through the aortic valve into the ascending aorta. A 5 Fr Berenstein exchange catheter® (Cordis, Florida, United States America) was placed and was exchanged for an 0.035" Lunderquist guidewire® (Cook Medical. Indiana, United States America). After serial dilations until the dilator 29 Fr, A 32F chest tube was placed inferior to the thoracotomy at the level of the anterior axillary line, making a muscular tunnel to allow passage of the Lunderquist Guidewire® (Cook Medical. Indiana, United States America). The chest tube was removed. A 31 Fr Spectrum® cannula (Spectrum Medical, South Carolina, United States America) was advanced over the guidewire (across the tunnel). Cannula positioning was guided by TEE, the two sets of inflow drainage orifices were visualized within left ventricle under TEE *(Fig. 2)*, The most proximal drainage orifice was located immediately above aortic valve *(Fig. 3)* After adequate positioning of the inflow and outflow ports (aortic arch area) *(Fig. 4)* was confirmed, MCS was initiated successfully. Adequate biventricular function on central ECMO via the Spectrum® cannula (Spectrum Medical, South Carolina, United States America) was verified on TEE and the CPB was weaned.

She was now in INTERMACS 1 on central VA Apical ECMO *(Fig. 5) (Fig. 6)*. After eight days, LVAD Heartmate 3® (Abbot, Illinois, United States America) was implanted, complicated by right ventricular failure and acute kidney injury, she required two days later a Protekduo® (Cardiac Assist, LivaNova, London, United Kingdom) as "oxy-right ventricular assist device", and decannulated for improvement nine days later. For the acute kidney injury she was on hemodialysis, with renal recovery. She has been stable, without complications related to the LVAD, now as a bridge to decision, according with her evolution, bridge to transplant can be the next step.

COMMENT

This case report introduces a novel, minimally invasive surgical technique for central VA-ECMO, using the apical placement of a Spectrum cannula (Spectrum Medical) via a left thoracotomy. This approach successfully served as a bridge to a durable implantable LVAD in a patient for whom conventional temporary mechanical circulatory support devices, such as the Impella® platform or peripheral VA-ECMO, were not viable.

MCS is used in the treatment of cardiogenic shock in order to improve hemodynamics when initial therapy has failed to achieve adequate tissue perfusion.[4] Cannulation for VA-ECMO can be done either peripherally, with venous drainage from the femoral or internal jugular vein and

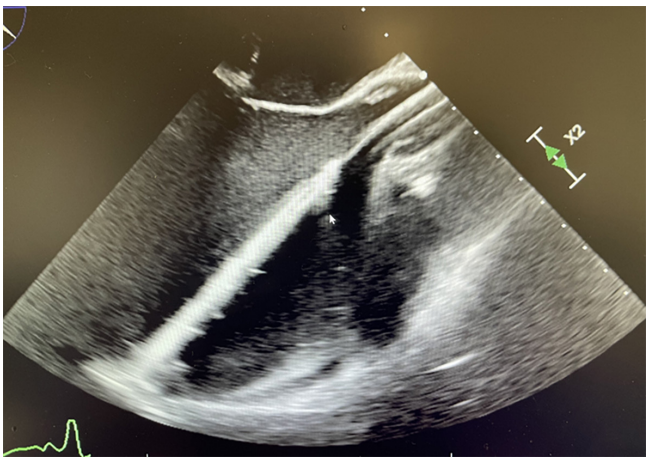

Figure 2: Spectrum cannula with the aortic valve open, showing drainage orifices located beneath the valve.

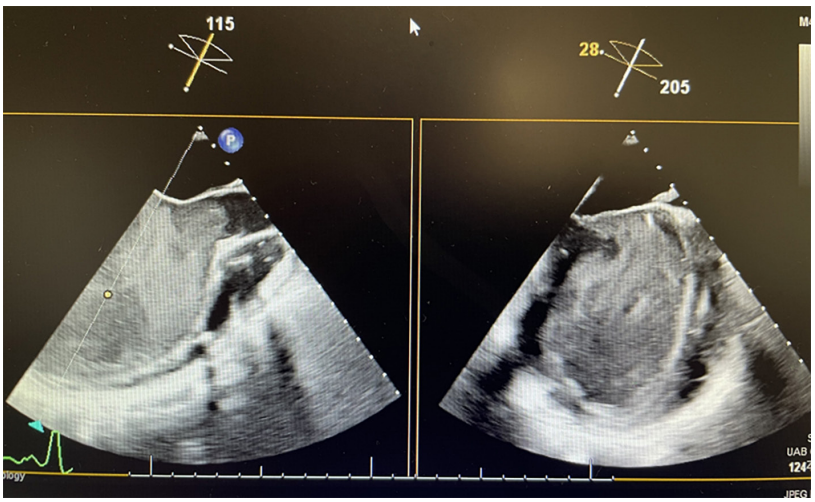

Figure 1:

Pronounced stasis on left ventricle with imminent thrombus formation.

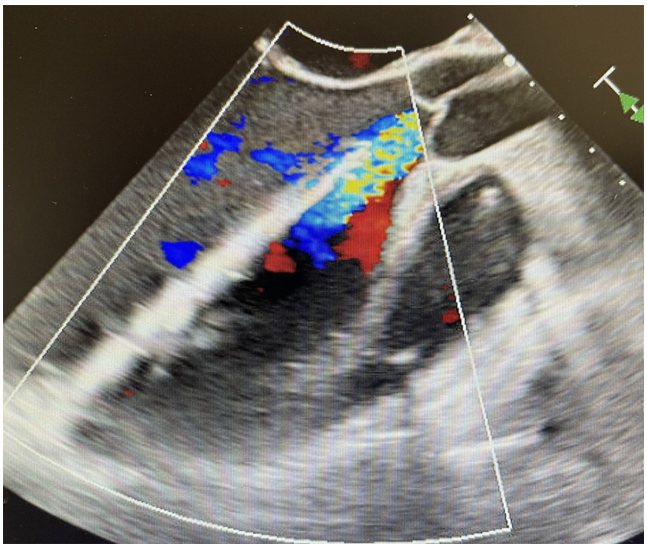

Figure 3: Doppler color imaging of drainage orifices beneath the aortic valve.

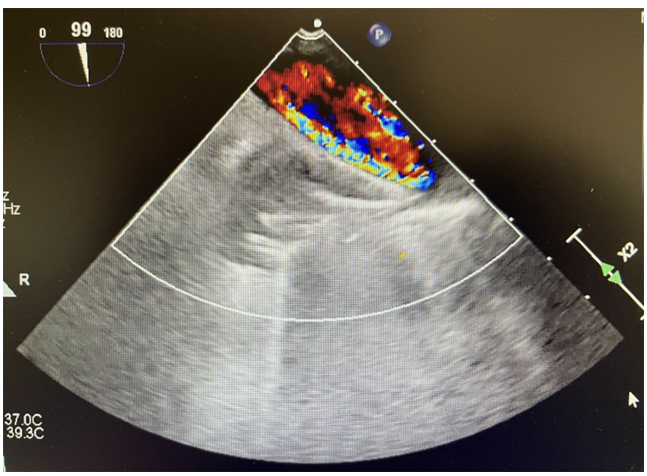

Figure 4: Doppler color imaging of distal delivery orifices in the aortic arch.

arterial return access through the femoral or axillary artery, or centrally, with direct cannulation of the aorta and the right atrium.[5,6] Central cannulation allows for antegrade arterial return and can be used when adequate flow cannot be achieved via peripheral cannulation, but it must be performed surgically, and is usually done through median sternotomy.[7] However, minimally invasive techniques, such as transapical placement under the guidance of TEE, have been described for central cannulation using devices such as the ProtekDuo® (Cardiac Assist, LivaNova, London, United Kingdom).[8-10] Additionally, the use of transapical dual-lumen cannula may be associated with decreased hemolysis, improved mobility, and earlier freedom from mechanical ventilatory support.[11] This technique has been used successfully as a bridge to durable implantable LVAD placement as well as a bridge to recovery.[12,13] Other short-term mechanical circulatory support devices include IABPs, as well as intravascular microaxial left ventricular assist devices, such as Impella® platform devices.[14,15] However, IABPs and Impella® both require access via either the axillary or the femoral artery. Our case describes the successful minimally invasive placement and use of a Spectrum® cannula (Spectrum Medical, South Carolina, United States America) for central VA-ECMO in a patient who did not have adequate access, as a bridge to LVAD, after which the patient achieved cardiac recovery.

Capelli published the largest case series to date documenting the safety and efficacy of transapical VA-ECMO cannulation with the ProtekDuo cannula® (Cardiac Assist, LivaNova, London, United Kingdom). Our surgical technique followed the same steps and principles.[8] As the ProtekDuo cannula® (Cardiac Assist, LivaNova, London, United Kingdom), the Spectrum® cannula (Spectrum Medical, South Carolina, United States America) was designed for Right ventricular Support. However, it introduces an important modification, this cannula is designed with an additional set of orifices to ensure more complete and more effective right ventricular decompression. This is particularly relevant given that the ProtekDuo cannula® (Cardiac Assist, LivaNova, London, United Kingdom) is no longer available, making our technique a critical alternative for managing complex cases. Some multiples reports showed the use of the spectrum® cannula (Spectrum Medical, South Carolina, United States America) as Right Ventricular Support.[16-18]

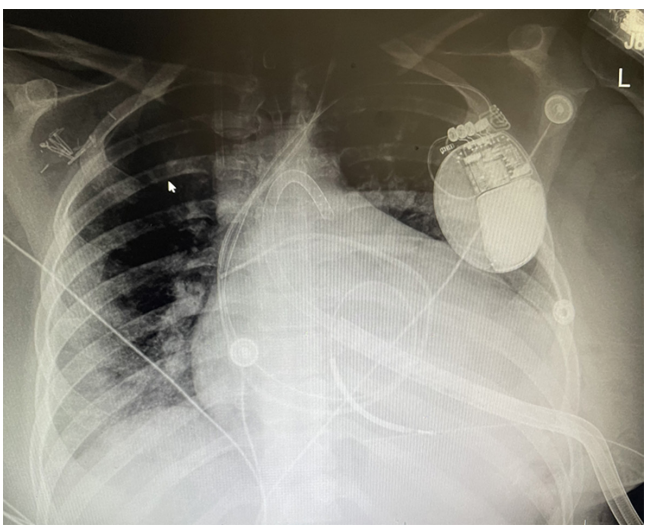

Figure 5: Postoperative chest X-ray.

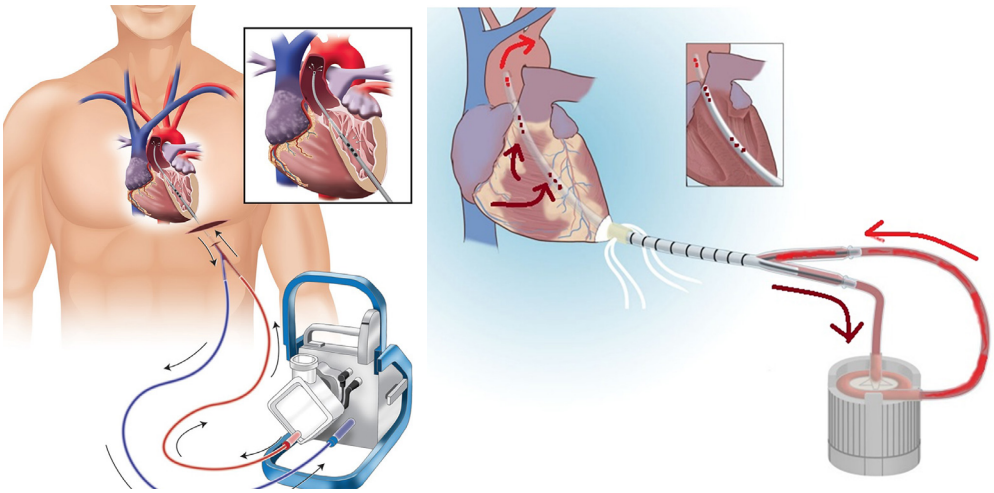

Figure 6:

Diagram illustrating the fundamental operation of central extracorporeal membrane oxygenation using the apical dual lumen spectrum cannula.

However, the apical technique provides Left ventricular decompression with optional biventricular support and respiratory support. The successful application of this method allowed the patient to be supported for approximately one week, a timeframe that allowed for clinical stabilization and decision-making regarding destination therapy. This highlights the viability of this minimally invasive central VA-ECMO approach as a durable bridge to either recovery or long-term mechanical support. Furthermore, the technique avoids the risk of aortic insufficiency and intravascular hemolysis often associated with other support devices. By facilitating ambulation and early freedom from mechanical ventilation, it may also contribute to improved patient outcomes and quality of life. To our knowledge, this represents the first reported case of using a Spectrum® cannula (Spectrum Medical, South Carolina, United States America) for minimally invasive central VA-ECMO as a bridge to a durable mechanical circulatory support device. This technique should be considered in the therapeutic repertoire of temporary circulatory support strategies, especially in situations where other methods are not feasible due to unfavorable anatomy, inadequate flow, or significant hemolysis. In complex and seemingly intractable clinical scenarios. *"*Alea iacta est*"*, this quote by Julius Caesar describes the moment when an irrevocable decision is made and a point of no return is crossed, implying that there is no turning back and one must face whatever comes next. However, this approach offers a viable and effective solution.

CONCLUSIONS

This novel central cannulation technique using an apical placement of a Spectrum cannula for VA-ECMO provides LV decompression with optional biventricular support and respiratory support to facilitate ambulation while avoiding many of the risks of traditional cannulation, this unique case was bridge to LVAD, however, bridge to decision, transplant or recovery are some potential therapeutic goals. It has been demonstrated that this technique with ProtekDuo cannula was used safely when there is not any other option for MCS. Further rigorous studies are warranted to continue documenting outcomes using this novel Spectrum cannula before its use can become widespread.

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