Femoral Veno-Arterial Extracorporeal Membrane Oxygenation using a novel bi-atrial cannula for venous dranaige and left ventricular venting

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Abstract

Extracorporeal life support (ECLS) is an expanding technology for patients in cardiogenic shock. Most patients requiring ECLS can be managed with percutaneous veno-arterial (VA) femoral cannulation. Despite sufficient extracorporeal circulatory support, an unclear number of patients develop left ventricular distension which can result in increased wall tension and stress as well as worsening pulmonary edema. Indications to vent the left ventricle can be controversial. When venting is indicated a number of additional procedures may be considered including inotropic support, intra-aortic balloon pump, Impella, balloon atrial septostomy, or placement of a transseptal cannula. We present a unique case of a femoral VA Extracorporeal membrane oxygenation (ECMO) as bridge to transplant (BTT) with left-sided venting using a Bio-medicus NextGen cannula (Medtronic) with a transseptal approach.

Introduction

Extracorporeal membrane oxygenation (ECMO) has revolutionized the treatment of severe cardiac and respiratory failure. The use of ECMO as bridge to transplantation (BTT) is increasing (1), and heart transplantation today remains as the gold standard for end-stage heart failure refractory to medical treatment. Although the number of patients with ECMO as BTT is small, it may increase with the changes to the heart allocation system (2). Left ventricular (LV) venting strategies to avoid events related to LV distention are an essential component of peripheral veno-arterial ECMO. We present a case of femoral ECMO as BTT using the Bio-medicus NextGen cannula (Medtronic) for simultaneous drainage and LV venting.

Case Report

A 53-year-old male with heart failure secondary to ischemic cardiomyopathy and mitral regurgitation underwent CABG and mitral valve repair 3 years prior to presentation with improvement in symptoms. He subsequently developed cardiac arrest requiring dual-chamber ICD placement. He did well for 6 months, until he presented with increased edema and decreased functional capacity. Echocardiography revealed an LV ejection fraction of 15%. Coronary angiography revealed patent bypass grafts without new focal lesions. Right heart catheterization revealed elevated filling pressures and a depressed cardiac index. He was started on intravenous inotropes and an intraaortic balloon pump was placed, however, his hemodynamic status continued to decline. The decision was made to increase level of support to VA ECMO as bridge to transplant (BTT). We decided to use a Bio-medicus NextGen multi-stage cannula for left atrial (LA) VA ECMO in order to obtain left-sided venting and venous drainage simultaneously. Using ultrasound guidance and a micropuncture technique, a right common femoral arterial access was obtained and a 6 French sheath was placed. Right femoral angiography demonstrated a suitable vessel for large-bore access and mapped the

superficial femoral artery (SFA) for placement of the antegrade sheath. The access to the SFA was then obtained and a 6 French x 24 cm braided arrow sheath was inserted for antegrade perfusion. The right femoral venous access was obtained using ultrasound guidance and a micropuncture technique and a 7 French sheath was placed. The patient was heparinized to achieve an activated clotting time (ACT) greater than 300 seconds. Next, an SL-1 sheath and BRK needle were used to perform transseptal puncture under real-time transesophageal echocardiographic guidance. The SL-1 sheath was removed and a ProTrack wire (Baylis; Mississauga, ON, Canada) was advanced into the LA. Next, the atrial septostomy was performed using a 6 mm x 40 mm peripheral balloon. Then, the venous tract was serially dilated and a 23 French Bio-medicus NextGen cannula multistage was inserted with 4 cm of its tip in the LA, leaving the first set of ports inside of the LA for LV venting, and the second set of ports in the inferior vena cava (IVC) for venous drainage; followed with a 17 French arterial cannula placed in the right common femoral artery and the patient was initiated on LA-VA ECMO. The arterial return cannula was connected to the antegrade perfusion sheath to provide flow to the right lower extremity. The patient remained stable after the procedure, without signs of LV distension and no complications. A suitable donor was available 3 days later, and he underwent a successful heart transplantation.

Discussion

In the past 10 years, the number of ECMO cases has increased, especially in the adult population (1). Undoubtedly, ECMO is a real revolution in the treatment of cardiac and respiratory failure, and its role is continuously evolving. ECMO as BTT is increasing (2).

Veno-arterial (VA) ECMO is used for cardiogenic shock from various causes that include acute myocardial infarction, myocarditis, acute decompensated heart failure, pulmonary embolism, post-cardiotomy cardiogenic shock, early or acute graft dysfunction, and refractory cardiac arrest. It can be used as a bridge to recovery, heart transplantation, or more durable mechanical circulatory support. There has been rapid growth of ECMO as a rescue therapy in the setting of acute cardiac failure, although the number of patients bridged to heart transplantation is small (3), it may increase with the implementation of changes to the adult heart allocation system (1,3).

Left ventricular distention can develop rapidly after peripheral VA-ECMO initiation, given the corresponding elevation in LV afterload which can lead to worsening LV end-diastolic volume and pressure. These condition changes can lead to reductions in transmural myocardial perfusion and impairs myocardial recovery and function. Resulting pulmonary hypertension and pulmonary edema diminishes the likelihood of ECMO weaning. In order to maximize the likelihood of cardiac recovery, some authors recommend LV decompression during VA-ECMO (4). The indication to vent the LV remains controversial. Generally, venting is utilized in cases of pulmonary edema, ventricular distension secondary to high afterload and inadequate venous drainage as well as with hearts without obvious ejection and a closed aortic valve or a significant aortic valve regurgitation (5).

Strategies to decompress the left ventricle include Impella, balloon atrial septostomy (with or without atrial stenting), a separate transseptal LA cannula (ie. Tandem Heart), transaortic cannula from the left subclavian, a cannula in the pulmonary artery and direct percutaneous apical LV venting (4). Furthermore, LA-VA ECMO has been described in which a single, multi-stage cannula is used to vent both atria (6). Dulnuan reported 3 patients using this technique with effective decompression of the LA with improvement of pulmonary edema (7).

To our knowledge, this is the first case in the literature to specifically describe the use of the NextGen cannula (Fig.1) for LA-VA ECMO. This cannula was originally designed for minimal invasive mitral surgery in which the conformation of the holes made it ideal for draining both atria. However, its design also makes it ideal for LA-VA ECMO. Inserted via a conventional transseptal approach, the first set of holes reside in the LA, while the second set terminate in the IVC (Fig. 2), allowing an effective venous drainage and left-side venting with just one cannula.

Conclusions

Most patients requiring VA-ECMO for cardiogenic shock can be managed initially with femoral VA ECMO. In cases that develop LV distension, a left-side venting procedure should be performed. The use of a transseptal NextGen cannula allows venous drainage and LV venting simultaneously, avoiding the use of an additional device and their respective complications.

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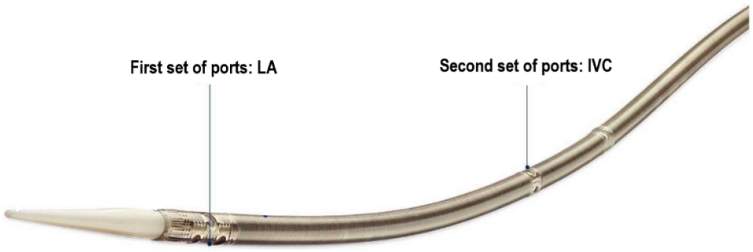

Fig.1: Bio-medicus NextGen (Medtronic) Multistage venous cannula.

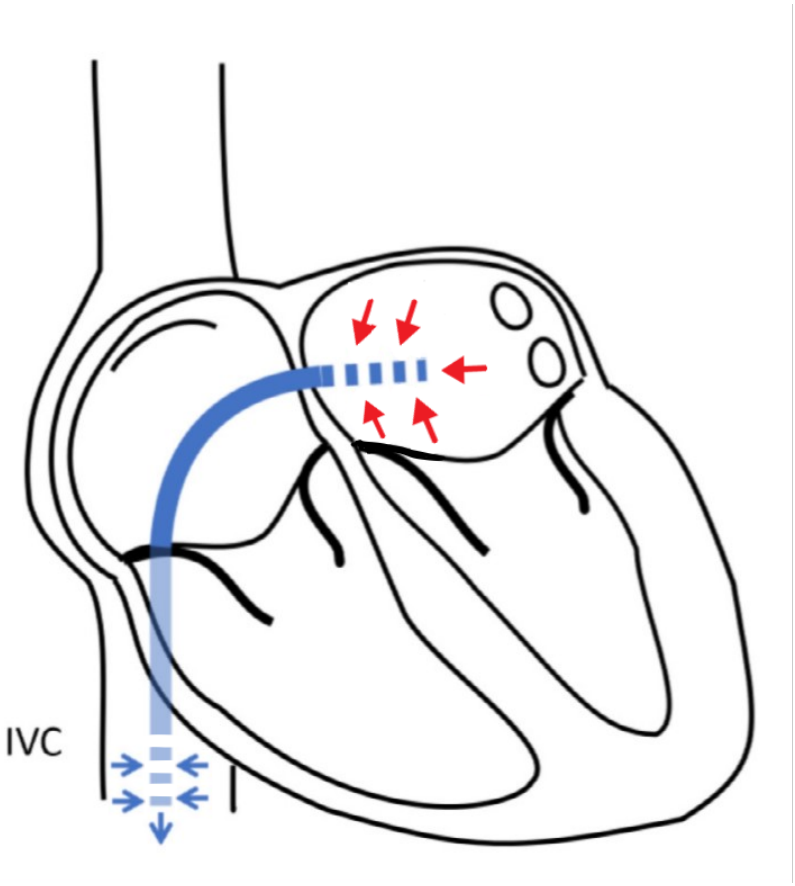

Fig.2: Bio-medicus NextGen (Medtronic) cannula with proximal ports in the LA for left-side venting and distal ports in inferior vena cava for venous drainage.