

How-to-do-it

Insertion of Bicaval Dual Lumen Extracorporeal Membrane Oxygenation Catheter with Image Guidance

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Correct placement of the Avalon Elite Bicaval Dual Lumen catheter (Avalon Laboratories, LLC, CA) for single-site venovenous extracorporeal membrane oxygenation (VV ECMO) is safe using image guidance. Using this technique, 26 of 27 patients (96%) had uneventful placement of the cannula in the right internal jugular vein. One patient had a superior vena cava injury during serial dilation, and another patient required cannula repositioning for improved flows. We recommend using both fluoroscopy and transesophageal echocardiogram (TEE) for training purposes or during initial use of the Avalon Elite. As proficiency improves, TEE at the bedside provides an excellent standard of care. Double-lumen ECMO catheters can be effectively placed under image guidance with minimal need for repositioning. ASAIO Journal 2011; 57:203–205.

Extracorporeal membrane oxygenation (ECMO) is used in adults for severe pulmonary or cardiopulmonary failure. For patients with purely pulmonary processes, it is possible to use venovenous ECMO (VV ECMO) and avoid the ischemic and neurologic side effects sometimes associated with venoarterial ECMO.¹ There are two common configurations of VV ECMO: single-site cannulation of the right internal jugular (RIJ) vein and the more common two-site cannulation, involving the femoral and internal jugular veins.

Zwischenberger and coworkers described the first double-lumen (DL) catheter large enough to accommodate the high flows required for adult ECMO patients. The Wang-Zwischen DL cannula was shown to be feasible in large animals with sustained flows of 2.1 L/min.² One lumen drains deoxygenated blood from the superior and inferior vena cava (SVC and IVC) by openings in the proximal and distal catheter, respectively, whereas the second lumen delivers oxygenated blood to the right atrium (RA).

Using this technology, Avalon Laboratories developed the first Food and Drug Administration-approved DL catheter designed for adult ECMO supporting up to 6 L/min.³ The Avalon Elite BiCaval Dual Lumen catheter (Avalon Laboratories, LLC, CA) reduces the recirculation seen with the traditional VV setup by directing oxygenated blood across the tricuspid valve (TV)² (Figure 1). With these improvements, single-site VV ECMO cannulation has increased in popularity.⁴ We report our approach for percutaneous insertion of the Avalon Elite catheter by the RIJ for VV ECMO.

Technique

Our protocol for percutaneous insertion of the Avalon Elite catheter evolved as we gained experience. The right neck and chest are prepped aseptically, and prophylactic antibiotics are administered. A transesophageal echocardiogram (TEE) and fluoroscopy are performed. The use of both imaging modalities confirms proper cannula placement and correct orientation of the ports.

The RIJ is accessed in a standard fashion through a posterior approach that is slightly higher on the neck. This allows for a better angle and transition from the RIJ to the SVC, which facilitates placement of a large dilator and the 31 Fr catheter (Figure 2). The guidewire is advanced after venous return is confirmed. Correct positioning of the guidewire in the IVC is confirmed by TEE and fluoroscopy. Heparin is given, and an incision is made to accommodate the cannula. The dissection is sharply carried through the subcutaneous tissue to the level of the RIJ. Serial dilation is completed with a standard dilator kit. In the adult population, we typically select 23 Fr, 27 Fr, or 31 Fr sized cannulae depending on the patient's physiologic needs.

The cannula is inserted under image guidance with its tip confirmed to be in the IVC (Figure 3). The cannula ports are deaired, attached to the ECMO circuit, and flow is started. TEE is used to confirm that the outflow port is in the RA and oriented toward the TV. The proximal and distal inflow ports must be located in the SVC and IVC, respectively. Care must be taken to avoid passage of the distal catheter into a hepatic vein. Correct port positioning is essential to effective Avalon catheter insertion. Incorrect orientation of the internal port openings for either the inflow or outflow ports may lead to inadequate flows or recirculation.

The cannula is secured to the skin with 2-0 braided polyester sutures. A chlorhexidine impregnated sterile dressing is placed over the insertion sight.

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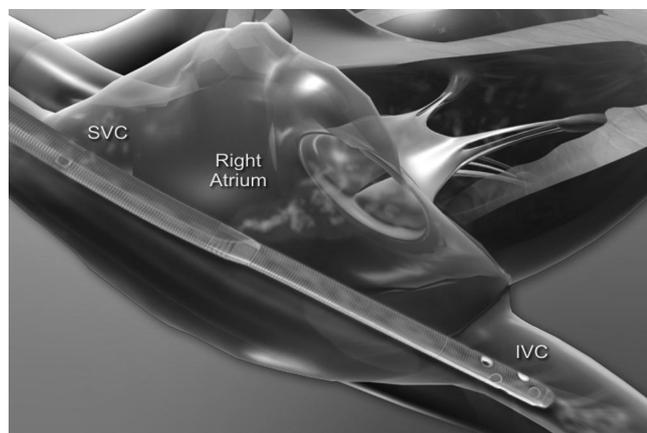


Figure 1. The Avalon Elite double-lumen cannula has drainage ports in the SVC and IVC and an inflow port in the right atrium facing the tricuspid valve. SVC, superior vena cava; IVC, inferior vena cava.

Results

We have placed 27 Avalon cannulae with the only significant injury occurring during the first catheter placement by a junior operator. Since then, the experienced staff have not had difficulty with catheter insertion. One cannula was incorrectly oriented and required reorienting at the bedside. No cannulae were inadvertently dislodged. Full flows and adequate gas exchange were documented in all patients (means of 4.25–5.5 L/min for the 27 and 31 Fr catheters).

Discussion

As the use of ECMO for adult pulmonary failure grows, ECMO centers are increasingly using DL cannulae for VV ECMO.⁵ For isolated pulmonary diseases, the traditional two-site VV ECMO is an option limited by recirculation, inadequate venous drainage, and inefficient gas exchange.⁶ Pediatric DL catheters have been available for nearly 20 years, but their applications are limited in adults due to inadequate flows and

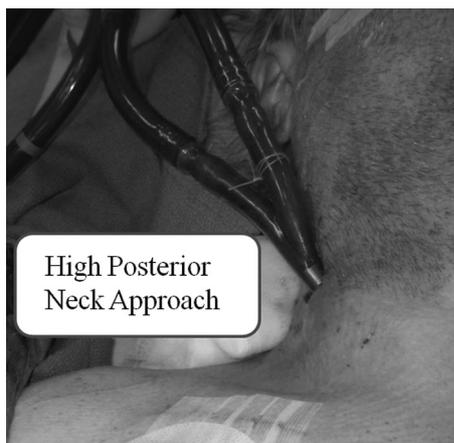


Figure 2. The catheter is inserted using a posterior approach to the neck.

persistent recirculation.^{7,8} Recirculation occurs when a portion of the oxygenated blood being infused from the ECMO circuit immediately is drained without first being circulated systematically.

Okamoto *et al.*¹ developed a 15 Fr double-balloon, DL cannula and were able to show its effectiveness in dogs with maximum flows of 40 ml/kg (2.4 L in a 60 kg person); however, the size of the catheter limited its use to children. Wang and Zwischenberger developed an improved DL cannula for VV ECMO. Marketed as the Avalon Elite Bi-Caval Dual Lumen catheter, the device is the first of its kind to offer a platform for single-site VV ECMO in the adult population. This catheter is used frequently in our patients with acute respiratory distress syndrome. We have always achieved adequate physiologic gas exchange and have not needed to add an additional venous cannula for VV ECMO.

The advantages of the single-site VV ECMO include freeing the femoral vein, which facilitates patient participation in physical therapy or preserves it as another access point. If extubated on ECMO, the patient can be more easily mobilized. In addition, by not cannulating the femoral vein and using one site for central access, there is one less site for infection and a reduction in nursing care. It also decreases chances for accidental dislodgement.

Potential Complications and Risk-Reducing Strategies

As with any surgical procedure, there is risk for complications. These risks are generic to central line placement in the right neck including inadvertent carotid artery injury and pneumothorax. This has not occurred in our experience with ECMO cannulation, but the risks could be minimized by using ultrasound guidance if the anatomy is challenging. The operator should be experienced in central line placement before attempting this procedure. We minimize risk of infection through meticulous sterile technique, routine cleaning of the insertion site, and regular sterile dressing changes.

Bleeding at the cannulae site usually responds to holding pressure. If this is insufficient, then a carefully placed suture should achieve hemostasis.

Potential complications unique to the Avalon Elite cannula include incorrect port orientation. For optimal results, the Avalon Elite's inflow ports must be positioned in the IVC and SVC, with the infusion port oriented toward the TV. TEE and fluoroscopy demonstratively facilitate cannula positioning.

During our first cannula placement, the proximal SVC was damaged by the dilator, which required repair. Real-time image guidance allowed this to be immediately diagnosed, and conducting the procedure in the operating room with an experienced thoracic surgeon allowed for easy repair. The vena cava can be damaged at several points during catheter placement. Blind insertion of wire can damage the hepatic veins, coronary sinus, or the IVC, but this risk is minimized by placing the wire under image guidance. If the wire kinks or coils, a stiffer wire can be used before reattempting the procedure. The wire can coil in the RA if the cannula and wire are advanced together. This has the potential to perforate the heart but is easily avoided with routine guidewire skills. With image

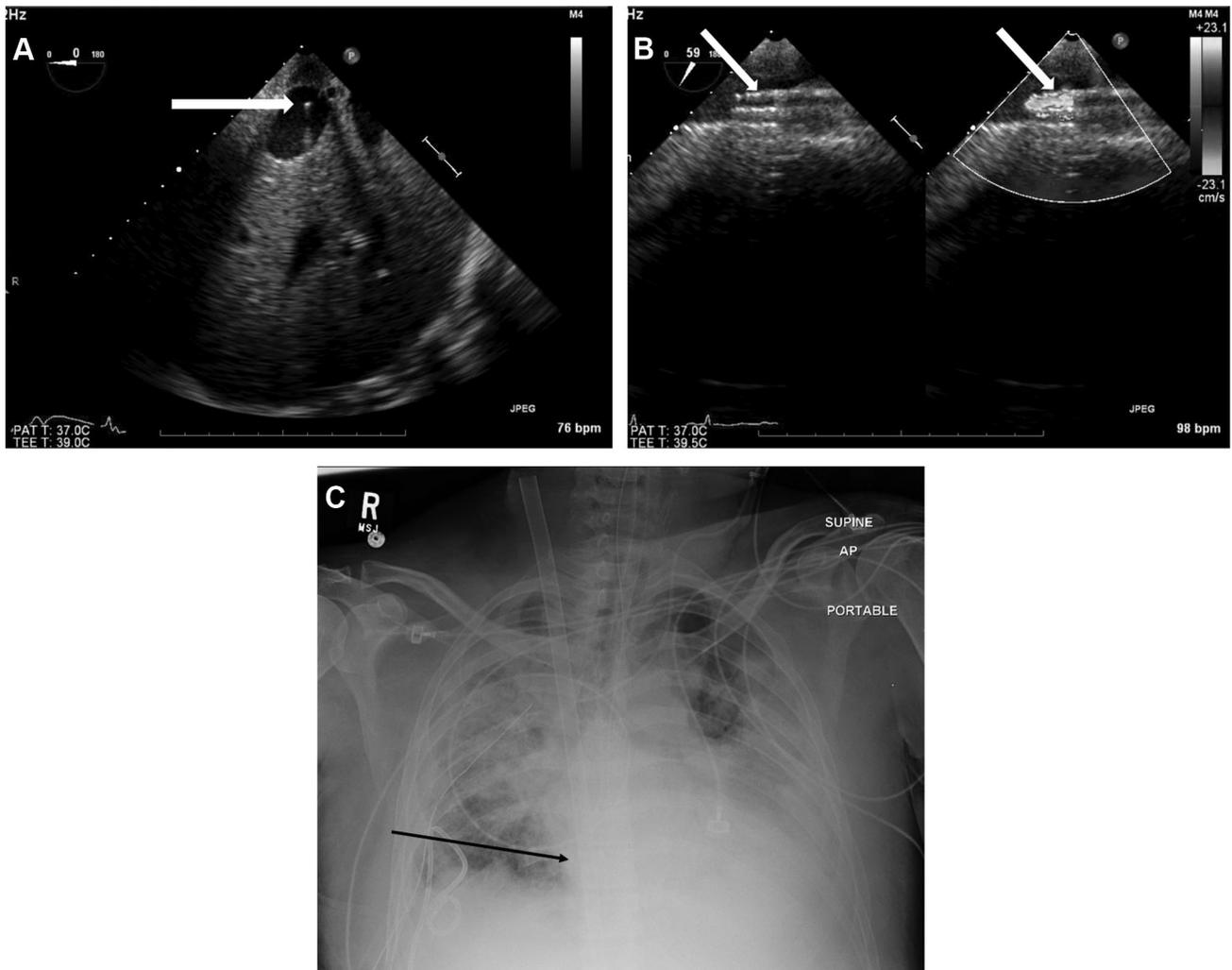


Figure 3. A–C: The wire or catheter tip in the IVC on TEE and CXR. IVC, inferior vena cava; TEE, transesophageal echocardiogram; CXR, chest x-ray.

guidance, DL cannulation for VV ECMO is safe and reproducible with minimal risk to the patient.

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