Operative Techniques in
Thoracic and
Cardiovascular Surgery

Ambulatory Extracorporeal Membrane Oxygenation

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Introduction

The rationale for ambulatory extracorporeal membrane oxygenation (ECMO) is simple:

(1) Upright patients who are ambulatory and socially interactive provide the most effective vehicle for clinical recovery or subsequent bridge to transplant.
(2) No lung disease or pulmonary injury benefits from paralysis, sedation, and intubation with nonphysiological positive pressure ventilation.

The objective data for these simple observations are well established and include the traditional morbidities of ventilator-associated pneumonias, barotrauma as a consequence of positive pressure ventilation, the requirements of sedation and paralytics to facilitate permissive hypercapnea as a strategy to limit barotrauma, and the profound deconditioning of both respiratory and skeletal muscle because of "ventilated, bed-bound" care.

Although the use of *ambulatory ECMO* is an extension of traditional extracorporeal technologies, it is more "goal directed" and dynamic. The multiple cannulation strategies common to ambulatory ECMO are designed to facilitate an extubated and ambulatory patient. It is neither new nor novel and is analogous to the ventricular assist technologies common to patients with acute cardiogenic shock and congestive heart failure. Early deployment of technology to resuscitate the sick patient rather than reanimate the moribund is *always* the goal of extracorporeal support technologies. Nonetheless, the "peripheral" hybrid technologies of venovenoarterial ECMO and the application of "central" cannulation with "oxyRVADs" (right ventricular assist device with an in-line oxygenator) can salvage the sickest patients with medically refractory end-stage lung disease to ambulatory status.

The following description of cannulation strategies is "goal directed" and "case specific." Each is designed to support ambulatory patients with distinct clinical needs. Hypercapnea, hypoxia, or cardiopulmonary collapse as a consequence of *cor pulmonale* require different strategies of initial ECMO deployment. The described techniques are not exhaustive. Any cannulation strategy that delivers an adequate cardiac output with adequate gas exchange in an ambulatory patient is effective. Clinical need determines cannulation strategy. "Thought algorithms" regarding the *application of ECMO*—why are you doing this and what do you hope to accomplish—and the *deployment of ECMO*—how do we do it and when do we try—are useful in establishing conceptual ground rules for device deployment.

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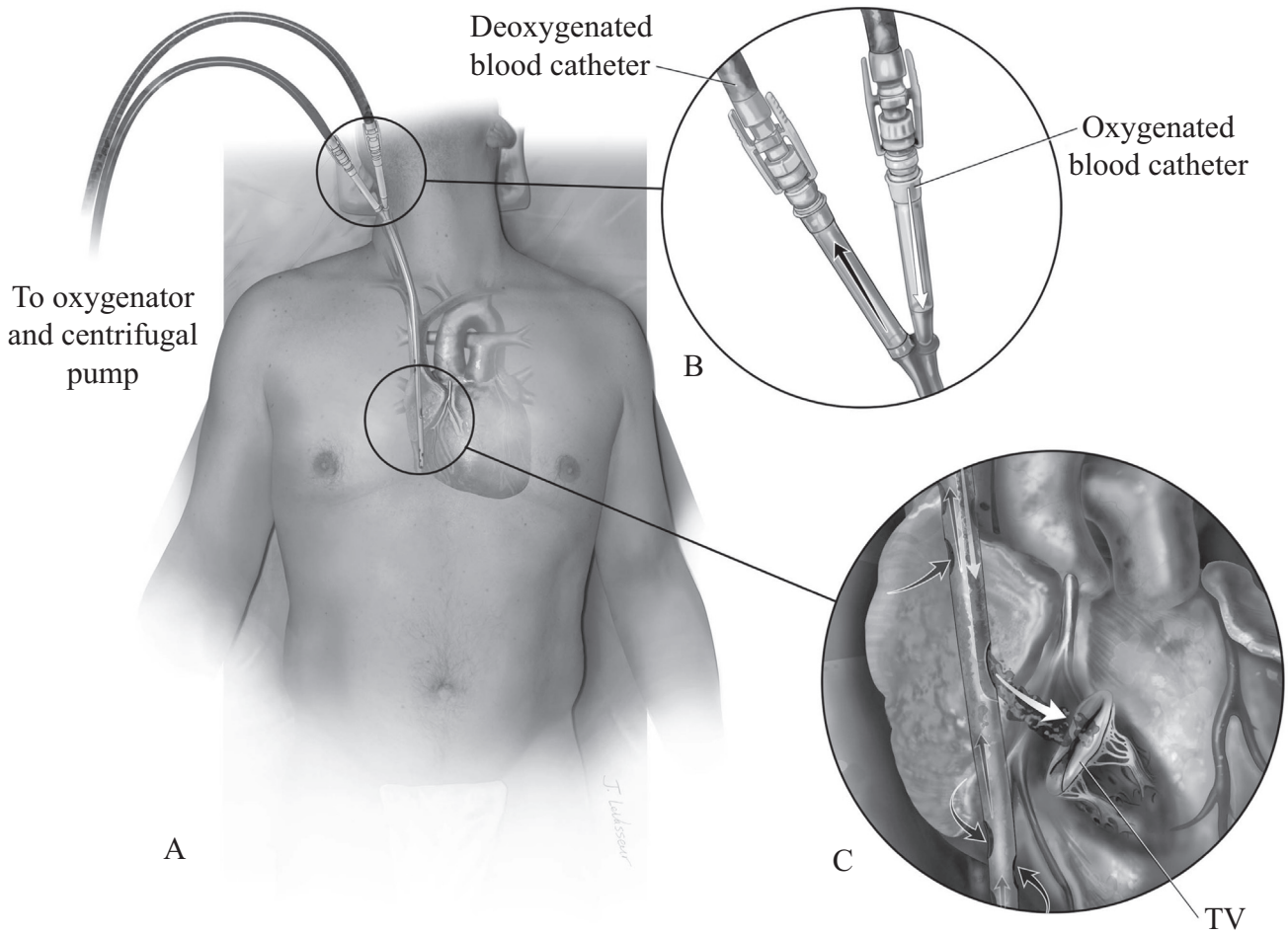

Figure 1 Percutaneous dual-lumen cannulation (DLC) for venovenous (VV) ECMO. The Avalon Elite Bi-Caval Dual Lumen Catheter (Maquet) is positional and requires interventional deployment with transesophageal echocardiography or fluoroscopy or both. Distinct venous inflow from both IVC and SVC and directional outflow across the tricuspid valve limit mixing of preoxygenator and postoxygenator blood and improve efficacy to facilitate ambulation. The cannula can be deployed via internal jugular or left subclavian veins. In patients with suprasystemic pulmonary artery pressures, combined DLC VV ECMO and atrial septostomy can provide hemodynamic support of the ambulatory patient without central cannulation.[2] We routinely use the 27-Fr dual-lumen venovenous cannula (adult cannula are 31 cm in length and vary in diameter from 20-31 Fr). Pediatric cannula (13-19 Fr) can provide effective extracorporeal carbon dioxide removal as an integrated tool with mechanical ventilation. IVC = inferior vena cava, SVC = superior vena cava.