



## **ECMO and the Standardization of Lung Transplantation**

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- Lung transplantation is considered the gold standard therapy for end-stage pulmonary disease.
- THE fastest growing solid organ transplant
  - 56.4% from 2007 → 2014
  - 13.2% from 2015 → 2016
  - 2,345 in 2016 alone
- Waiting list is quickly increasing; donor lungs available does not match the demand.<sup>1-3</sup>
- Acceptance rate for donor lungs: 22%<sup>4,5</sup>
- Contact with external environment makes the lungs more vulnerable to deterioration
- Factors inducing lung injury → precluding suitability:
  - Mechanical ventilation
  - Pulmonary atelectasis
  - Excessive fluid resuscitation
  - The brain death process

### **Historical perspective of extracorporeal membrane oxygenation (ECMO)**

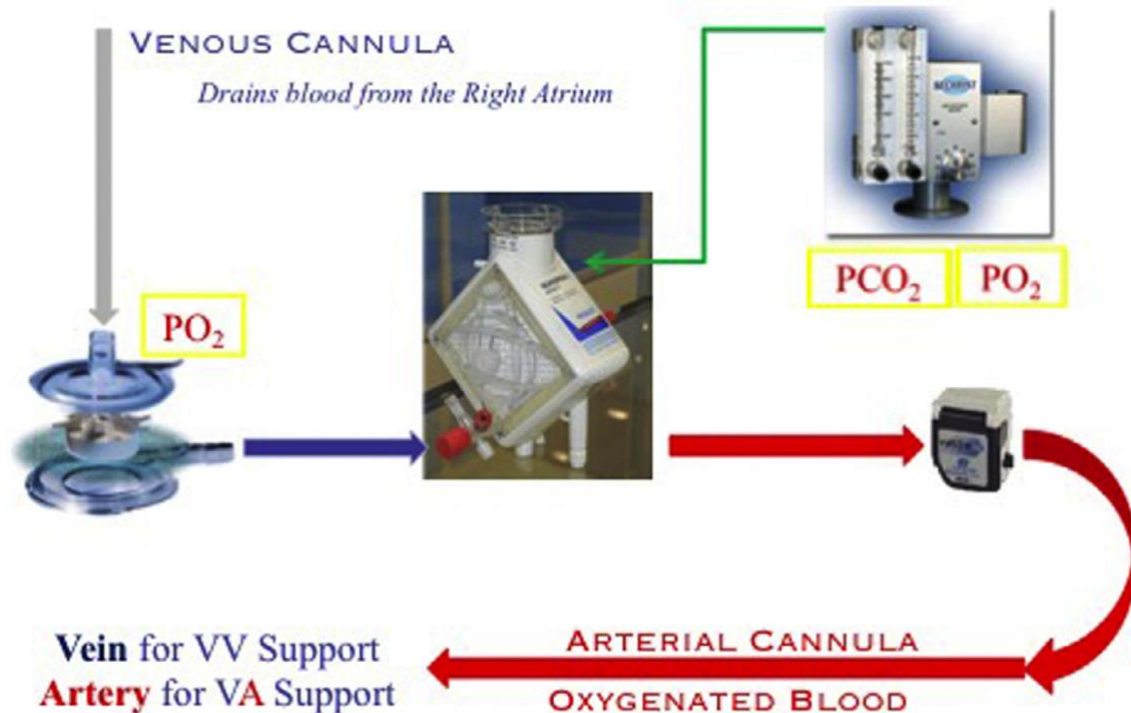
- Historic means to increase availability:
  - Single-lung transplantation
  - Living lobar lung transplantation
  - Marginal or extended criteria donor organs
- Only with modest effect on organ availability.<sup>6</sup>
- The use of ECMO prior to transplantation has extended the survival period for patients with end-stage lung disease during their wait

- Indications and Contraindications<sup>7</sup>:

ECMO indication	ECMO contraindication
Refractory hypoxemia	Ineligibility for lung transplantation
Refractory hypercarbia	Irreversible end multiple-organ damage
Right heart failure	Sepsis and bacteremia
Severe pulmonary hypertension	Not able to systemically anticoagulate
Difficult management of conventional ventilation	Uncontrolled metastatic disease
Lung transplantation candidate	Acute intracerebral hemorrhage or stroke

- Veno-venous ECMO (**VV**-ECMO) is normally required for patients with end-stage lung disease who are unable to oxygenate or remove excess CO<sub>2</sub> in the presence of maximal ventilatory support
- Veno-arterial ECMO (**VA**-ECMO) is used with patients who have elevated pulmonary artery pressure and/or cardiac dysfunction<sup>7</sup> (Figure 1).
- The increased use of ECMO as a bridge to lung transplantation has led to a significant improvement in the 1-year survival rate and has reduced intensive care unit detrimental complications.<sup>8</sup>
- Bleeding is a major complication with ECMO
  - Labs checked every 4 hours
  - Activated clotting time range: 160 - 200 seconds.<sup>7,9</sup>

Figure 1. Schematic diagram of ECMO machine



## **Lung transplantation and Advantages of ECMO**

- Most common complication of lung transplantation: primary graft failure
  - Highly related to prolonged ischemic-reperfusion injury
- Balance between transplantation surgical time and graft ischemic time essential to ensure overall long-term outcome of lung transplantation.<sup>10</sup>
- Cardiopulmonary bypass (CPB) was the standard modality during complicated lung transplantation
- Hypothetical benefits of providing controlled low-pressure reperfusion have been challenged
  - Inflammatory response → coagulopathy, cytokine release, complement activation → end-organ damage
- Use of CPB has recently been cited as an independent risk factor associated with primary graft failure.<sup>11</sup>
- ECMO has demonstrated significant advantages over CPB for both intraoperative and early post-transplantation outcomes (Figure 2)
- In comparison to CPB, ECMO-supported lung transplantations have:
  - less mortality in 90 days
  - Fewer blood product transfusions.<sup>11</sup>
- ECMO support relieves stress on the right heart from refractory hypoxemia, refractory hypercarbia, and acidosis (which all increase pulmonary vascular resistance)
- Also allows early low-pressure, low-inspired oxygen (low FiO<sub>2</sub>) ventilation to the transplanted organ
- Avoiding ischemic-reperfusion injury<sup>9</sup> (Figures 3 and 4).

## **Fluid management on ECMO**

- Restrictive fluid administration was previously thought to reduce the incidence of postoperative lung injury or primary graft dysfunction.<sup>9</sup>
- Liberal fluid management now necessary to maintain adequate ECMO flow
- A balance of crystalloid vs colloid fluid administration is necessary to avoid excessive alveolar capillary leaking and thus primary graft dysfunction
  - Due to the ligation of the lymphatic system
- Transesophageal echocardiography can provide invaluable information for guiding appropriate fluid management, titrating vasoactive agents, and providing inotropic support during transplantation
- The literature has shown that a routine diuretic is not necessary, however, mannitol can be used as an oxygen free-radical scavenger and can provide an osmotic diuretic effect.<sup>12</sup>

Figure 3. The advantage of using ECMO to reduce pulmonary vascular resistance and right ventricle failure.

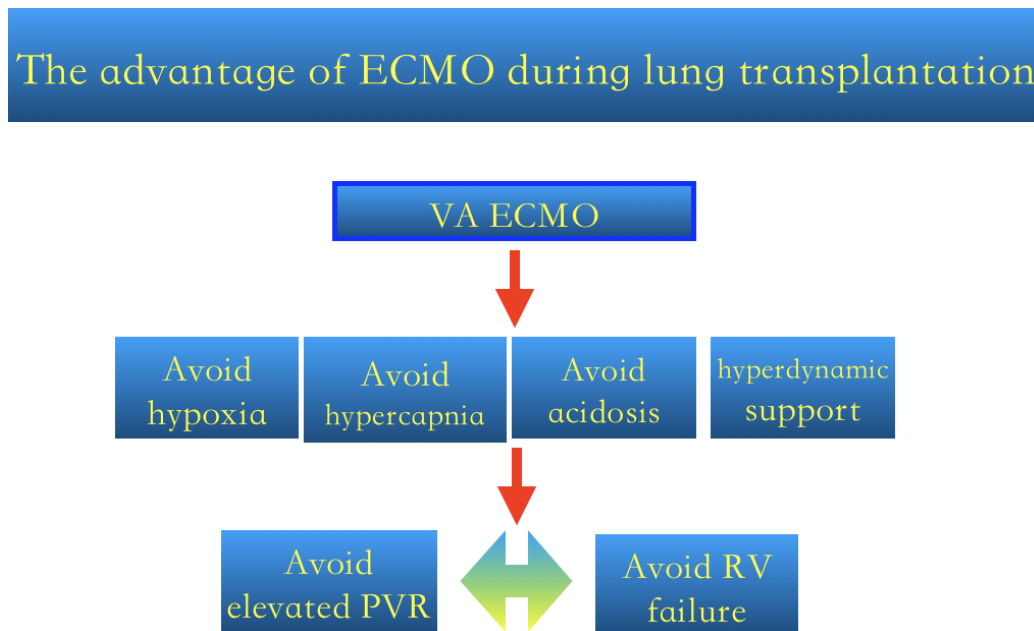
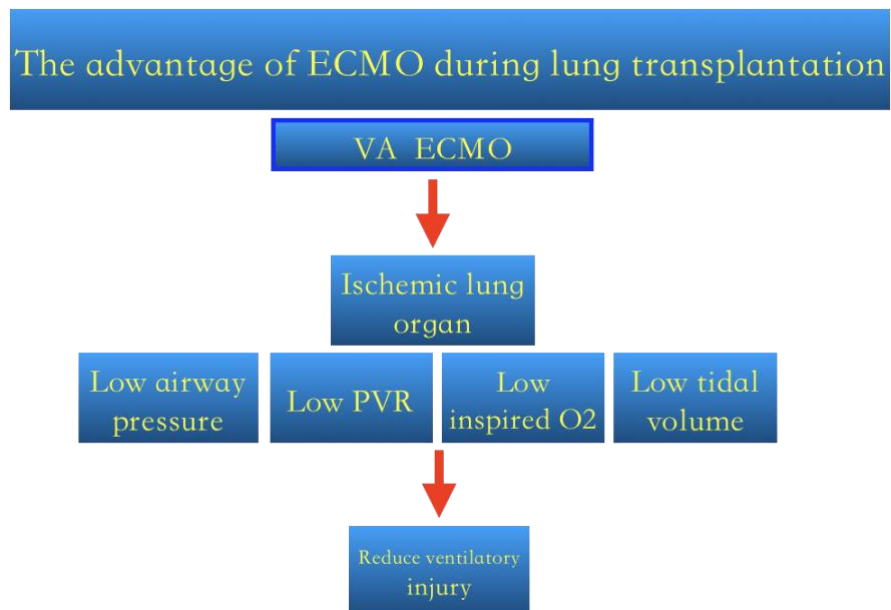


Figure 4. The advantage of using ECMO to reduce ischemic lung injury.



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