



Emerging Trends in Anesthesia for Lung Transplantation

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Lung transplantation is the primary surgical treatment for patients with end-stage lung disease (ESLD). A total of 2,524 lung transplants were performed in the United States in 2021, which represents an increase of 40% during the past 10 years, including 214 patients with COVID-19-associated lung disease (approximately 7% of the total number since the pandemic began) (asamonitor.pub/37XeH3A; *N Engl J Med* 2022;386:1187-8). Recent global data, which are captured by the International Society for Heart and Lung Transplantation (ISHLT) annual registry, note increases in both lung transplantations performed year over year as well as improving perioperative outcomes over time (*J Heart Lung Transplant* 2018;37:1169-83).

Multidisciplinary teams collaborate throughout the entire perioperative process, with anesthesiologists playing a key role from initial selection to postoperative care. Initially, candidates for transplant are stratified using the lung allocation score (LAS; range 0-100) that is based on clinical status and medical testing to estimate the disease severity and surgical risk. The highest LAS identifies which candidate will receive a transplant when a suitable donor lung becomes available. Once listed, preoperative optimization includes maximizing medical therapeutics for underlying ESLD, which may range from medical treatment to the inclusion of bridging mechanical circulatory support.

Perioperative extracorporeal membrane oxygenation therapy

One emerging trend is the increasing utilization of perioperative extracorporeal membrane oxygenation (ECMO) for preoperative bridging, intraoperative cardiopulmonary support, and postoperative prolongation for either primary graft dysfunction (PGD) or biventricular remodeling. Throughout the entire process, the role of the anesthesiologist is vital in the design and implementation of perioperative protocols within echocardiography, anticoagulation, and physiological management. The predominant form of preoperative bridging can be performed with venovenous (VV) ECMO for isolated re-



spiratory failure and has traditionally been utilized in either bi-femoral or femoral/internal jugular configuration. The recent development and widespread application of a new dual-lumen VV ECMO cannula has substantially affected the pre-transplant course of many patients. The cannula is most commonly inserted into the right internal jugular vein and often facilitates extubation and ambulation, two preoperative bridging goals that have been particularly important in patients who have prolonged VV ECMO prior to lung transplantation secondary to COVID-19 (*Mayo Clin Proc Innov Qual Outcomes* March 2022).

Intraoperative venoarterial (VA) ECMO is increasingly used for mechanical circulatory support during lung transplantation in lieu of standard cardiopulmonary bypass (CPB), as the former technique is associated with greater hemodynamic stability, improved peripheral perfusion, mitigation of lung ischemia-reperfusion injury, reduced transfusion requirements, decreased risk of postoperative PGD, and more favorable outcome. As the utilization has increased, novel approaches to intraoperative support have emerged, including the creation of a hybrid VA ECMO/CPB circuit, which allows for a VA ECMO technique at a reduced cost as compared to a standard ECMO circuit while also providing the ability to seamlessly convert to CPB as needed (*ASAIO J* 2020;66:e123-5).

Postoperative deployment of ECMO can arise due to postoperative PGD, which occurs in as many as 30% of lung transplant recipients and remains the most common cause of mortality (*Anesthesiology* 2022;136:482-99; *J Thorac Dis* 2021;13:6618-27). The treatment of this complication initially involves lung-protective mechanical ventilation and administration of inhaled pulmonary

vasodilators, but severe cases often require VV ECMO (*Anesthesiology* 2022;136:482-99). Additionally, a technique that is particular to primary pulmonary hypertension as the presenting ESLD includes prolongation of VA ECMO to allow for biventricular remodeling in the immediate post-implantation period. Thus, a patient may be bridged to transplantation with ambulatory VV ECMO before surgery, undergo VV or VA ECMO intraoperatively, and transition back to VV or VA ECMO during the postoperative period.

International consensus guidelines for anesthetic management

The complex multidisciplinary team approach for patients undergoing lung transplantation requires intensive anesthetic planning and management. Notably, substantial differences in anesthetic management were identified in surveys that evaluated institutional practice patterns for lung transplantation (*J Cardiothorac Vasc Anesth* 2018;32:70-2). In response, an international task force published evidence-based consensus guidelines, based on a comprehensive review of the literature and expert opinion, for the perioperative management of patients undergoing lung transplantation, including patient selection, preoperative assessment, management of the organ donor, intraoperative care, use of transesophageal echocardiography (TEE), and postoperative considerations (*J Heart Lung Transplant* 2021;40:1327-48). Led by Dr. Nandor Marczin at Imperial College London, these guidelines represented the joint efforts of numerous international societies, including the European Association of Cardiothoracic Anaesthesiology and Intensive Care, Society of Cardiovascular Anesthesiologists, and the ISHLT. A multidisciplinary team approach, one in which the cardiac anesthesiologist plays a central role, is now recognized as essential for optimal care and outcome, especially considering the significant co-morbidities with which most of these patients present and the complexity of the surgical procedure itself (*J Cardiothorac Vasc Anesth* 2020;34:1669-80). From our perspective, non-transplant anesthesiologists should also be familiar with the latest principles



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of lung transplant management because these patients sometimes return to the OR for other surgical procedures.

Donor organ supply and anesthetic stewardship

A paucity of donor organ continues to limit the number of patients who receive lung transplants despite a steadily rising demand, as more than 1,000 patients in the U.S. are currently on the transplant waiting list (asamonitor.pub/37XeH3A). As a result of this mismatch, more organs are now accepted for transplant that may not have been used in the past. Several strategies are employed to optimize these organs, including the use of ex vivo lung perfusion (EVLP), which is a strategy to increase the pool of donor lungs by allowing their ventilation and perfusion after procurement. As a result, lungs obtained through extended donor criteria and donation after cardiocirculatory death and placed on EVLP may be evaluated for suitability several hours after they were originally explanted.

While anesthetic management may not have a direct impact on organ supply, a plan that is focused on minimizing the development of PGD can optimize supply by decreasing short-term morbidity and long-term mortality associated with PGD (*J Cardiothorac Vasc Anesth* 2022;36:805-6). With a thorough understanding of emerging trends in perioperative ECMO and international guidelines for anesthetic management, anesthesiologists can play a key role as leaders within the multidisciplinary team caring for patients undergoing lung transplantation. ■