The evolution of intraoperative support in lung transplantation: Cardiopulmonary bypass to extracorporeal membrane oxygenation

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The report of the first successful clinical heart-lung transplant by Reitz and colleagues1 at Stanford, and those that followed,2 ushered in a new enthusiasm for lung transplantation. It was soon recognized that lung transplantation was possible without concomitant heart transplantation, and en bloc double lung transplantation using cardiopulmonary bypass soon evolved.

Machuca and colleagues3 of the University of Toronto compare outcomes of intraoperative extracorporeal membrane oxygenation (ECMO) versus cardiopulmonary bypass (CPB) support in patients undergoing lung transplantation (LTx). This study is the first to address which method of extracorporeal intraoperative support may be superior in LTx, a topic of intense current interest. The matched cohorts (33 ECMO vs 66 CPB) resulted from a 7-year (2007-2013) review of 673 LTx’s performed at their Toronto program. Although retrospective and nonrandomized, the study groups are well matched and adequately powered; inclusion and exclusion criteria are sufficiently defined.

The contemporary period of LTx began in the late 1980s, following a critical assessment of experimental and clinical results of en bloc double LTx, commonly performed at that time.4,5 These investigators determined that en bloc “double” LTx, utilizing a central tracheal anastomosis, was technically feasible but frequently attended with severe airway complications, including dehiscence, necrosis, mediastinitis, sepsis, stenosis, and poor long-term survival. To address this problem, a technical alteration in the airway anastomotic technique was introduced. The en bloc tracheal anastomosis was abandoned for a more easily mastered bilateral sequential bronchial anastomosis. This approach avoided the need for CPB in many patients, reduced postoperative hemorrhage, and practically eliminated the life-threatening complications of airway necrosis and dehiscence. Bilateral sequential LTx, with or without CPB, quickly became the procedure of choice for double lung replacement.7-9

Subsequent studies examined predictors and indicators for CPB in LTx but found no reliable preoperative predictors for its use.10 A recent comparison of 259 single LTx’s, 53 (20.5%) with and 206 without CPB, revealed that although postoperative bleeding and transfusion requirements were greater with CPB, postoperative lung function and time to extubation were similar.11 A subsequent univariate and multivariate analysis by Weber and colleagues12 reviewed the association of intraoperative transfusion of packed red cells and fresh frozen plasma with mortality in 134 LTx recipients. A significant increase in mortality was observed in recipients receiving packed red cells and fresh frozen plasma (odds ratio, 1.10, \( P = .02 \); and odds ratio, 1.09, \( P = .03 \), respectively). In recipients who received >4 packed red cells, multivariate and univariate analyses showed a hazard ratio of 3.8 (range, 1.4-10.3, \( P = .003 \)). Nonsurvivors showed an increase in renal replacement need, primary graft dysfunction, postoperative ECMO support, multisystem organ failure, infection, sepsis, intensive care–unit readmission, and retransplantation.

The subsequent evolution in extracorporeal support brings us to the issue of arteriovenous ECMO (Figure 1), addressed here by Machuca and colleagues3 and others.13 The current study was undertaken to evaluate the less-complex technique of ECMO in LTx. Inherent in ECMO use is a reduction in the following: heparin requirement, prime volume, perioperative bleeding, and transfusion requirement. Based on the report by Weber and colleagues,12 postoperative morbidity and mortality would be expected to be lower in LTx patients supported on ECMO than they are in CPB patients.

The current study demonstrates that the intraoperative and 72-hour postoperative requirement for blood transfusion significantly favors the ECMO group. Results showed no statistical difference in the requirement for postoperative ECMO, renal dialysis, re-exploration for bleeding, 90-day mortality, or 12-month Kaplan-Meier survival. The authors have adopted arteriovenous ECMO as their primary method of intraoperative support for LTx.

The next evolution in intraoperative ECMO support for LTx will most likely rest on the ability of veno-venous ECMO to provide adequate oxygenation and support while avoiding the requirement for arterial cannulation. No study to date has addressed its utility in LTx. If veno-venous ECMO is found to be beneficial, and the indications for its application in LTx are well defined, a further evolution...
may be to a singular double-lumen veno-venous ECMO cannulation, as has been used for a bridge to transplantation, in acute respiratory distress syndrome, and recently in pulmonary resections in patients with severely compromised pulmonary function.14

It must be emphasized that the majority of single LTxs, and many bilateral sequential LTxs, can be performed without the use of any extracorporeal circulatory lung support. Such an approach remains the most desirable, when possible, but it requires competent and attentive anesthesia management. When ECMO is required, facilitated conversion to CPB is mandatory. Conditions that commonly necessitate this conversion include serious bleeding, circulatory insufficiency, and complications in which full circulatory support is needed for management of right or left heart dysfunction and unanticipated concomitant cardiac intervention.

References


