Extra-corporeal membrane oxygenation for post-cardiotomy respiratory failure

Michael S. Firstenberg¹*, J. Michael Smith², Erik Abel¹, Danielle Blais¹, Louis B. Louis¹, Benjamin Sun¹ and Susan D. Moffatt-Bruce¹

¹Division of Cardiothoracic Surgery, The Ohio State University Medical Center, Columbus, OH, USA; ²Division of Cardiac Surgery, The University of Cincinnati, Cincinnati, OH, USA

Abstract
Respiratory failure subsequent to cardiac surgery is associated with significantly high morbidity and mortality. We present post-cardiotomy adult respiratory distress syndrome (ARDS) that was successfully managed with extra-corporeal membrane oxygenation. This treatment modality should be considered for similar cases of ARDS refractory to conventional measures.

Keywords: extracorporeal circulation; mechanical circulatory assistance; respiratory failure

Respiratory complications are common after-procedures requiring cardio-pulmonary bypass. Fortunately, respiratory insufficiency typically responds to targeted anti-microbials where indicated, diuresis, and ventilator support with aggressive pulmonary toilet. However, profound or refractory hypoxemia, increases in peak airway pressures and hypercarbia with concordant acidosis and hemodynamic instability may develop in spite of maximal and appropriate support. Adult respiratory distress syndrome (ARDS) is an infrequent, but well-known, cause of morbidity and mortality following elective cardiac surgery. We present a case of unilateral respiratory failure, after single lung isolation for minimally invasive right thoracotomy cardiac surgery, which required veno-veno extra-corporeal membrane oxygenation (ECMO) support to allow for adequate recovery.

Case
A 63-year old with hemodynamically significant mitral regurgitation despite a previous mitral valve repair for mitral stenosis several years prior to her current hospitalization. Her major comorbidities consisted of pulmonary hypertension, morbid obesity, obstructive sleep apnea, atrial fibrillation, and non-insulin-dependent diabetes. Pre-operative assessment confirmed preserved biventricular function, normal right atrial and ventricular size, and no coronary artery disease. She underwent elective mitral valve replacement via a mini-right thoracotomy using single lung ventilation (placement confirmed with bronchoscopy). Peripheral arterial and venous cannulation was performed from a right femoral cut down. Using a beating heart technique, the left atrium was opened approximately 1 cm above the pulmonary veins and the valve was replaced with a mechanical prosthesis. The left atrial appendage was oversewn and a cryo-maze was performed. The left atrium was closed, the lungs were slowly re-inflated, and she was weaned from bypass without difficulty or inotropes. Intra-operative transesophageal echo (TEE) confirmed that the valve was functioning well, there was good biventricular function, and flow was observed from all four pulmonary veins. The double-lumen endotracheal tube was changed to a standard single lumen tube and additional blood or blood products were not required. Within several hours she developed worsening hypoxemia, hypercarbia, and a respiratory acidosis with worsening hemodynamics. A chest X-ray demonstrated complete ‘white-out’ of the right lung. Chest tube drainage was minimal. Bronchoscopy was unremarkable with minimal secretions and confirmed the proper positioning of the endotracheal tube. She was transferred to our institution for possible ECMO support. Upon arrival (Fig. 1) her initial arterial blood gas was pH = 7.33, pCO₂ = 46, pO₂ = 53 on 100% oxygen and 15 positive end-expiratory pressure (PPEP) (Assist control, rate = 25, volume = 350 ml). She was atrial-ventricular (AV) paced with a systemic pressure of 81/52 and a pulmonary artery pressure of 56/38, cardiac index = 1.75 l/min/m² on high-dose norepinephrine (0.16 mcg/kg/min), vasopressin (0.06 U/min), dobutamine...
(5 mcg/kg/min), and milrinone (0.25 mcg/kg/min). No improvement was seen with inhaled nitric oxide or a brief trial of jet ventilation. She was taken to the operating room, where repeat TEE confirmed the previous findings. Due to the presumed ‘normal’ post-operative cardiac function, the decision was made to implement veno–veno ECMO. The right groin was re-opened and the femoral vein was directly cannulated with an 21 French cannula, which was positioned at the level of the right atrium. A similar cannula was placed percutaneously into the left femoral vein and was advanced to the iliac vein bifurcation using the umbilicus as a landmark. ECMO was initiated using a Medtronic Biomedicus BP-80 pump and tubing circuit† (Minneapolis, MN, USA) and a Maquet Quadrox D oxygenator (Wayne, NJ, USA) (Initial flows = 5.5 l/min, gas sweep = 6 l/min, and oxygen concentration = 100%). Within several hours her physiology improved and she was weaned from her vasoactive agents. Improvements in her respiratory acidosis and hypoxemia allowed for a lung protective strategy (FIO₂ = 40%, 5 PEEP, Assist control, rate = 8). Anti-coagulation was held for approximately four post-cannulation and then, with minimal evidence of bleeding, low-dose heparin was started (5 U/kg/h, no titration). After 24 h, full heparinization was initiated with a goal of PPT = 50–70 s. Repeat bronchoscopy was unremarkable and respiratory bacterial, fungal, and viral cultures were negative. Coinciding with improvements in her chest X-ray and pulmonary mechanical, we were able to slowly wean the ECMO oxygenation and flows. ECMO was removed after 7 days of uncomplicated support and several days later she was extubated. On post-operative day 21 she was discharged to home, ambulating without difficulty, shortness of breath or requiring oxygen. Her discharge X-ray was interpreted as normal and without pathologic changes (Fig. 2).

Discussion

Adult respiratory distress syndrome following cardiac surgery, although rare (0.5–2% of cases), is associated with a 25% mortality (1). Risk factors include re-operative surgery, multiple blood transfusions, and post-operative cardiogenic shock (2). Conversely, 21% of post-cardiac surgery mortalities are directly linked with respiratory complications (3). Management is typically supportive with lung protective strategies that minimize barotrauma. Nevertheless, technical (mechanical) and infectious causes need to be considered (4). In the case presented, there was no airway obstruction determined by bronchoscopy, pleural effusions/hematoma or pulmonary venous obstruction determined by TEE. The presumed diagnosis was ischemia-reperfusion injury following single lung ventilation – a clinical scenario that has been observed in up to 5% of patients undergoing single lung ventilation for pulmonary resections (5).

The use of ECMO has been described after similar complications in patients following lung transplantation. Mason and colleagues (6) reported a 4% incidence of lung transplant recipients requiring ECMO support. In this population, causes of lung failure were early graft failure often due to reperfusion injury (57%), pneumonia/sepsis (26%), and acute rejection (17%). Left atrial anastomotic problems occurred in 3 of 22 patients. ECMO was used for an average of 4 days and 1-month survival was 62%. While the need for aggressive immunosuppression probably placed this group in a higher risk profile than our patient, it was based upon this and similar experiences that
prompted our aggressive salvage approach to our presented patient.

Recent experiences with ECMO in patients with ARDS have been favorable when compared to maximal medical management (7). Although typically used for post-cardiotomy failure following cardiopulmonary bypass, growing experience for primary respiratory failure has permitted expansion of indications. Survival for isolated respiratory failure has been reported to be approximately 57% with survival following cardiac failure was less than 35% (8). Although the outcomes of patients supported for respiratory failure following cardiac surgery are unclear, a reported 57% survival to discharge in patients requiring salvage ECMO support following pulmonary thromboembolectomy justifies ECMO for respiratory failure following cardiac surgery (9). As the clinical status can deteriorate rapidly, early referral or consideration should be considered in patients developing prompt respiratory failure—particularly if a high-risk hospital transfer is required.

Critical to successful outcomes is the rapid implementation of support prior to the development of potentially irreversible multi-organ system failure—and in particular, anoxic neurological damage. Although protocols can vary considerably, we advocate consideration for ECMO prior to the onset of renal failure, medically refractory metabolic and/or respiratory acidosis, and an escalating requirement for vasoactive infusions or inotropes.

Conclusions

This case describes the successful use of veno-veno ECMO for the management of acute ARDS following cardiac surgery. Early implementation of ECMO, before irreversible end-organ damage, has been shown to be useful in patients with refractory cardio-pulmonary failure. ECMO should be considered and advocated in post-cardiotomy patients with respiratory failure particularly when associated with hemodynamic instability.

Conflict of interest and funding

The authors have not received any funding or benefits from industry to conduct this study.

References


*Michael S. Firstenberg
Division of Cardiothoracic Surgery
The Ohio State University Medical Center
N817 Doan Hall, 410 W 10th Avenue Columbus, OH 43212, USA
Tel: +1 614 366 7414
Fax: +1 614 293 4726
Email: Michael.Firstenberg@osumc.edu

Citation: Mechanical Circulatory Support 2010, 1: 5489 - DOI: 10.3402/mcs.v1i0.5489