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Procurement of lungs for transplantation following donation after circulatory death: the Alfred technique

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ABSTRACT

Introduction: Donation after circulatory death (DCD) is an evolving method for lung transplantation (LTx) with results comparable to donation after brain death (DBD).
Materials and Methods: DCD lung transplant program requires a systematic approach for an efficient utilization of hospital resources. The surgical techniques have been developed to minimize the ischemic time during lung procurement. We have presented our management protocol and the surgical techniques as used at the Alfred Hospital in Melbourne, Australia.
Results: We have transplanted 92 recipients with lungs procured from 91 donors over an 8 year period from May 2006 to July 2014. This accounted for an extra 19% lung transplant operations performed during this time period. Operative mortality was 1% and 8 year survival was 71% in DCD lung recipients.
Conclusions: DCD lung transplantation provides an additional significant pool of lung donors with satisfactory short and long term outcomes.

1. Introduction

Donation after circulatory death (DCD) represents a potential large pool of donors for lung transplantation (LTx). Early and late LTx clinical outcomes following DCD have been satisfactory and are at least comparable with the results from brain dead donors [1]. The surgical technique is similar in principle to the well-established organ donation from brain dead donors. However, there are several issues that are unique to the DCD lung procurement as we will report. These issues include assessment and management of the donors, declaration of death, and the steps to minimize warm ischemic time.

2. Materials and Methods

Our Institutional Guidelines for the management of a Maastricht Category III DCD lung donor in the intensive care unit (ICU) have previously been published [2]. Limited thoracic surgery including previous chest drain insertion and previous cardiac surgery are not absolute contraindications to DCD lung retrieval in our experience.

The operating room (OR) staff and the organ procurement teams are initially notified a minimum of 4 h before withdrawal of life-sustaining treatment (WLST). Subsequently, a multidisciplinary team meeting takes place in the OR 30 min before WLST to clarify mode and timing of withdrawal,

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staffing, equipment, and administration of heparin. WLST and declaration of death in our institution occur in ICU only and not in the OR as the ICU is felt to be less intimidating environment for the family members who may wish to be present. After WLST, the declaration of death is made when there has been no pulsatile trace on the arterial line for 5 min, with or without electrocardiogram activity and the donor is transported to the OR expeditiously and ideally within 10 min of the declaration of death.

On arrival in the OR, after confirmation of identity, the donor is reintubated by the anesthesiologist before transfer to the OR table. Rapid prepping and draping is carried out. The thoracic and abdominal teams commence surgery simultaneously. Instruments that would be needed by the thoracic team from the median sternotomy until the administration of pulmonary flush solution are placed on a separate trolley. To avoid any delay in passing instruments to the operating surgeon, these instruments are handed over by the first assistant to the operating thoracic surgeon (Fig. 1A). An expeditious median sternotomy is performed. The first assistant passes sterile tubing to the anesthesiologist for the administration of pulmonary flush solution. The pericardium is opened. A long hemostat is used to retract the adventitia of the main pulmonary artery (MPA) and allow the cannulation site to become accessible. A 4-0 prolene suture on an RB-1 needle (Ethicon Inc, Somerville, NJ) is used to place a purse string suture on the MPA (Fig. 1B). A number 11 knife is used to perform arteriotomy, which is dilated with another long hemostat. A cannula is placed in the MPA. Perfadex (Vitrolife, Gothenberg, Sweden) is infused at a dose of 50–70 mL/kg. Heparin is either given systemically as per local guidelines or alternatively added to the Perfadex solution. The tip of the left atrial appendage is amputated to allow free drainage of pulmonary flush solution. Critically, both lungs are ventilated during this time to allow the proper distribution of pulmonary flush solution bilaterally. The inferior vena cava is partially divided to allow the liver preservation solution to drain in to the pericardial cavity. To avoid inadvertent cardiac stimulation and reanimation, ventilation does not commence until a minimum of 15 min after cardiac arrest. A fiber-optic bronchoscopy is then performed when practical, to exclude unsuspected post mortem aspiration.

Both pleurae are widely opened and cold saline is used for topical hypothermia. Next, the descending thoracic aorta at the level of diaphragm is clamped to prevent flushing of bronchial arteries with renal preservation solution (Fig. 2A). The pericardial opening is extended in a horizontal fashion at the level of the diaphragm as far as possible. The lungs are then inspected and palpated to assess the suitability of the organs. Some dissection is performed during the administration of pulmonary flush solution to facilitate separation of the heart from the lungs. The superior vena cava is mobilized from its pericardial reflection and from the right pulmonary artery (PA) (Fig. 1B). The azygos vein is divided. The right PA is then separated from the ascending aorta and the ascending aorta is dissected from the MPA. Once the pulmonary flush solution has been administered, the cannula is removed.

The anterior pericardium is excised up to the level of the pulmonary hila. The superior vena cava is divided and the inferior vena cava is transected as close to the right atrium as possible. The left lung is retracted anteriorly and superiorly and the inferior pulmonary ligament is divided. The posterior plane, which separates the lung from the esophagus and descending thoracic aorta, is dissected with scissors (Fig. 2A). Attention then turns to the right lung. The dissection is similar on the right side. It is important to avoid any injury to the posterior wall of the right or left main stem bronchi during this part of the dissection. The bronchi can be protected by the nonoperating hand of the surgeon that is also retracting the lung while scissors are used to divide tissues.

The superior aspect of the aortic arch is exposed and is divided as distal as possible along with the proximal arch vessels. The trachea is dissected between the index finger and thumb. Minimal dissection of the soft tissues around the trachea is performed. A TA-30 stapler (Covidien, Dublin, Ireland) is passed around the trachea. The lung is then inflated with 50% oxygen to approximately 80% of its tidal volume. The anesthesiologist withdraws the endotracheal tube. The stapler is used to divide the trachea. Any remaining posterior mediastinal attachments are divided with scissors. The heart–lung bloc is then moved to the back table.

The separation of the heart from the lungs involves dividing the main PA proximal to its bifurcation (Fig. 2B). The left atrial cuff is then divided in a way to provide equal-sized cuffs for both lungs. The left main stem bronchus is divided with a TA-30 stapler leaving the tracheal cuff attached to the right main stem bronchus. Cold Perfadex solution is used to retrogradely flush the pulmonary veins (Fig. 2B). The ostium of each pulmonary vein is individually cannulated for Perfadex delivery. Flushing is continued until clear effluent appears from each PA (Fig. 2B).

Our protocol has recently been modified to include topical cooling of lungs if there is a delay of >45 min between the time of treatment withdrawal and certification of death [3]. Apical and basal pleural drains are placed (Fig. 3). Cold Perfadex (2.8 L) is connected to the basal chest drain via the tubing. An infusion is commenced with cold fluid bilaterally. The pleural spaces are filled and the effluent is removed via the apical drains bilaterally. The infusion is ceased at this stage, and the basal drains are clamped. A second bag is connected to each apical chest drain on each side and these bags are placed in ice containers to keep them cold. The fluid is left in the pleural cavity for 30 min. The bags (attached to the apical drains) placed in ice are removed and the infusion is commenced into the pleural cavity. Simultaneously, the empty basal bags are placed into the containers of ice, and clamps are opened to allow fluid to drain out of the pleural cavities into the bags while the colder solution is infusing in the apical drains. This procedure is repeated as long as required to facilitate procurement. This technique provides additional protection for 6 h.

After retrieval, bagging and storage on ice, DCD lungs retrieved in this fashion are suitable to be implanted into standard LTx recipients without further assessment. Specifically, *ex vivo* lung perfusion is not mandated simply because the donor was DCD [4].

3. Results/Discussion

We do not accept DCD donors who have had previous thoracic surgery including pleurodesis. We have procured lungs from patients who have had previous cardiac surgery including those who have had internal thoracic artery harvested. Our