Anesthesia Guidelines for Heart-Lung Transplant

Anesthesia for Heart, lung, heart-lung transplant

Keyword: Heart transplantation, Lung transplantation, heart lung transplantation, transplant, immunosuppression, organ donation, organ donor, UNOS, United Network for Organ-Sharing, organ transplantation

Rationale, pathophysiology, anesthetic implication:

With improving medical care and more advanced technology, there are increasing numbers of patients with end-stage heart and/or lung diseases awaiting organ transplantation. If only the heart is needed, orthotopic heart transplant suffices. So is an end-stage lung disease, single lung transplant or double lung transplant is needed depending on degree of severity of pulmonary failure and primary pathology. If patient with congenital heart disease develops severe pulmonary hypertension or patient with end stage pulmonary disease who develops cor pulmonale, typically, en bloc heart and lung transplant is required.

The common indications for orthotopic heart transplant are shown in table 1. Generally, the most common indication is cardiomyopathy from idiopathic or from coronary artery diseases. However, with better medical care, there is also increasing numbers of patients with end stage heart failure from congenital heart disease.

Table 1 Indications for orthotopic heart transplant

<table>
<thead>
<tr>
<th>Indications for orthotopic heart transplant</th>
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<tbody>
<tr>
<td>1) Cardiomyopathy</td>
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<tr>
<td>a. Dilated cardiomyopathy from various causes e.g. coronary disease, viral, drug induced (adriamycin), metabolic disorder, chronic arrhythmia</td>
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<tr>
<td>b. Hypertrophic cardiomyopathy</td>
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<tr>
<td>c. Restrictive cardiomyopathy e.g. sarcoidosis, amyloidosis, endomyocardial fibrosis (EMF), hemochromatosis, glycogen storage disease</td>
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<tr>
<td>2) Congenital Heart Disease e.g. failing Fontan, end stage disease following surgical repair</td>
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<tr>
<td>3) Other indications e.g. unresectable cardiac tumors, Kawasaki’s syndrome</td>
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The common indications for lung transplant are shown in table 2. The most common reasons include cystic fibrosis, COPD, pulmonary fibrosis, etc. Generally, these patients are hypoxemic, requiring home oxygen therapy, dealing with chronic lung infections and the primary disease almost always affect both lungs, which means limited pulmonary reserve during one lung ventilation. For single lung transplant, it is much possible to perform the surgery without cardiopulmonary bypass machine (CPB) by ventilating the remaining lung. If double lung transplant is planned, it is still possible to perform sequential double lung transplant without CPB using alternate one lung ventilation. Although, this can be complicated and impossible if the native pulmonary function is far diminished or in the patients with pulmonary hypertension. Hence, some institutions advocate performing the double lung transplant on CPB.
Table 2 Indications for lung transplant

<table>
<thead>
<tr>
<th>Pre-transplant diagnosis</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Cystic fibrosis</td>
<td>42%</td>
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<tr>
<td>Pulmonary vascular disease</td>
<td>21%</td>
</tr>
<tr>
<td>Bronchiolitis obliterans</td>
<td>10%</td>
</tr>
<tr>
<td>Primary alveolar proteinosis</td>
<td>6%</td>
</tr>
<tr>
<td>Pulmonary fibrosis</td>
<td>7%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>12%</td>
</tr>
</tbody>
</table>

For en bloc heart-lung transplant, this will definitely require CPB. Most common indication is severe pulmonary hypertension despite optimum medical therapy or end stage lung disease which complicated with cor pulmonale. These patients are usually extremely ill and have very limited reserves. The number of cases is limited due to short supply of suitable donor blocs. Also, with improving and early therapy, both medical and isolated lung transplant, prior to development of cor pulmonale plays a substantial role in reducing candidates.

Goals of anesthesia
1. To provide general anesthesia to those patients, monitoring and maintenance of the cardiovascular and pulmonary physiology.
2. Safe transport to the intensive care unit and adequate postoperative analgesia.

Patient preparation
Generally, heart or lung or heart and lung transplant donors are cadavers. (In some institution, the living donor lung transplant are being pioneered using one or 2 lobes from the matched donor). Matching and summon in the recipients in timely fashion made them presented as an urgency or emergency. This means that NPO time and risk of aspiration must be considered. Some immunosuppressants are only in enteral form (e.g. Sirolimus, Everolimus, etc) and the patients are required to take those before surgery. After a safe induction with cricoid pressure, one must remember not to suction out these medications before they are absorbed.

Some heart transplant recipients have undergone previous heart surgeries e.g. CABG, previous heart transplant(s), Fontan operation, etc. Occasionally, patients are already on ventricular assist device (VAD) or extracorporeal membrane oxygenator (ECMO) awaiting the heart. Therefore, the condition for each of them may vary extremely. The mildest presentation will be a very low EF ventricle depending on continuous milrinone infusion with evidence of end organ failure.

When patients are called to receive heart, lung or heart and lung transplant, there often is some psychological responses. Most of the patients express a high level of anxiety. Majority of patients and family are already informed about the risks and possible complications including death.
Usually the time to assess the patients is limited preoperatively; however, the vital information should always be obtained. All the required data should already be available when the patients are on the waiting list e.g. echocardiogram, cardiac catheterization data, pulmonary function test, response to iNO (inhaled nitric oxide), etc. For patients with pacemaker and or AICD, the device needed to be interrogated or turned off (for AICD) with stand by external defibrillator.

Another concerns is the information about the donor organ, this depends on institution protocol regarding privacy. If access allowed, some basic information about the donor organ e.g. Donor’s age, Donor’s size (weight and height) – for organ size matching, cause of death, down time (arrest time), echocardiogram or catheterization data of donor’s heart, blood group, viral profile e.g. Hepatitis C/B, etc, these data can help a great deal providing anesthesia care to the recipients.

Room Preparation

These patients are soon to be immunocompromised (or already are, if they have previous transplant). At Siriraj hospital- Thailand, this means using sterilized corrugated tubing, new ETT, newly reinstituted drugs, bacterial filters and exercise all the sterilization techniques to the maximum e.g. using sterile gloves for endotracheal suction. Prepare large bore IVs, warming devices, blood and blood components if the recipient is status post multiple previous operations or being anticoagulated e.g. in patients with Thoratec® VAD system. Prepare defibrillator with external pad applied on the chest wall for a redo- sternotomy or in the patient who has multiple episodes of VT/VF especially when the AICD has been turned off.

All ASA standard monitorings should be ready. Arterial line is mandatory for CPB cases and extremely useful in lung transplant for frequent ABG samplings. The central venous line (CVL) seems mandatory for CPB cases for monitoring and administering inotropes. For heart transplant case, placing the line too deep can cause some troubles to the surgeon if the SVC will be anastomosed (Generally, not – they usually suture on both atria – except when patients has right sided SVC). I, personally, prefer to place the multilumen catheter in either subclavian vein as the evidence has shown that it is least infected when compare to the other sites. If the pulmonary artery catheter (PAC) is needed, I prefer to place it in the right IJ despite the concern of preserving the right IJ for future repeated biopsy for follow up. I found the manipulation of PAC from other entries besides the right IJ is quite troublesome especially when the EF is low and the pacing/AICD wire presents. There PAC should be inserted to only 15-20 cm in the native dysfunctional heart and later, floated into the PA of the transplanted heart. If the monitoring of the PAP or CO of the old heart is desired, it can be pulled back during CPB and re-position as well.

The vascular ultrasonography can be useful for assessing patency of these large veins due to previous surgeries, ECMO cannulations or presence of multiple leads for biventricular pacer and or AICD. The PA catheter is optional for heart transplant and uncomplicated single lung transplant but considered very useful for patient with pulmonary hypertension, double lung transplant or heart and lung transplant. Make certain that the protective plastic sleeve is intact because the catheter will be pulled back and reinserted during the procedure.
Intraoperative TEE can be useful for heart transplant, heart and lung transplant but less beneficial in uncomplicated single lung transplant.

One-lung ventilation is required for single lung transplant and sequential double lung transplant. The double lumen tube (DLT) is more preferable than other methods e.g. bronchial blocker, Univent tube, etc. The current FOB at Siriraj- Olympus® LF-2 will not pass well with DLT 35 Fr, hence, if the patient is not too small – using DLT at least 37 Fr is preferable. The right sided DLT is absolutely needed for left side single lung transplant and vice versa. Ideally, both right sided and left sided DLTs are needed for sequential double lung transplant off CPB and this means changing the tube in the middle of the case. (I have not, to date, providing anesthesia care for sequential double lung transplant at Siriraj, but the surgeon –Dr. Sagiyaluck have told me that he can suture the left main bronchus distal to our left DLT cuff. If that holds true, there is no need to change the DLT and only left sided DLT will suffice). Fiberoptic bronchoscope (FOB) are essential for evaluate the position of the tube and also the tracheal/bronchial anastomosis. It would be unwise to insert or re-adjust the DLT blindly with a fresh bronchial anastomosis in place.

Epidural catheter should be placed for patients undergo an uneventful single lung transplant if no systemic heparinization (although, the surgeon may request small bolus of heparin before suturing the vessels). However, this may not be accomplished if there was an uncertainty about needs for CPB in recipients with severe hypoxemia).

Intraoperative management

Heart Transplant
The anesthetic care for heart transplant is similar to other CPB cases. The corticosteroid and immunosuppressants need to be administered before reperfusion of the transplanted heart (generally, the time the aortic cross clamp removed and the new heart starts to beat). Documenting the total ischemic time (from donor’s clamp on time to recipient’s clamp off time) is crucial as it is one of the predictors of the transplanted cardiac function. Generally, if the donor’s heart is in a good condition (young age, good function by echo or clean coronary from coronary angiogram, etc), no or very short arrest time and the ischemic time is less than 4 hour, the prognosis is very good. Although, it is not uncommon to witness these previously healthy transplanted hearts requiring not less than moderate amount of inotropic supports. The wide QRS and hyperacute T wave noted when the heart start beating is a good evidence of ischemic-reperfusion injury.

The newly transplanted heart is a denervated heart and has no intrinsic sympathomimetic responses to physiologic stimulations. Normally, the newly transplanted heart rate should be around 100 by pharmacologic or pacing supports. If no PAC inserted, the overall graft function can be assessed using TEE or other clinical markers e.g. perfusion signs (peripheral limbs’ temperature, capillary refills, etc), BP, urine output, SVC oxygen saturation, serial lactate level.

The bleeding should be anticipated if the patient has previous heart surgeries or has severe liver dysfunction or being anticoagulated preoperatively. Large amount of bloods and blood products
Loading on the newly transplanted heart is a major concern especially when the kidneys are no longer working.

**Lung Transplant**

I, personally, always perform a thorough bronchoscopy and suctioning the newly transplanted lung prior to inflation because of residual amount of lung fluid and secretion. This bronchoscopy also allow us to visualize the fresh bronchial anastomosis which all the surgeon mandate to inspect when finished. If epidural catheter is not placed before surgery, it’s usually placed later (mostly in the ICU). Early extubation is encourage because spontaneous breathing is likely to help with healing and minimize air leaks (if any) compare to positive pressure ventilation; it also helps decrease risk of ventilator associated pneumonia. However, this may not be easily fulfilled if the new graft function is still recuperating. Extubation can be achieved when lung mechanics are great and the patient is awake and strong enough to cough and the gas exchanges are in acceptable range. It can be hardly done without epidural analgesia.

If extubation is not attempted or unsuccessful, a safe exchange of DLT to single lumen tube should be made. The risk of having unfamiliar staffs in the ICU taking care of patient with DLT is far greater than tube-exchange by competent anesthesiologists. There are number of ways to make this a safe event.

**Heart-Lung Transplant**

In heart-lung transplant, the care is more like the heart transplant, given that it’s done with CPB. In addition to concerns about new cardiac graft function, there is also the concern about new pulmonary grafts function. Occasionally, iNO can helps reduce pulmonary arterial hypertension and minimize the V/Q mismatch.

**Postoperative implications**

Poor graft function can be expected in either cardiac graft or pulmonary graft if the donor organs are not in pristine conditions. Acute and subacute rejection can also implicate the postoperative courses. In the perfect setting, the recovery from either heart, lung or heart-lung transplant can be surprisingly fast while in the worst scenario – it can also be slow and complicated recovery. Arrhythmia is an early sign of acute rejection in heart transplantation while the systolic function is still intact. Frequently, effective bronchial hygiene therapy and bronchoscopy are needed following lung transplant. Immunosuppressants are pivotal for organ survivals. Depending on institution protocol, the lung transplant and heart-lung transplant patients should be in isolated room, using droplet precaution while the heart transplant patient should be in isolated room, using contact precaution at minimum.

**References**


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