Lung Transplantation
Anesthesia Guideline
University of Washington Medical Center
Department of Anesthesiology & Pain Medicine

Overview

1) Most lung transplants involve bilateral lung transplant, however occasional single lung transplants will occur. Double lung transplantation is done via a clamshell incision, while single lung transplantation is done via a thoracotomy.

2) Lung transplantation may be done with or without cardiopulmonary bypass (see below)

3) Underlying lung disease includes COPD, pulmonary hypertension, pulmonary fibrosis and cystic fibrosis.

4) Timing and coordination of the donor and recipient operating rooms is often critical in order to minimize ischemic time. Timing issues can be difficult and close communication between the donor and recipient sites is needed.

Anesthesia Set-Up

1) Drug infusions are the same as for a cardiac surgery case, eg epinephrine, phenylephrine, vasopressin, insulin, nitroglycerin.

2) The anesthesia set-up is generally identical as for a cardiac surgery case, including TEE.

3) An SVO2 PA catheter is generally used. The PA catheter may be placed prior to or after induction of anesthesia. Placement prior to induction may be desirable in high risk patients with severe pulmonary hypertension.

4) Double lumen endotracheal tubes are virtually always used except in unusual circumstances (eg hypothetically a single lumen tube would be an option in a patient with a difficult airway undergoing transplantation with cardiopulmonary bypass—this will be rare)

5) An Arrow MAC 3 lumen introducer sheath should be used since peripheral IVs are not reliable due to the positioning of the arms (wrapped on a bar over the head for a clamshell incision).

6) Radial a-lines are generally used, although there can be problems, again due to arm positioning for a clamshell incision. A femoral a-line can be added if needed.
Preinduction management

1) When the patient arrives in the holding area (or operating room if brought directly to the OR) confirm that the oral immunosuppressants have been given (cyclosporine and prednisone, see drug checklist). If these drugs have not been given obtain them from the pharmacy and administer prior to induction.

2) Confirm that the other immunosuppressant drugs and antibiotics are available (see checklist).

3) An IV suitable for induction and an arterial line are placed, usually in the holding area.

4) Epidural catheters may be placed in suitable patients if there is time to do so. Most patients do not have epidural catheters placed prior to surgery. If an epidural catheter is placed in a patient with severe pulmonary hypertension, it may be wise not to test the catheter preoperatively, as the response to local anesthetic sympathectomy in these patients may be unpredictable.

Induction

1) A SURGEON CAPABLE OF INSERTING A CHEST TUBE AND PLACING THE PATIENT ON CARDIOPULMONARY BYPASS MUST BE PRESENT DURING INDUCTION OF ANESTHESIA.

2) Preoxygenation should be accomplished very deliberately to assure maximum total body oxygen content. Preoxygenation may have to be accomplished with the patient sitting if a completely supine posture is intolerable.

3) Consideration should be given to administration of nitric oxide (NO) during preoxygenation for patients with severe pulmonary hypertension. NO should at least be immediately available for any patient with severe pulmonary hypertension.

4) Choice of induction agents can be tailored to the individual patient based on the experience and preference of the anesthesiologist. Consider that right coronary perfusion pressure may be critically important in patients with severe pulmonary hypertension and right ventricular hypertrophy. Some patients will be “full stomach”.

5) Consider placing a single lumen endotracheal tube prior to a double lumen endotracheal tube. The advantage of this approach is that the single lumen endotracheal tube is generally placed more quickly, positive pressure ventilation can be established, and any hemodynamic consequences can be evaluated and treated without the distraction of adjusting the position of the double lumen tube. When the patient is hemodynamically stable, the single lumen endotracheal tube can then be changed to a double.

6) Beware of the following problems after intubation.
   a. Air trapping in COPD may impede venous return and produce hypotension. Use a I:E ratio greater than 1:3 and adjust ventilation accordingly.
   b. Rupture of blebs in COPD may produce a pneumothorax or tension pneumothorax. Rapid placement of a chest tube in this situation may be lifesaving.
   c. Secretions in patients with cystic fibrosis can obstruct bronchi and endotracheal tube lumens
   d. Patients with pulmonary hypertension can develop serious hemodynamic instability following induction of anesthesia, the mechanism of which is not always evident. Acute right heart failure can occur in this setting. Treatment is empirical. Quickly obtaining TEE images may help establish a diagnosis. Consider using vasopressin instead of phenylephrine in this group since PVR is not increased by vasopressin.
**Surgery**

1) Basiliximab 20 mg at time of skin incision

2) Decide with the surgeon whether the patient will tolerate single lung ventilation or whether cardiopulmonary bypass will be needed. Increased pulmonary artery pressures increase the likelihood of requiring cardiopulmonary bypass. Patients with severe pulmonary hypertension tend to develop acute right heart failure when single lung ventilation is attempted. Likewise, severe hypoxemia or hypercarbia during single lung ventilation may require treatment with cardiopulmonary bypass.

3) Administer aminocaproic acid to patients undergoing cardiopulmonary bypass

4) Administer methylprednisolone 1 gram iv push bolus just prior to reperfusion of the first lung, and 500 mg iv push bolus just prior to reperfusion of the second lung.

5) If cardiopulmonary bypass is utilized, measure coagulation on bypass and treat coagulopathy as needed.

6) Separation from bypass should ordinarily by simple and not require inotropic support since the heart is not arrested during bypass.

7) Ventilate the transplanted lungs with the lowest possible inflation pressures. Pressure control ventilation is usually convenient for this purpose. PEEP = 5 should be added routinely.

8) Fluid management. Use as little crystalloid fluid as possible and no colloid (such as albumen or hetastarch), as these tend to worsen pulmonary edema. Liberal use of packed red cells is encouraged if needed to maintain intravascular volume. While perioperative hematocrit in cardiac surgery patients tends to be in the 20's, perioperative hematocrit in lung transplant patients tends to be in the 30's.

9) TEE can be very useful for management preload and evaluating ventricular function, especially the function of the right ventricle. Patients with right ventricular hypertrophy are susceptible to right ventricular outflow tract obstruction following lung transplantation. RVOT obstruction is analogous to LVOT obstruction and should be treated by increasing preload, avoiding catecholamines, and avoiding unnecessary pulmonary artery vasodilation. TEE may also be useful for evaluating pulmonary venous obstruction.

**Post Surgery**

1) The double lumen tube should ordinarily by changed to a single lumen tube prior to transport to the ICU. Do not use tube exchange catheters to accomplish this, as newly created bronchial anastomosis can be traumatized.

2) Transport to ICU intubated with standard monitoring and propofol sedation.

3) Notify Acute Pain Service either to manage the epidural placed preoperatively or to plan for placing an epidural postoperatively.
LUNG TRANSPLANT CHECKLIST

☐ 1) Check that oral cyclosporine has been given: 5 mg/kg if creatinine <1.2, 2 mg/kg if creatinine >1.2. Rounded to nearest 25 mg. Check that oral prednisone has been given: 1 mg/kg, round to nearest 5 mg

☐ 2) Cefuroxime 1.5 gm IV preop and Vancomycin 1 gm IV infusion over 30 min.

☐ 3) Basiliximab 20 mg IV at time of skin incision

☐ 4) Methylprednisolone 1000 mg IV push bolus just prior to reperfusion of first lung

☐ 5) Methylprednisolone 500 mg IV push bolus just prior to reperfusion of 2nd lung

☐ 6) Nitric oxide in the room