Lung Transplantation

48

Jose Ramon Matilla Siguenza, Clemens Aigner, and Walter Klepetko

Introduction

Lung transplantation is the established treatment for nonmalignant parenchymal and vascular lung diseases after all other treatment options have failed. The first lung transplantation was performed in 1963 by James Hardy (Hardy 1963). Since the late 1980s, the number of these procedures has risen constantly, and today more than 2,700 transplants are reported to the International Society for Heart and Lung Transplantation registry each year (Christie 2010).

There is a broad spectrum of pulmonary diseases that pose a potential indication for lung transplantation. General prerequisites for considering transplantation are a limited life expectancy due to end-stage lung disease, failure of all other conservative and surgical treatment options, and continuous disease progression. The decision regarding transplantation is based not only on functional criteria, but also on the prognosis of the specific disease, especially as it relates to the subjective impression of quality of life (Orens 2006).

Although infectious lung diseases such as cystic fibrosis always require double-lung transplantation, for other indications, single-lung transplantation is an option as well; however, long-term results generally are better after bilateral transplantation. Bilateral procedures are performed with the sequential technique (Kaiser 1991). Single-lung transplantations are performed mainly to minimize operative risk or because of specific donor-related issues, such as unilateral localized pathologies; organ shortage; or specific anatomic considerations in the recipient.

Initially, heart–lung transplantation was the procedure of choice for pulmonary vascular diseases. However, because right ventricular function can be restored fully, these patients now are treated with lung transplantation alone, and heart–lung transplantation has become a very rare procedure reserved for patients with complex cardiac defects and secondary pulmonary hypertension.

Intraoperative extracorporeal support, if necessary, may be given by extracorporeal membrane oxygenation or cardiopulmonary bypass via either central or peripheral cannulation (Aigner 2007). Advanced operative techniques especially important for pediatric recipients include lobar and split-lung transplantation; however, these procedures are performed only in specialized centers. Additionally, living donation may be an option for selected patients.

In view of the shortage of donor organs, non–heart-beating donation and ex vivo lung perfusion are promising options for enlarging the donor pool.

Changes in immunosuppression and new drug development have improved the results of lung transplantation substantially.

J.R. Matilla Siguenza (✉) • C. Aigner • W. Klepetko
Department of Thoracic Surgery, Medical University of Vienna,
Waehringer Guertel 18-20, Vienna 1090, Austria
e-mail: thoracicsurgery@meduniwien.ac.at

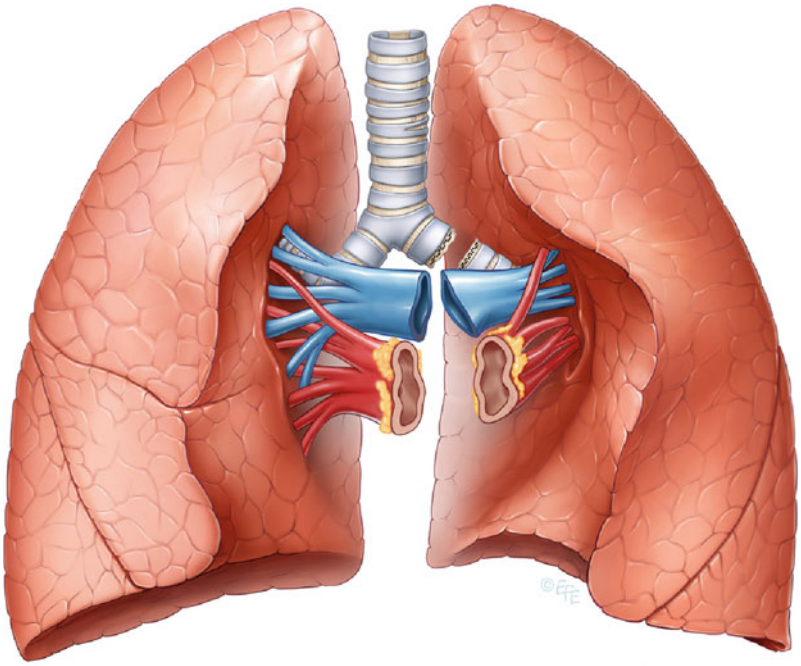
H.C. Dienemann et al. (eds.), *Chest Surgery*, Springer Surgery Atlas Series,
DOI 10.1007/978-3-642-12044-2_48, © Springer-Verlag Berlin Heidelberg 2015

Harvesting Technique

Figure 48.1

Lungs are harvested via a standard midline sternotomy. After the pericardium and both pleurae are opened, the lungs are palpated and examined visually. The superior and inferior venae cavae are encircled, and a suture is placed around the superior vena cava to prepare for later ligation. The aorta and pulmonary artery are separated; then, a pursestring suture is placed in the main pulmonary artery approximately 1–2 cm central to the bifurcation to ensure adequate perfusion of both lungs and to leave a sufficient length of main artery in case the heart is to be harvested simultaneously. After full heparinization of the donor with 300 IU/kg of heparin, the pulmonary artery is cannulated. Most centres administer 500 μg of prostaglandin E_1 intravenously or directly into the pulmonary artery prior to any vascular occlusion. Thereafter, the superior vena cava is ligated. The inferior vena cava is clamped to allow a sufficient cuff for both the heart and liver. Finally, the ascending aorta is cross-clamped and perfusion with a preservative solution is started. Most centers use 4–6 L of extracellular dextran solution for preservation. Immediately after cross-clamping, the auricle of the left atrium is opened to allow drainage of the preservative solution. If the heart is to be harvested simultaneously, the solution is administered via the ascending aorta and drained via an incision in the inferior vena cava. During the entire perfusion period, the lung is ventilated to allow optimal distribution of the preservative solution. As soon as perfusion is complete, ventilation is stopped and the perfusion cannulas are removed. If the heart is to be harvested, that step is done immediately after perfusion, usually by first dissecting the inferior vena cava. During separation of the left atrium, special attention must be paid to ensure a sufficient cuff for both the lungs and the heart. Too much upward traction on the heart should be avoided to ensure normal vein anatomy, especially on the right side, and to avoid cutting too peripherally. Finally, the superior vena cava and aorta are divided. The pulmonary artery is divided just central to the bifurcation to maximize the length of the main truncus for heart transplantation and the full length of the left and right main arteries for lung transplantation. Retrograde flush perfusion of the lungs with preservative solution may be performed either at this stage, with the lungs in situ, or on the back table after removal. After the heart is removed, the pericardium is incised caudally down to both pulmonary ligaments. Starting on either side, the pulmonary ligament is divided, then the dissection is carried upward along the posterior mediastinum anterior to the esophagus until it reaches the level of the upper trachea. Thereafter, dissection is performed on the other side. During this maneuver, the azygos vein has to be divided on the right side and the descending aorta on the left. Next, the anterior trachea is prepared cervically, and the remaining tissue lateral to the trachea, including the carotid artery, subclavian artery, and corresponding veins, is divided. This leaves the entire double-lung block just connected to the trachea. The lungs are moderately inflated, and the trachea is stapled as cranially as possible. Finally, the lungs are removed from the donor chest cavity. After the lungs are inspected carefully, separation may be performed at the back table. After the posterior pericardium is dissected, the left atrium and the pulmonary arteries are separated in the midline. Thereafter, the left main bronchus is prepared and stapled just below the carina. Care must be taken not to denude the bronchus to avoid ischemic complications of the anastomosis after transplantation. The lungs are stored inflated on Perfadex (Vitrolife, Englewood, CO) and cooled on ice at 4 °C for transport. Harvesting is standardized as described earlier in brain-dead donors. In non–heart-beating donors, additional logistic preparations with topical cooling of the lungs in the donor may be necessary (Aigner 2003b, Orens 2003)

Figure 48.1

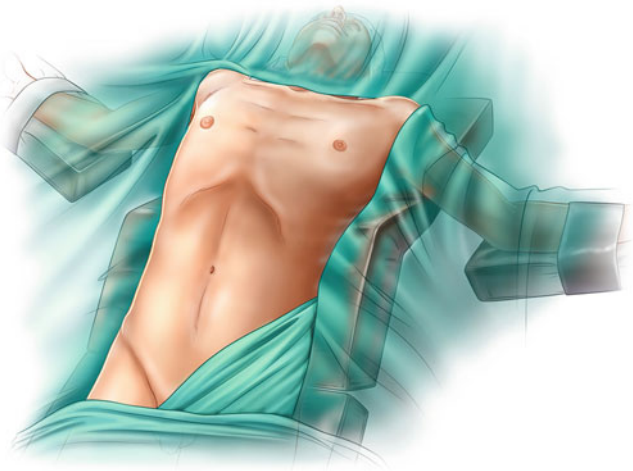


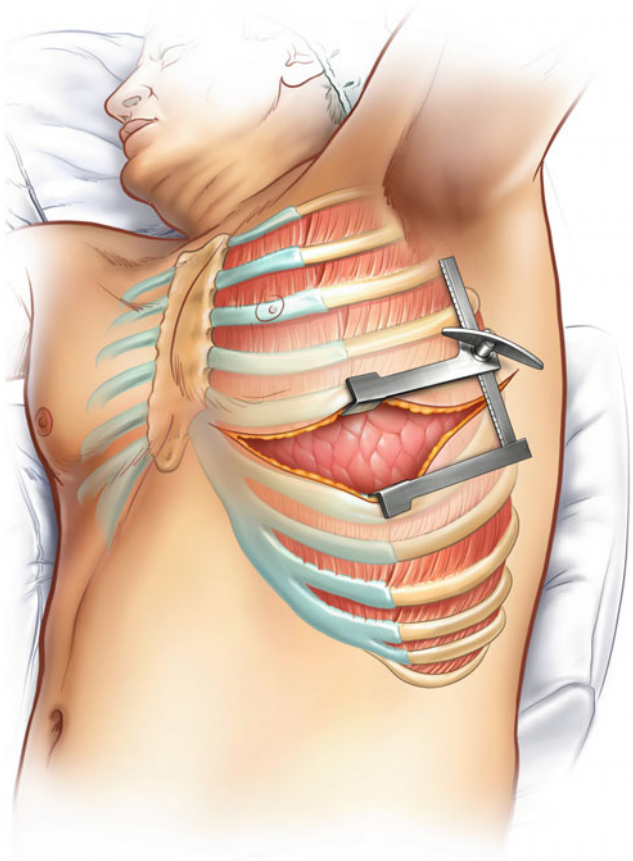
Single-Lung Transplantation Technique

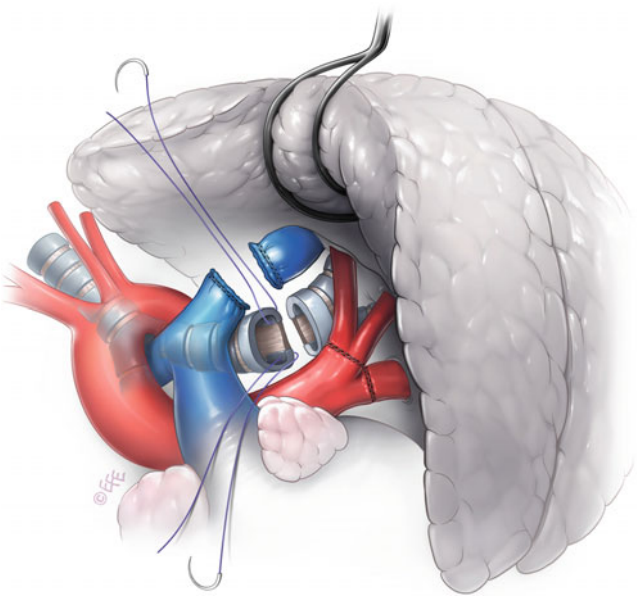
Figures 48.2, 48.3 and 48.4

The patient may be placed either in a supine position with the arms abducted and chest elevated as for double-lung transplantation or at a 45° angle with the ipsilateral arm positioned above the head to improve exposure to the posterior hilum. At least one groin is scrubbed to allow placement of cannulas for extracorporeal support. Anterolateral thoracotomy is performed, preferably in the fourth intercostal space on the right side and the fifth intercostal space on the left. Standard pneumonectomy with stapling of the pulmonary artery and veins is performed. The bronchus is prepared centrally and cut with a scalpel. Two polydioxanone (PDS) 4-0 stay sutures are placed at the angle between the membranous portion and the cartilaginous part. After the lung is removed from the chest cavity, the pericardium is opened above the superior pulmonary vein and the left atrium is dissected circumferentially. Thereafter, the pulmonary artery is dissected intrapericardially as centrally as possible. After the intrapericardial dissection is complete, the posterior mediastinum may be closed with a PDS 4-0 suture to prevent bleeding, which is difficult to control after the lung has been implanted. Before implantation begins, it is crucial to achieve accurate haemostasis

Figures 48.2, 48.3 and 48.4



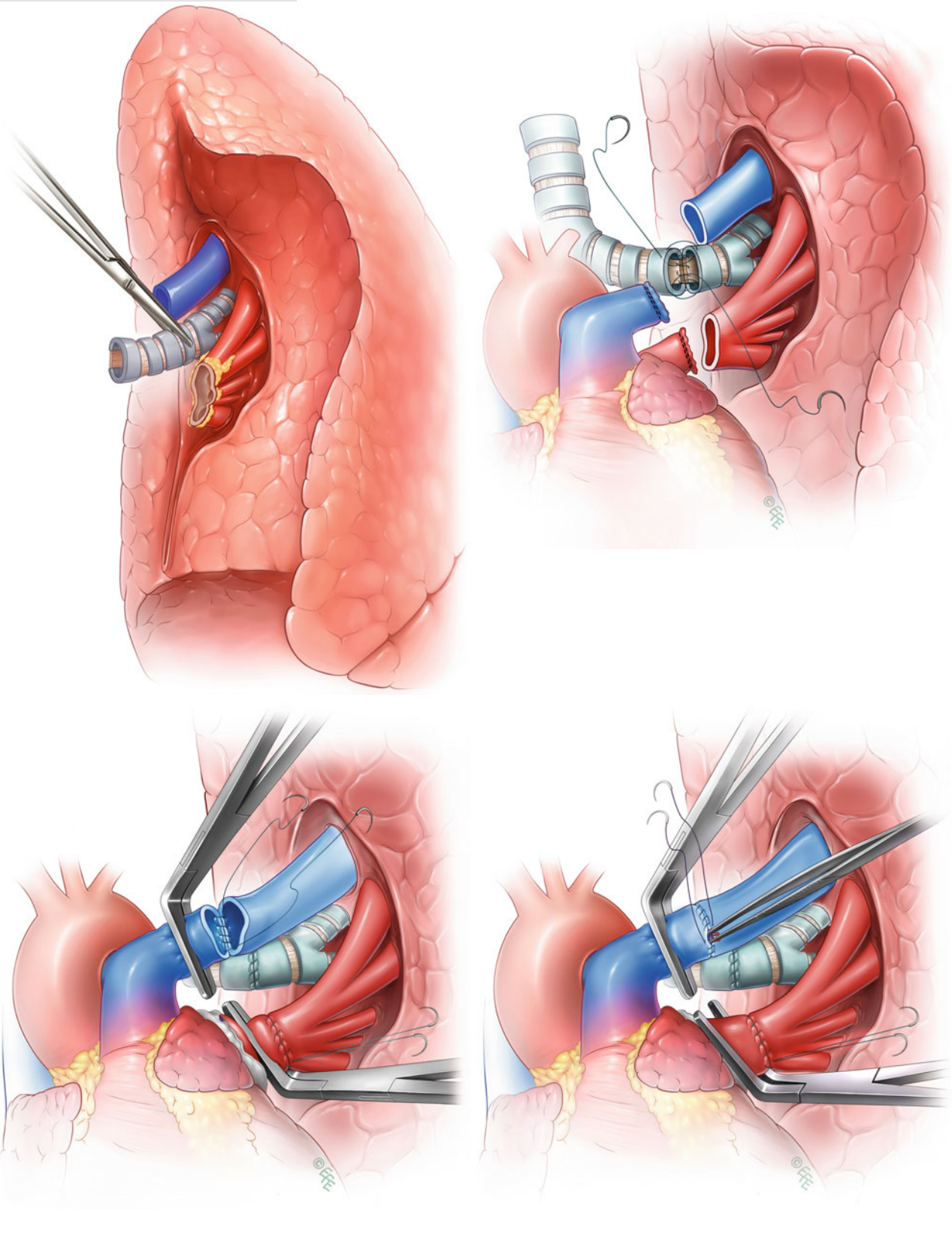




Figures 48.5, 48.6, 48.7 and 48.8

The donor lung is removed from the cooling box, and the vessels are prepared and shortened. While the peribronchial tissue is strictly protected, the bronchus is shortened so that one cartilage ring remains after the upper lobe bronchus is separated. After a bacteriological swab and flushing of the bronchial system with physiologic sodium chloride solution, the lung is transferred to the recipient chest cavity, with ice slush applied for topical cooling. The bronchus is anastomosed with double-armed PDS 4-0 sutures starting at one end of the cartilaginous part and going over the membranous portion in a single running suture; a single running suture also is used for the anterior cartilaginous part. In case of a bronchial size mismatch, the imbalance is adjusted over the whole circumference. Efforts to cover the anastomoses with tissue usually are unnecessary, except for the occasional interposition of a donor pericardial flap between the bronchus and pulmonary artery (Aigner 2003a). Next, the left atrium is clamped intrapericardially, opened, and anastomosed at a level at which myocardial muscle tissue is present, because at the level of the veins, the tissue is too fragile to allow a safe anastomosis. Usually, a 4-0 Prolene running suture is used. An everting suture technique with direct adaption of donor and recipient endothelium is preferred to minimize the risk of thrombosis. The suture is secured with a clamp but, at this stage, is not yet knotted. Thereafter, the pulmonary artery is centrally clamped and opened. The anastomosis is performed again with a running technique using a 5-0 Prolene suture. The vessels should be kept short enough to avoid kinking. After the initial dose of immunosuppressant is administered, retro- and antegrade flushing is performed to de-air the vasculature and flush out the preservative solution. Then, the sutures of the vessels are knotted. Protective ventilation without a manual recruitment maneuver is started at this stage. If the procedure is done without extracorporeal support, controlled reperfusion should be performed for 10 min with partial manual compression of the pulmonary artery to avoid initial volume overload of the implanted lung. Finally, meticulous hemostasis is performed with special attention paid to the donor pulmonary ligament and pericardium, which may be the source of significant bleeding; 24 F drains are placed in the costodiaphragmatic sinus and toward the apex, and the thoracotomy is closed. It may be beneficial to insert an additional small drain that may be left in place to avoid basal fluid collection without compromising patient mobilization after the standard chest drains are removed

Figures 48.5, 48.6, 48.7 and 48.8

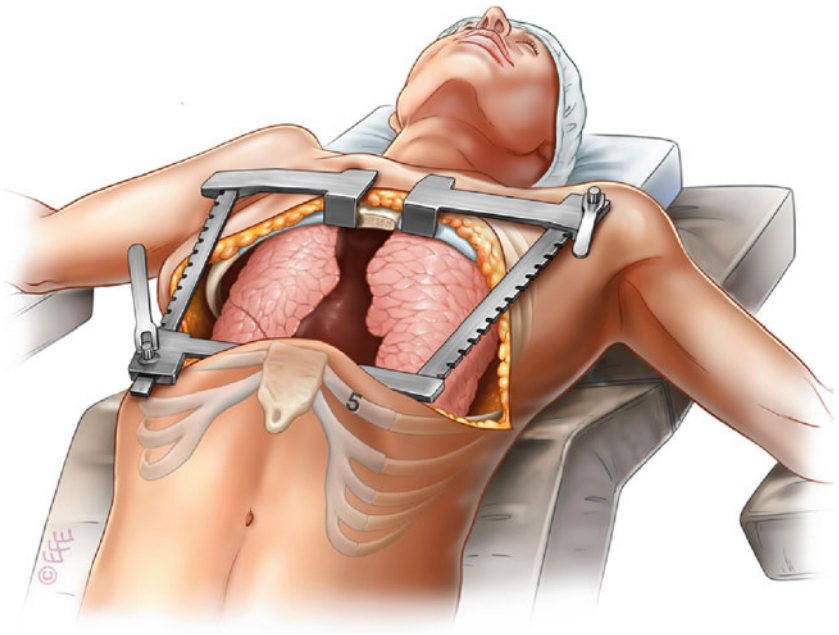


Double-Lung Transplantation Technique

Figure 48.9

For double-lung transplantation, the patient is placed in the supine position as described previously. The procedure may be performed via two separate anterolateral thoracotomies or via a clamshell incision in which the thoracotomies are connected by a transverse sternotomy with ligation of the internal mammary arteries and dissection of the retrosternal fat tissue. Which approach to use depends on the anatomic situation, the recipient's size, and whether extracorporeal support is required intraoperatively. Central cannulation is possible through a right anterolateral thoracotomy; however, a clamshell incision usually is performed in these cases. Recipient pneumonectomy and implantation of the donor lung are performed sequentially as described for single-lung transplantation. Which side is transplanted first depends on the ventilation–perfusion scan and the anatomic situation. Usually, the functionally worse side is transplanted first

Figure 48.9



Conclusion

Aside from some variation in details, the surgical technique for single- and double-lung transplantation is established throughout the world. Although lung transplantation still is a technically demanding procedure, morbidity and mortality directly related to the surgical technique can be minimized by meticulous performance of each step. Appropriate surgical training and experience in thoracic surgery are mandatory for performing this procedure successfully.

References

Aigner C, Jaksch P, Seebacher G, Neuhauser P, Marta G, Wisser W, Klepetko W (2003a) Single running suture—the new standard technique for bronchial anastomoses in lung transplantation. Eur J Cardiothorac Surg 23:488–493

Aigner C, Seebacher G, Klepetko W (2003b) Lung transplantation. Donor selection. Chest Surg Clin N Am 13:429–442

Aigner C, Wisser W, Taghavi S, Lang G, Jaksch P, Czyzewski D, Klepetko W (2007) Institutional experience with extracorporeal membrane oxygenation in lung transplantation. Eur J Cardiothorac Surg 31:468–473

Christie JD, Edwards LB, Kucheryavaya AY, Aurora P, Dobbels F, Kirk R, Rahmel AO, Stehlik J, Hertz MI (2010) The Registry of the International Society for Heart and Lung Transplantation: twenty-seventh official adult lung and heart-lung transplant report—2010. J Heart Lung Transplant 29:1104–1118

Hardy JD, Webb WR, Dalton ML Jr, Walker GR Jr (1963) Lung homotransplantations in man. JAMA 186:1065–1074

Kaiser LR, Pasque MK, Trulock EP, Low DE, Dresler CM, Cooper JD (1991) Bilateral sequential lung transplantation: the procedure of choice for double-lung replacement. Ann Thorac Surg 52:438–445

Orens JB, Boehler A, de Perrot M, Estenne M, Glanville AR, Keshavjee S, Kotloff R, Morton J, Studer SM, Van Raemdonck D, Waddel T, Snell GI, Pulmonary Council, International Society for Heart and Lung Transplantation (2003) A review of lung transplant donor acceptability criteria. J Heart Lung Transplant 22:1183–1200

Orens JB, Estenne M, Arcasoy S, Conte JV, Corris P, Egan JJ, Egan T, Keshavjee S, Knoop C, Kotloff R, Martinez FJ, Nathan S, Palmer S, Patterson A, Singer L, Snell G, Studer S, Vachiery JL, Glanville AR, Pulmonary Scientific Council of the International Society for Heart and Lung Transplantation (2006) International guidelines for the selection of lung transplant candidates: 2006 update—a consensus report from the Pulmonary Scientific Council of the International Society for Heart and Lung Transplantation. J Heart Lung Transplant 25:745–755