World J. Surg. 25, 244–250, 2001
DOI: 10.1007/s002680020025

WORLD
Journal of
SURGERY

Living Donor Lung Transplantation

Robbin G. Cohen, M.D., Vaughn A. Starnes, M.D.

Department of Cardiothoracic Surgery, University of Southern California School of Medicine, USC Healthcare Consultation Center, 1510 San Pablo Street, No. 415, Los Angeles, California 90033, USA

Published Online: March 20, 2001

Abstract. Since 1993 a total of 101 living-donor bilateral lung transplants have been performed with acceptable results when compared with those utilizing cadaveric lung grafts. Though most recipients were patients with cystic fibrosis who were rapidly deteriorating, the indications for live-donor lung transplantation have been expanded to include some cystic fibrosis patients in a more elective setting, as well as select patients with other end-stage pulmonary diseases. One-year Kaplan-Meier recipient survival is 72%. Seventy-six percent of deaths occur within the first 2 months after transplantation. The most common cause of death is infection, which accounts for 62% of the 1-year mortality rate. The incidence of rejection is 0.8 episodes per patient. Thirty percent of rejection episodes are unilateral, and most tend to be mild. Altogether, 203 patients have undergone donor lobectomy, with a mean age of 37 ± 12 years (range 18–56 years). Operations included left lower lobectomy (102 patents), right lower lobectomy (97 patients), and right middle and lower lobectomy (4 patients). There has been no donor mortality. Postoperative Rand 36 Question Quality of Life scores, rating physical function, social functioning, and role limitation due to physical and emotional health, are well over 92 (of a possible score of 100). Eighty-five percent of donors said that their health was no different or improved since donation.

Expanding indications and improved results with lung transplantation resulted in a 1600% increase in the number of potential recipients on waiting lists between 1988 and 1993 [1]. Whereas donor pools have remained relatively static, recipient waiting times have increased annually, as have the number of potential recipients who die while awaiting lung transplantation. In fact, the United Network for Organ Sharing (UNOS) reported that in 1996 the median waiting time for a cadaveric lung transplant was 566 days; and of 3557 patients on the waiting list, 386 died during that year alone [2]. Among patients with cystic fibrosis, who account for the sickest potential transplant recipients, 20% of wait-listed patients die while waiting for a cadaveric pulmonary graft [3, 4]. Though numerous methods for increasing the cadaver donor pool have been suggested, such as relaxing the strict criteria for acceptable grafts, none has significantly increased the number of grafts available for lung transplantation.

The concept of live-donor lobar lung transplantation was introduced in 1992 by Starnes et al. [5] as an alternative to cadaveric lung transplantation in children. They postulated that an adult lobe might provide adequate ventilation and perfusion to take the place of a pediatric lung. In 1993 this concept was expanded to include bilateral lobar transplants in patients with cystic fibrosis. Since then, more than 60 living donor bilateral lung transplants have been performed at the University of Southern California with acceptable results when compared with lung transplantation utilizing cadaveric lung grafts. Though most recipients were patients with cystic fibrosis who were rapidly deteriorating and could not wait for cadaveric grafts, our indications have been expanded to include some cystic fibrosis patients in a more elective setting and selected patients with other end-stage pulmonary diseases.

Though similar in concept to cadaveric whole-lung transplantation, living-donor lung transplantation presents a number of unique issues with respect to recipient and donor selection, donor lobe procurement and preservation, implantation, and postoperative care. The details of each are described.

Correspondence to: R.G. Cohen, M.D., e-mail: rcohen@hsc.usc.edu

Methods

Recipient Selection and Demographics

Decisions regarding the appropriate time to consider cadaveric lung transplantation are usually based on the patient's condition versus an approximation of how long a potential recipient can wait for cadaveric lung grafts. Indications for referral for lung transplantation may include an increased frequency of infections or hospitalizations, increasing oxygen requirements, decreasing exercise tolerance, progressive weight loss, decreasing pulmonary spirometry, clinical signs of right heart failure, or recurring life-threatening pulmonary complications such as hemoptysis or pneumothoraces. Most candidates for living-donor bilateral lung transplantation are patients with end-stage lung disease who have met the requirements for and were listed for cadaveric lung transplantation but whose clinical courses predicted that they would not survive the wait for cadaveric lung grafts owing to an exacerbation of one or more of the factors listed above. A number of relative and absolute contraindications have been developed for both cadaveric and living-donor lung transplantation. They are listed in Tables 1 and 2 [6].

Bilateral lobar transplantation is particularly suited for patients

Table 1. Relative contraindications for lung transplantation.

Multiple drug-resistant gram-negative organisms in sputum
Endotracheal intubation and mechanical ventilation
High-dose corticosteroids
Previous thoracic surgery
History of psychosocial illness or poor compliance
Malnutrition or obesity
Poorly controlled diabetes

Table 2. Absolute contraindications for lung transplantation.

Recently treated or widespread malignancy
Cerebral dysfunction
Bacterial sepsis
Acquired immunodeficiency syndrome (AIDS) or severe congenital immunodeficiency
Neuromuscular weakness
Pan-resistant *Pseudomonas*
Active pulmonary mycobacterial tuberculosis
Irreversible renal insufficiency or hepatic dysfunction

Table 3. Diagnoses of patients undergoing bilateral living-donor lung transplant.

Diagnosis	No. of patients
Cystic fibrosis	50
Primary pulmonary hypertension	4
Postchemotherapy pulmonary fibrosis	2
Idiopathic pulmonary fibrosis	1
Bronchopulmonary dysplasia	1
Obliterative bronchiolitis (OB)	1
Posttransplant OB	1
Total	60

with end-stage lung disease due to cystic fibrosis. These patients tend to be small children and young adults in whom two pulmonary lobes from normal-size adults have the potential to provide adequate pulmonary function. Furthermore, patients with cystic fibrosis are prone to rather sudden bouts of deterioration and death because of their chronic state of cardiorespiratory compromise and chronic infection. The ability to offer these patients urgent lung transplantation when it has become clear that they would not survive to cadaveric transplantation has been life-saving for most patients. Of sixty patients undergoing bilateral lobar transplantation since 1993, fifty had cystic fibrosis. Other diagnoses are listed in Table 3. All patients were oxygen-dependent, 67% were hospital-bound, 40% were on preoperative steroids, and 18% were ventilator-dependent. Their mean carbon dioxide tension was 71 mmHg (range 36–180 mmHg), and the mean forced expiratory volume in 1 second (FEV_1) was 19% of predicted (range 8–30%). Approximately two-thirds of patients required "urgent" transplantation in that their life expectancy was thought to be 1 week or less. Seventy-five percent of patients were adults with a mean age of 27 years (range 18–47 years), and 25% were children with a mean age of 13 years (range 9–17 years) [7]. Approximately half of patients have been male and half female.

Donor Evaluation and Selection

Evaluation of potential donors for living-donor pulmonary transplantation requires a thorough physiologic and psychiatric assessment. The donor evaluation process is extensive and time-consuming, as many potential donors must be evaluated frequently to find a suitable pair for a given recipient. Because of ethical concerns regarding the risk and the motivation for donation, only parents or close relatives of recipients were originally considered. With increased experience, donor criteria have been expanded to include extended family and unrelated volunteers whose motives and social situation have been carefully evaluated by an independent psychiatrist and a social worker. Potential donors are also counseled extensively by physicians regarding the operative procedure, expected hospital course, potential risks, and short- and long-term outcomes of donor lobectomy. Most potential donors have the opportunity to meet with others who have been donors in the past.

Table 4. Donor criteria for living-donor lung transplantation.

ABO blood group compatibility
Age < 55 years
General good health
No recent viral infections
Normal chest radiograph
No significant pulmonary pathology on computed tomography (completely normal on donor side)
Oxygen tension > 80 mmHg on room air
FEV_1 and FVC $> 85\%$ predicted
Normal echo- and electrocardiogram
No previous thoracic operation on donor side

FEV_1: forced expiratory volume in 1 second; FVC: forced vital capacity.

Criteria for donor selection are listed in Table 4 [8]. ABO blood group compatibility with the recipient is initially confirmed. Though tissue typing is performed retrospectively, it is not a crucial part of the preoperative evaluation. In fact, living-related recipients have not had an immunologic advantage with respect to postoperative rejection when compared to recipients who received lobes from unrelated donors. Potential donors then undergo chest radiography, computed tomography (CT) of the chest, and full spirometry with arterial blood gas analysis. Once these test results are deemed acceptable, further evaluation includes cultures to exclude current and previous bacterial, viral, and fungal infections and serologic tests for hepatitis A, B, and C, human immunodeficiency virus, varicella, Epstein-Barr virus, herpes simplex virus, and cytomegalovirus.

Body habitus and size also play a role in donor selection. Because the height of the donor lobes affects how well they will fill the thorax of the recipient, those from tall donors tend to "fit" better than lobes that are short and more broad-based. Once an acceptable donor pair has been selected for a given recipient, one donor is chosen to undergo right lower lobectomy and the other left lower lobectomy. Because the right lower lobe tends to be smaller than the left lower lobe, the larger donor is usually chosen for donation of the right lower lobe. If the donors are the same size, the side of donation is assigned arbitrarily.

Surgical Technique

The surgical techniques for both donor and recipient operations have been previously described [8, 9]. Three operating rooms and surgical teams work simultaneously. When the recipient is an

adult, all three operations are performed in the same hospital. When the recipient is a child, the donor operations are performed at USC University Hospital, and the donor lobes are transported to Children's Hospital Los Angeles for implantation.

Donor Lobectomy

Prior to performing the first living-donor lobectomies for lung transplantation, it was necessary to determine which lobes could be most easily and safely removed and which could be most easily implanted into the recipients. The first two living-related lobar transplants were "single lung" transplants performed in children. One utilized the right upper lobe of the recipient's mother. This procedure required that the pulmonary artery be removed with the graft and implanted into the recipient as a Carrel patch, with reconstruction of the donor's right pulmonary artery with a pericardial patch. Though successful, this procedure was thought to be too complicated for routine use. The other single lobe transplant utilized the middle lobe of a living-related donor, which was implanted into an infant with pulmonary hypertension. This procedure failed because of what was thought to be an inadequate vascular bed in the small middle lobe. Further study of the anatomy of the pulmonary arteries, veins, and airways and their relations suggested that the right lower lobe would be best removed from a live donor and implanted into the right side of the recipient, and the left lower lobe from another donor would be most easily removed and implanted into the left side of the recipient. This has remained our model for bilateral lobar lung transplantation.

Several important differences exist between lobectomy for malignancy or infection and donor-lobectomy for lung transplantation. Because the donor lobe must function immediately after implantation, care is taken not to injure it. A posterolateral thoracotomy is used to provide optimal exposure. Lung clamps and excessive manipulation of the donor lobe are avoided. To minimize air leaks in the recipient, most of the dissection in the fissure is carried out on the side of the remaining lung. Donor lobes must be excised with an adequate cuff of bronchus, pulmonary artery, and pulmonary vein to allow implantation into the recipient. This must be accomplished without compromising the structure or function of the remaining lung.

After placement of an epidural catheter for analgesia, general endotracheal anesthesia is induced and fiberoptic bronchoscopy performed. The airways are examined for anatomic abnormalities that might affect excision and implantation of the donor lobe and for evidence of infection or inflammation. A double-lumen endotracheal tube is then placed and the patient moved into the lateral decubitus position. An intravenous infusion of prostaglandin E_1 (PGE_1) is initiated to dilate the pulmonary arterial vasculature. This aids in distribution of the preservation solution, which is administered just after explantation. A posterolateral thoracotomy incision is made and carried through the fourth interspace. The lung is carefully examined for evidence of pathology not seen on the CT scan, to evaluate the size and shape of the donor lobe, and to determine whether the fissures are complete or require extensive dissection. The details of the donor-lobectomy procedures were originally described in 1993 and are repeated here [8].

Donor Right Lower Lobectomy

For right lobectomy in the donor, after the chest is opened the lung is carefully inspected to exclude pathology that might have been missed during the preoperative evaluation. The inferior pulmonary ligament is incised with cautery, as in a standard lobectomy. The mediastinal pleura is dissected anteriorly as far superiorly as the superior pulmonary in, and posterior to, the inferior aspect of the takeoff of the right upper lobe bronchus.

After confirming that venous drainage from the right middle lobe does not enter the inferior pulmonary vein, the pericardium surrounding the inferior pulmonary vein is incised. This maneuver allows a vascular clamp to be placed on the left atrium so an adequate pulmonary venous cuff remains on the donor lobe (Fig. 1). Dissection in the fissure is then carried out to isolate the pulmonary artery to the right lower lobe and to define the anatomy of the pulmonary arteries to the right middle lobe. The most desirable anatomy is when there is adequate distance between the takeoff of the middle lobe artery and the pulmonary artery to the superior segment of the right lower lobe. This allows placement of a vascular clamp below the middle lobe artery, leaving sufficient vascular cuff for the pulmonary arterial anastomosis at implantation (Fig. 2). Once the vascular dissections are complete, the fissures are stapled and raw areas of pulmonary parenchyma cauterized to minimize air leaks in the recipient.

After the lobar dissection is completed, the lung is reinflated by the anesthesiologist. Heparin (10,000 units) and methylprednisolone (500 mg) are administered intravenously, and the lung is ventilated for 5 to 10 minutes. The lung is then deflated on the donor side, and a vascular clamp is placed on the pulmonary artery above the planned point of transaction. A second vascular clamp is then placed on the left atrial side of the inferior pulmonary vein. Placing the clamps in this sequence avoids vascular congestion of the pulmonary graft. The pulmonary artery is then transected with an adequate vascular cuff for the anastomosis to the recipient without compromising the artery to the superior segment of the lower lobe. An adequate length of pulmonary artery must remain to repair it without compromising the remaining pulmonary arterial branches. The inferior pulmonary vein then is transected with a small cuff of left atrium, after which attention is focused on the bronchus to the right lower lobe, which is now exposed underneath the transected pulmonary artery. As little dissection as possible is performed around the bronchus to preserve the blood supply of both the bronchus on the donor lobe and that of the remaining lung. The right middle lobe bronchus is identified, and a knife is used to transect the bronchus to the lower lobe. The incision starts in the bronchus intermedius above the bronchus to the superior segment of the right lower lobe and moves obliquely to just below the takeoff of the right middle lobe bronchus. The lobe is transported to a separate sterile table for preservation. The donor's pulmonary artery and veins are repaired with running monofilament suture. The bronchus is closed with interrupted sutures of 5-0 polypropylene. The chest is then closed in the traditional manner.

Donor Left Lower Lobectomy

For left lower lobectomy in the donor, the chest is opened, and the inferior pulmonary ligament is incised as for the right side. The dissection of the pulmonary artery to the lower lobe is performed

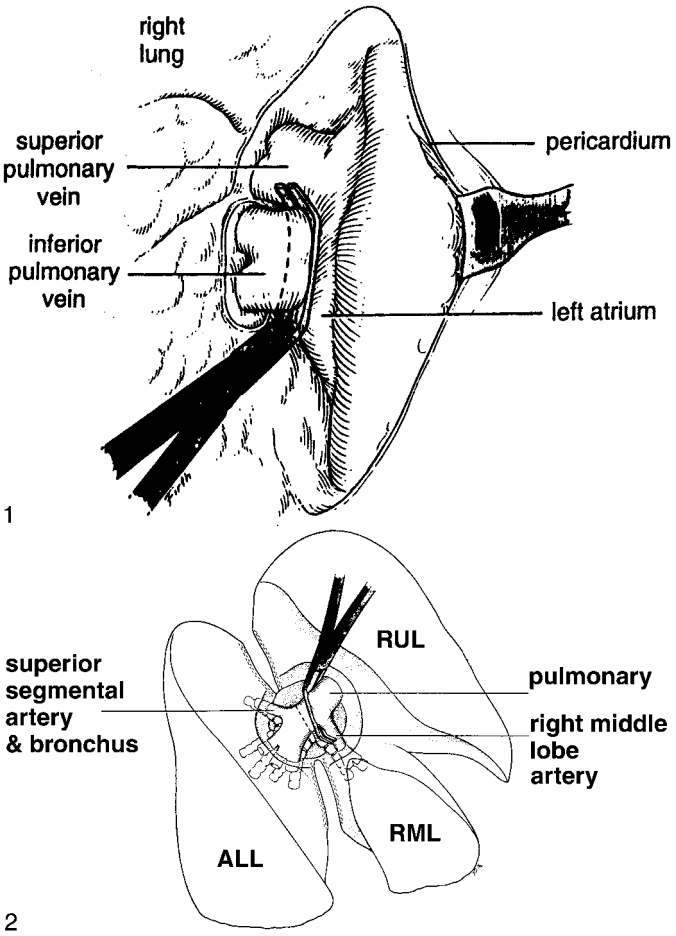

Fig. 1. Dissection of the donor right inferior pulmonary vein so a vascular clamp can be placed on the intrapericardial left atrium. (From Cohen et al. [8], with permission. Reprinted with permission from the Society of Thoracic Surgeons.)

Fig. 2. Dissection and clamping for division of the pulmonary artery for donor right lower lobectomy. RUL: right upper lobe; RLL: right lower lobe; RML: right middle lobe. (From Cohen et al. [8], with permission. Reprinted with permission from the Society of Thoracic Surgeons.)

so a vascular clamp can be placed proximal to the pulmonary artery to the superior segment of the lower lobe. If a lingular artery takes off too far distal to the artery to the superior segment of the lower lobe and is small, it is ligated and divided. The pericardium is opened circumferentially around the inferior pulmonary vein. Fissures, which tend to be less complete on the left side than on the right, are divided with staplers. At completion of the dissection, the lung is inflated, and heparin and methylprednisolone are given as for the right side. The left lung is then deflated, and the pulmonary artery and vein are clamped and transected. The exposed bronchus to the left lower lobe is followed upward until the lingular bronchus is identified. The main bronchus is transected tangentially starting at the base of the upper lobe bronchus and ending 2 cm proximally, approximately 3 mm superior to the bronchus to the superior segment of the left lower lobe (Fig. 3). The left lower lobe is then taken to a separate table for preservation, and the donor vessels and bronchus are repaired.

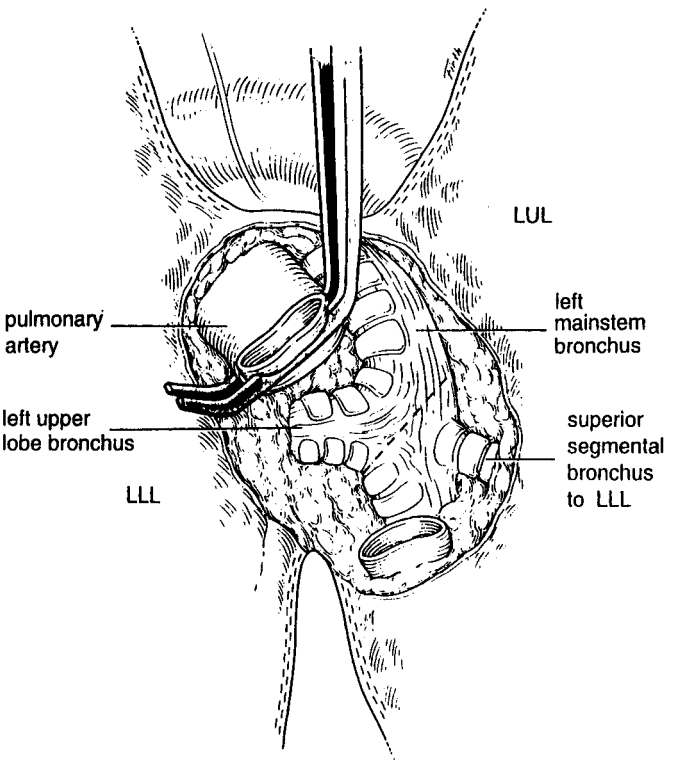

Fig. 3. Dissection and division of the donor left lower lobe bronchus. LUL: left upper lobe; LLL: left lower lobe. (From Cohen et al. [8], with permission. Reprinted with permission from the Society of Thoracic Surgeons.)

Pulmonary Preservation

In contrast to harvesting cadaver donor organs, living donor explantation does not allow for in vivo flushing and cooling of the grafts with high-potassium-containing preservation solutions. As a result, explanted lobes are transported to a separate sterile table where the bronchus is gently ventilated by hand. The pulmonary artery and vein are alternatively cannulated and perfused with 1 liter of cold modified Euro-Collins solution until uniform blanching of the graft is achieved, and the effluent drainage becomes clear. The grafts are then inflated and transported to the recipient operating room for implantation.

Recipient Operation

The donor and recipient operations are coordinated to minimize the cold ischemia time of the grafts. The recipient operation is performed on cardiopulmonary bypass through a clamshell incision, which allows adequate exposure of both pleural spaces. This point is particularly important in recipients with cystic fibrosis, who tend to have dense adhesions between the chronically infected lungs and the chest wall. Once the recipient pneumonectomies have been completed, the lobes are implanted sequentially starting with the bronchial anastomosis. The pulmonary venous anastomosis is then performed by anastomosing the pulmonary vein of the donor lobe to the superior pulmonary vein of the

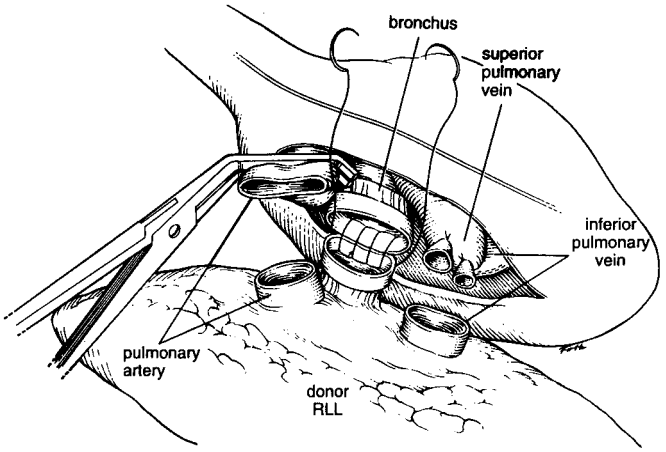

Fig. 4. Right lower lobe (RLL) implantation in the recipient. Donor inferior pulmonary vein is anastomosed to the superior pulmonary vein of the recipient.

recipient. The pulmonary artery anastomosis is performed last (Fig. 4). After the anastomoses on the second graft are completed, both lungs are gently inflated, and the recipient is weaned from cardiopulmonary bypass. At completion of the transplant operation, transesophageal echocardiography and bronchoscopy are performed to ensure that the vascular and bronchial anastomoses are technically and functionally adequate.

Recipient Postoperative Management

Depending on the degree of pulmonary infection and adhesions, most patients, especially those with cystic fibrosis, tend to be hemodynamically labile for the first 24 hours after transplantation. Inotropes and pressors, such as dopamine, are used for cardiovascular support as necessary. Most recipients remain on mechanical ventilation for 48 to 72 hours to avoid atelectasis and provide complete expansion of the undersized transplanted lobes. Minimal suction on chest tubes is used for the first day and is increased, if tolerated, to a maximum of 20 cm of suction. Chest tube drainage, which is usually serous, can be significant and prolonged. This is probably due to failure of the lobes to fill the entire hemithoraces. Postoperative immunosuppression consists of standard three-drug therapy, usually consisting of cyclosporine, azathioprine, and prednisone. *Pneumocystis carinii* prophylaxis with trimethoprim-sulfamethoxazole is routine. Cytomegalovirus (CMV) prophylaxis, consisting of CMV hyperimmune globulin combined with intravenous ganciclovir and oral acyclovir is given to all patients with a CMV-positive donor, regardless of the recipient's preoperative CMV status. Patients with CMV-negative donors receive oral acyclovir for the first 6 months after operation.

Patients are monitored for rejection based on their clinical picture and their pulmonary function tests. Those with clinical or laboratory evidence of rejection undergo bronchoscopy with bronchoalveolar lavage and transbronchial biopsies to confirm the diagnosis. Rejection episodes, when they occur, tend to be mild and are treated with pulsed steroids.

Table 5. 1-Year postoperative spirometry in recipients.

Test	Mean (%)	Range (%)
FVC	73	50–103
FEV_1	74	53–95
$DLCO/V_A$	87	52–103
$FEF_{25–75}$	90	66–150

FVC: forced vital capacity; FEV_1: forced expiratory volume at 1 second; $DLCO/V_A$: carbon monoxide diffusing capacity/alveolar ventilation; $FEF_{25–75}$: forced expiratory flow rate at 25% to 75% of forced vital capacity.

Results

Recipient Outcome

Recipient postoperative results have been reported on several occasions [6–9]. Since January 1993, more than 100 patients have undergone bilateral living-donor lobar transplantation. The 1-year Kaplan-Meier survival is 72%, which compares favorably with 1-year survival for cystic fibrosis patients who undergo bilateral cadaveric whole-lung transplantation. About 76% of deaths occur within the first 2 months after transplantation [7]. The most common cause of death has been infection, which accounts for 62% of the 1-year mortality. Other causes of mortality included multiorgan failure, chronic rejection, pulmonary embolism, and nonspecific graft failure. The incidence of rejection is 0.8 episodes per patient. Thirty percent of rejection episodes are unilateral, and most tend to be mild. All have responded to augmentation of steroid doses. The average number of HLA matches and mismatches has been 2.9 (range 0–6). Thus far, living-related donation has not appeared to provide recipients with an immunologic advantage over patients who receive lobes from unrelated donors.

Postoperative pulmonary function in recipients of bilateral live-donor lung transplantation improves steadily up to 9 to 12 months after operation, at which time it tends to plateau. The results of spirometry in 34 patients who have had at least 1 year of follow-up are listed in Table 5. Because of the theoretic concern over the potential for postoperative pulmonary hypertension, and the entire recipient cardiac output goes to only two lobes, 17 recipients (4 given transplants for primary pulmonary hypertension) have undergone postoperative right heart catheterization. The mean pulmonary artery pressure was 20 mmHg (range 13–38 mmHg), and the average pulmonary vascular resistance was 1.8 Woods units (range 1.0–1.4 Woods units) [7]. Chronic rejection manifesting as bronchiolitis obliterans has been diagnosed in 13% of patients. Of 47 patients surviving more than 2 months, 22 returned to work.

Donor Outcome

Since January 1993 a total of 137 patients have undergone donor lobectomy with a mean follow-up of 33 months. There have been 75 men and 62 women, with a mean age of 37 ± 12 years (range 18–52 years). Operations included left lower lobectomy (70 patents), right lower lobectomy (63 patients), and right middle and lower lobectomy (4 patients). Because of the close anatomic

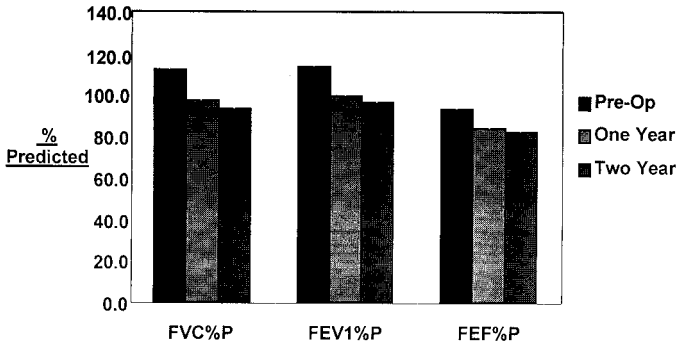

Fig. 5. Before and after operative spirometry after living-donor lobectomy for pulmonary transplantation. FVC%P: percent predicted forced vital capacity; FEV1%P: percent predicted forced expiratory volume at 1 second; FEF%P: percent predicted forced expiratory flow rate.

relation between the pulmonary arteries and bronchi of the right middle lobe and superior segment of the lower lobe, both lobes were removed from the first three right-sided donors to provide ample cuffs of pulmonary artery, vein, and bronchus for implantation. The middle lobe was then discarded. These patients all had prolonged postoperative air leaks. By accepting shorter vascular and bronchial cuffs on the donor lobes (2 mm is usually sufficient) and reconstructing the remaining pulmonary artery or bronchus when necessary, the need to remove the middle lobe with the right lower lobe has been eliminated.

The median postoperative hospital stay after donor lobectomy was 9 days (range 4–36 days). This was longer than expected and exceeds our mean hospital stay for lobectomies performed for lung cancer. Explanations include the fact that most of the dissection in the fissures on donor lobectomies is performed on the remaining side to limit air leaks in the recipient. Also, most donors have normal-size lungs that do not fill the remaining space as well as the more emphysematous lungs frequently seen in lung cancer patients. The result is prolonged air leaks or chest tube drainage in many patients. There has been no donor mortality. Five patients have required surgical reexploration during the early postoperative period for bleeding ($n = 2$), sterile empyema ($n = 1$), bronchopleural fistula ($n = 1$), or retained foreign body ($n = 1$). The only delayed complication of living-donor lobectomy requiring hospitalization has been pericarditis in six patients, two of whom required surgical drainage.

Spirometry after living-donor lobectomy is depicted in Figure 5. The FEV_1 decreases approximately 17%, although even after lobectomy values for most donors tend to stay in the normal range. All donors, including those whose recipients died postoperatively, are asked to fill out a Rand 36 Item Health Survey 1.0, which has been modified with questions that relate specifically to pulmonary donation for transplantation. After patients have recovered from their operations, scores rating physical function, social functioning, and role limitation due to physical and emotional health are well over 92 (of a possible score of 100). Eighty-five percent of donors said that their health was no different or had improved since donation. Ninety-nine percent of patients have responded that they felt no pressure to donate and had no regrets having donated [10].

Discussion

The concept of utilizing two living-donors for bilateral pulmonary transplantation was immediately controversial owing to the unknown risk to otherwise healthy donors. Whereas some decried the potential for "300% mortality" from involving three patients in a single transplant operation, most realized the value of tapping a new source of organs for lung transplantation. The addition of living donors to the donor pool benefits the list of potential recipients in two ways. First, it allows many patients to have transplants of living donor lobes who would otherwise die while waiting for a cadaveric donor. Second, by taking these recipients off the list, those who are not candidates for living-donor transplants may have a greater chance of undergoing transplantation.

The experience at USC demonstrates that living-donor lobar bilateral lung transplantation is a safe, reproducible procedure, with outcomes comparable to those with cadaveric lung transplantation. At present, this procedure seems best suited for children and small adults for whom normal-size or large donors can be found. The pulmonary function and hemodynamics provided by two transplanted lobes seems to be adequate for an excellent quality of life in these recipients. In fact, it is our hope that indications for this procedure can be expanded in the future.

Long-term and short-term morbidity associated with the donor lobectomy operation is acceptable. Though the operation tends to be technically more demanding than lobectomy for diseases such as lung cancer, it can be performed safely and with excellent results. With few exceptions, donor recovery has been uneventful. Quality of life and satisfaction with having participated are uniformly high.

Résumé

Depuis 1993, 101 transplantations du poumon, bilatérales, provenant de donneurs vivants ont été réalisées avec des résultats acceptables par rapport aux transplantations à partir des poumons de cadavre. Bien que la plupart des receveurs soient des patients ayant une fibrokystose en voie de dégradation rapide, les indications à la transplantation du poumon provenant de donneur vivant se sont étendues pour inclure d'autres cas plus sélectionnés de fibrokystose pulmonaire, ainsi que quelques autres patients ayant une maladie pulmonaire terminale. La survie des receveurs selon la méthode de Kaplan Meier a été de 72%. Soixante-six pourcent des morts se produisent pendant les deux premiers mois après la transplantation. La cause la plus fréquente de mortalité est l'infection, ce qui représente 62% de la mortalité à un an. L'incidence du rejet est de 0.8 épisodes/patient. Trente pourcent des épisodes de rejet sont unilatérales, et la plupart ont une tendance à être modéré. Deux cent trois donneurs (âge moyen 347 ± 12 ans (extrêmes 18–56)) ont eu une lobectomie: inférieure gauche (102 patents), inférieure droite (97 patients) et moyenne et inférieure droite (4 patients). On n'a observé aucune mortalité parmi les donneurs. Les scores de qualité de vie postopératoire selon la méthode Rand (36 questions), évaluant la fonction physique, la fonction sociale et la limitation en rapport avec la santé physique et émotionnelle, sont bien au-dessus de 92 (d'un maximum possible de 100). Quatre-vingt cinq pourcent des donneurs ont dit que leur état de santé était similaire ou s'était amélioré après la transplantation.

Resumen

Desde 1993 se han practicado 101 trasplantes bilaterales de donantes vivos con resultados aceptables al compararlos con trasplantes provenientes de donantes cadavéricos. Aunque la mayoría de los receptores han sido pacientes con fibrosis quística en rápido deterioro, las indicaciones para trasplante de donante vivo han sido ampliadas para incluir a algunos pacientes con fibrosis quística en un contexto más selectivo, así como a algunos pacientes seleccionados con enfermedad pulmonar terminal. La tasa Kaplan-Meier de supervivencia a un año es de 72%; el 77% de las muertes ocurre en los primeros 2 meses luego del trasplante, y la causa más frecuente es infección, la cual representa el 62% de la mortalidad a un año. La incidencia de rechazo es de 0,8 episodios/paciente. Treinta por ciento de los episodios de rechazo son unilaterales y la mayoría tiende a ser leve. Doscientos tres pacientes han sido sometidos a lobectomía donante con edad promedio de 37 ± 12 años (rango 18–56 años). Las operaciones incluyen lobectomía inferior izquierda (102 pacientes), lobectomía inferior derecha (97 pacientes) y lobectomía media e inferior derecha (4 pacientes). No se ha registrado mortalidad en los donantes. La calificación postoperatoria de calidad de vida por el método Raud de 37 interrogantes que determina estado funcional físico, funcionamiento social y limitaciones por enfermedad física y emocional, es superior a 92/100. De los donantes, el 85% expresa que su estado de salud no ha cambiado desde la donación.

References

1. Edwards, E.B., Guo, T., Bowen, G.R., Daily, O.P.: The UNOS OPTN waiting list from 1988 to 1993. Clin. Transplant. *20*:71, 1993
2. UNOS Annual Report. UNOS Web Site (www.unos.org), 1998
3. Shennib, H., Noirclerc, M., Ernst, P., Metras, D., Mulder, D.S., Giudicelli, R., Lebel, F., Dumon, J.F.: Double-lung transplantation for cystic fibrosis: the Cystic Fibrosis Transplant Study Group. Ann. Thorac. Surg. *54*:27, 1992
4. Sharples, L., Belcher, C., Dennis, C., Higenbottam, T., Wallwork, J.: Who waits longest for heart and lung transplantation? J. Heart Lung Transplant. *13*:282, 1994
5. Starnes, V.A., Oyer, P.E., Bernstein, D., Bakum, D., Gamberg, P., Miller, J., Shumway, N.E.: Heart, heart-lung, and lung transplantation in the first year of life. Ann. Thorac. Surg. *53*:306, 1992
6. J.P. Schwartz , R.G. Cohen , V.A. Starnes : Living-donor lung transplantation for cystic fibrosis. In Advanced Therapy in Thoracic Surgery, Franco, K., Putnam, J., editors, Cambridge, Blackwell Science, 1998, pp. 377–386
7. Barr, M.L., Schenkel, F.A., Cohen, R.G., Barbers, R.G., Fuller, C.B., Hagen, J.A., Wells, W.J., Starnes, V.A.: Recipient and donor outcomes in living related and unrelated lobar transplantation. Transplant. Proc. *30*:2261, 1998
8. Cohen, R.G., Barr, M.L., Schenkel, F.A., DeMeester, T.R., Wells, W.J., Starnes, V.A.: Living-related donor lobectomy for bilateral lobar transplantation in patients with cystic fibrosis. Ann. Thorac. Surg. *57*:1423, 1994
9. Starnes, V.A., Barr, M.L., Cohen, R.G.: Lobar transplantation. J. Thorac. Cardiovasc. Surg. *108*:403, 1994
10. Uppal, K.M., Barr, M.L., Schenkel, F.A., Hagen, J.A., Fuller, C.B., Wells, W.J., Chan, K.M., Barbers, R.G., Starnes, V.A., Cohen, R.G.: Five years of living lobar donation for bilateral lung transplantation: long term results in 137 donors. J. Heart Lung Transplant. *18*:77, 1999