

Case Report
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The First Living-Donor Lobar Lung Transplantation in Korea: a Case Report

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ABSTRACT

Lung transplantation is the only treatment for end-stage lung disease, but the problem of donor shortage is unresolved issue. Herein, we report the first case of living-donor lobar lung transplantation (LDLLT) in Korea. A 19-year-old woman patient with idiopathic pulmonary artery hypertension received her father's right lower lobe and her mother's left lower lobe after pneumonectomy of both lungs in 2017. The patient has recovered well and is enjoying normal social activity. We think that LDLLT could be an alternative approach to deceased donor lung transplantation to overcome the shortage of lung donors.

Keywords: Lung Transplantation; Living Donor; Lobar Lung Transplantation

INTRODUCTION

Lung transplantation is the only treatment for end-stage lung disease, but the problem of donor shortage is unresolved issue. To solve this, the following initiatives are needed: to increase the rate of organ donation when a brain-death occurs; to improve the usage rate of donated lungs; to use the lungs from cardiac-death donors; and to permit lobar lung transplantation from living donors. Herein, we report the first case of living-donor lobar lung transplantation (LDLLT) in Korea.

CASE DESCRIPTION

A 19-year-old woman visited a local hospital with a history of ongoing dyspnea on exertion, edema in her lower extremities, and ascites in May, 2015. She was diagnosed with idiopathic pulmonary artery hypertension (IPAH) and underwent conservative medical care including diuretics; however, heart failure was progressive. One year ago, on 28th July 2016, considering

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Disclosure

The authors have no potential conflicts of interest to disclose.

Author Contributions

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lung transplantation, she was transferred to Asan Medical Center in Seoul, Korea. At the time of the first admission, she had New York Heart Association (NYHA) class II activity impairment, and the initial echocardiography showed severe tricuspid regurgitation (TR), and severe pulmonary hypertension with right ventricular (RV) dysfunction. Sudden onset of cardiogenic shock and epileptic seizure developed during the first admission as well. The patient was put on the the waiting list for lung transplantation as a status II recipient; however, lungs were not allotted for more than 1 year despite worsening symptoms. One month prior to surgery, the patient was readmitted because of NYHA class IV dyspnea, ascites, and lower extremity edema. The symptoms were not controlled even with maximum medical treatment, including oral sildenafil 20 mg three times a day (t.i.d.), spironolactone 25 mg once a day (q.d.), furosemide 40 mg t.i.d., warfarin 2 mg q.d., and macitentan 10 mg q.d. The last echocardiography before operation reported very severe tricuspid valve regurgitation and severe resting pulmonary hypertension with right ventricle dysfunction (**Fig. 1**). The patient's parents understood that the patient was not likely to have a lung transplant in time and were on standby to be living donors for their daughter. Since the current organ transplantation law in Korea does not permit the harvest of lungs from a living person, we waited for a deceased donor and consulted with related academic societies and the government. The patient's condition deteriorated critically and the LDLT operation proceeded without the legal problem being solved.

The operation was performed on 21st October, 2017 at Asan Medical Center, Seoul, Korea. The operation was carried out using four operating rooms, two for organ harvesting from the parents, one for preservation of the harvested lobes, and one for the recipient. Before the operation, the lobes were selected according to the pulmonary function test and volumetric calculation using chest computed-tomography. When the right lower lobe of the father and left lower lobe from the mother were used, the predicted vital capacity was around 70%. From the chest computed tomography (CT) data, 3D-printed lung phantoms of the recipient and two donors were manufactured in order to assist surgical planning (**Fig. 2**). The operation was performed by a previously reported method.¹ While the recipient underwent bilateral pneumonectomy under cardiopulmonary bypass (CPB), the parent's lower lobes were harvested using thoracotomy. The harvested lung was perfused with a total of 1 L of Perfadex (Vitrolife, Goteborg, Sweden) antegradely through lobar pulmonary artery and retrogradely via inferior pulmonary vein. The right side was firstly anastomosed in the order of bronchus, pulmonary vein, and pulmonary artery. After finishing anastomoses on both sides, the CPB could be weaned smoothly and bleeding was controlled meticulously. The total operation time was about 7 hours and 30 minutes, after which the patient was transferred to the medical intensive care unit. However, postoperative bleeding was noticed 6 hours after the transplantation, and reoperation for bleeding control and hematoma evacuation was done on postoperative day 1. From then, the rest of the course in the hospital was uneventful. Perioperative medications including immunosuppression and prophylactic antibiotics used as previously reported.² The patient's endotracheal tube was removed on the 6th postoperative day. She was transferred to the general ward on the 16th day, and discharged on the 39th postoperative day. Both donors were discharged on the 6th postoperative day without any complications other than mild thoracotomy-related pain. Postoperative echocardiography showed normal left and right ventricle systolic function and trivial TR with mild resting pulmonary hypertension (**Fig. 1**). Preoperative and chest X-ray at discharge showed marked improvement of cardiomegaly (**Fig. 3**). A recent pulmonary function test reported 1.85 L (60%) of forced expiratory volume in 1 second, and 2.15 L (63%) of forced vital capacity (FVC) at 2 months after operation. As of 5 months after surgery, the patient's

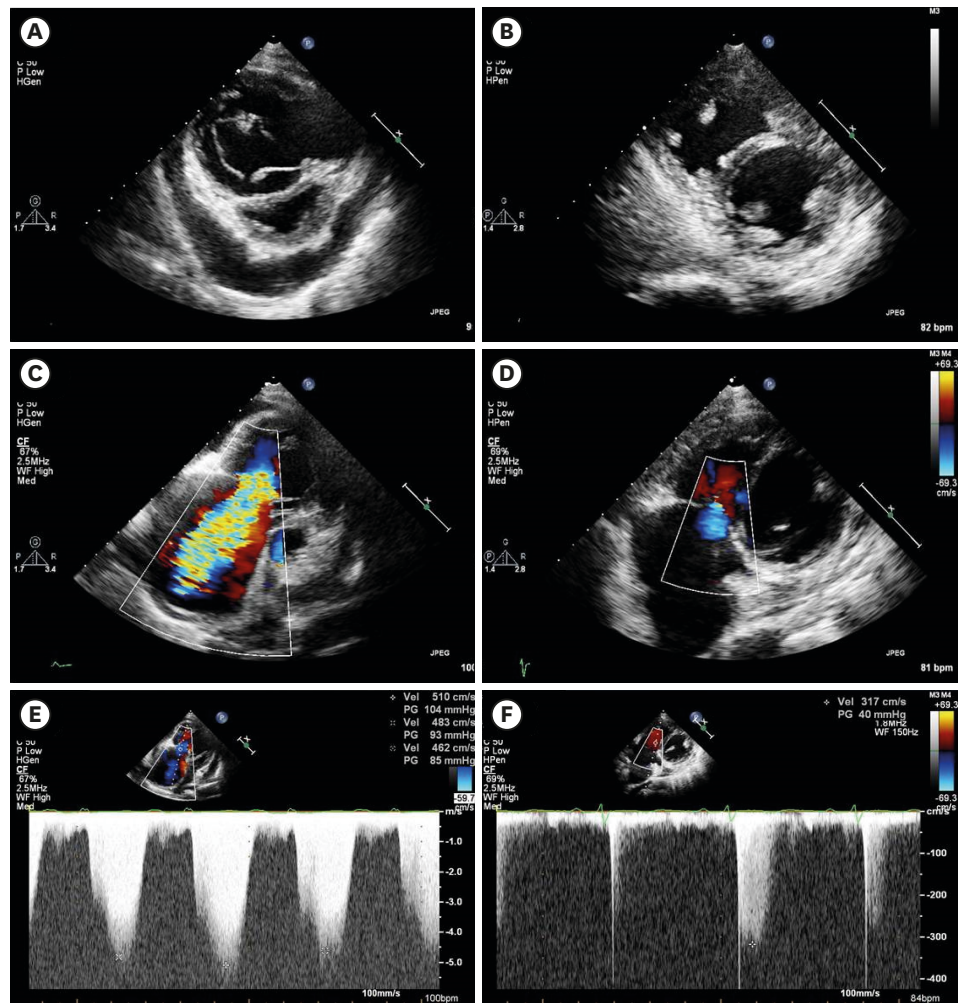


Fig. 1. Preoperative echocardiography (A, C, E) and postoperative echocardiography (B, D, F). Preoperative parasternal short axis view (A) demonstrated severe RV pressure overload with enlarged RV and D shaped left ventricle, compared with the remarkably decreased RV size postoperatively (B). Low parasternal view (C) showed severe dilation of right-sided heart with severe functional TR preoperatively. After transplantation, TR extent decreased significantly (D). The maximum TR velocity (TR Vmax) measured by continuous wave Doppler was 5.1 m/sec, suggestive of severe resting pulmonary arterial hypertension (estimated pulmonary arterial systolic pressure was 124 mmHg) (E). The follow-up echocardiography demonstrated TR Vmax decreased to 3.2 m/sec (F) 17 days after living-donor lobar lung transplantation. RV = right ventricular, TR = tricuspid regurgitation.

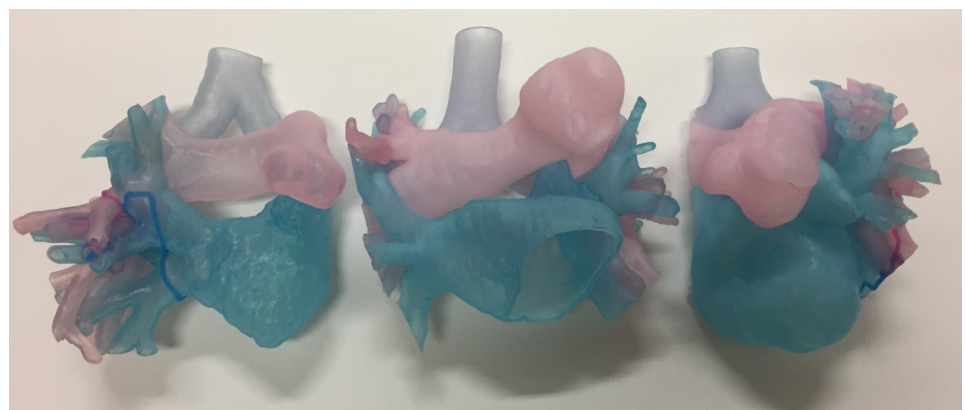


Fig. 2. 3D-printed lung phantoms of the recipient and two donors were manufactured in order to assist surgical planning. The middle one is the recipient's 3D models of pulmonary veins, pulmonary arteries and trachea, the left side is the father's right lung phantom, and the right one is the mother's left lung figures. 3D = three-dimensional.

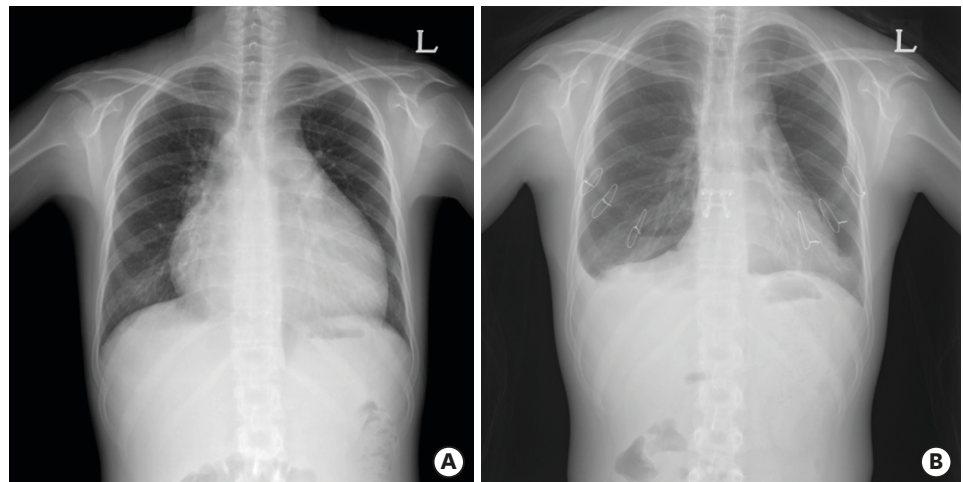


Fig. 3. Preoperative and postoperative chest PA taken on 39 days after transplantation. Compared with preoperative chest PA (A), postoperative chest PA shows marked improvement of cardiomegaly (B). PA = posteroanterior view.

condition is stable with NYHA class I activity and she is enjoying her social life, such as traveling with friends.

Ethics statement

Informed consent was submitted by the patient and the parents of the patient.

DISCUSSION

Lung is one of the most susceptible organs which can be damaged early when brain death occurred. Among 1,304 cases of brain death occurred between 2012 and 2016, 168 (12.9%) lung donations were actually transplanted to the recipients.³ This usage rate is remarkably low compared with those of kidney (94%), liver (86%), and heart (27.3%) donations. Considering that the rate of acquiring lungs in Japan is 63.0%,⁴ active intervention to increase the usage rate of the lungs in the event of brain death is necessary to overcome this donor-shortage issue. In specific conditions like this case, LDLLT is the only possible option to implant lungs in time before the patient's life threatened. IPAH is a disease that deteriorates the function of heart because of the increased resistance of pulmonary arteries, so the IPAH patients hardly get the status 0 or 1 according to the current Korean lung allocation score.⁵ However, in Korea, lungs are not included among the organs that can be explanted from a living person according to the organ transplantation law. We hope the law can be amended soon through this successful, first LDLLT case in Korea.

The LDLLT is a method of transplanting two lower lobes from two healthy donors to one recipient and was designed as an alternative to cadaveric lung transplantation (CLT) more than 20 years ago.⁶ One of the advantages of LDLLT over CLT is the possibility to control the timing of surgery, which allows the patient's lungs to be replaced before the patient's condition has deteriorated critically. It can be also helpful in pediatric patients with end-stage lung disease due to graft-versus-host reaction after bone marrow transplantation, whose condition is constantly deteriorating and yet their status remains low on the CLT waiting list. As for the other advantages of LDLLT, the extraction and transplantation of the lungs are

usually performed in the same hospital, which reduces the ischemia time. Additionally, the lobes from healthy donors remain functioning well without risk of infection or atelectasis, resulting in fewer postoperative complications, including graft failure or bronchial dehiscence.⁴ Regarding pulmonary function after implanting two lower lobes, the predicted FVC after LDLLT should be more than 50% of recipient, which is enough to maintain daily life and improves continuously until 2 years after surgery.⁷ Comparing the results of LDLLT to CLT, it seems that there is no significant difference between the two groups, even though some LDLLT reports from Japan have shown extraordinarily good 5-year survival.^{4,6,7}

Donor safety is one of the most important issues surrounding LDLLT. Lobectomy is a common procedure for the treatment of patients with various thoracic diseases, including lung cancer. After lower lobectomy, the lung function decreases by less than 20%; however, every LDLLT donor should show normal lung function, so this loss of lung function is not clinically meaningful with regard to enjoying daily life.⁷⁻⁹ Bowdish et al.⁹ reported that among 253 lung transplant donors, 20% (50/253) experienced donor complications, including minor problems such as prolonged air leakage or chest drainage. The need for re-operation due to bleeding accounted for 1.2%, bronchopulmonary fistula for 0.4%, and empyema for 0.4% of donor complications.⁹ The mortality after donation for LDLLT has not been reported so far. The RELIVE study in 2014 reported the results of a survey assessing the long-term stability of 369 LDLLT donors in the US from 1993 to 2006.¹⁰ Of the 369 donors surveyed, 18% experienced side effects, including reoperation (2.2%) and early re-admission (6.5%), with no mortality or need for lung transplantation; thus, they concluded that it is not appropriate to insist on LDLLT if the lungs from brain death donors are available. Recently, LDLLT is performed mainly in Japan, where since its introduction in 1998, the majority of lung transplantation patients have undergone LDLLT until 2010 when the revised Japanese Organ Transplant Law permitted the families of brain-dead patients to donate their organs. In 2015, among a total of 61 cases of lung transplantation in Japan, more than two-thirds of the cases used brain-dead donors.⁴

In conclusion, we report that the first LDLLT case in Korea was done successfully by the Asan Medical Lung Transplantation Team in 2017. The 19-year-old woman patient with IPAH received a lower lobe from each parent. The LDLLT could be an alternative approach to CLT to overcome the shortage of lung donors.

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