Spirometry After Transplantation: How Much Better Are Two Lungs Than One?

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Background. The purpose of this study was to determine how much double lung transplantation improves lung function over single lung transplantation and to identify predictors of lung function after transplantation.

Methods. From February 1990 to November 2005, 463 adults underwent lung transplantation. Among 379 of these patients (82%), 6372 evaluations of postoperative normalized forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC) were analyzed using longitudinal temporal decomposition methods for repeated continuous measurements. We characterized the time course of postoperative spirometry, compared it between double and single lung transplantation, and identified its modulators.

Results. FEV_1 (% of predicted) was only somewhat better after double than single lung transplantation (65%, 58%, and 59% vs 51%, 43%, and 40% at 1, 3, and 5 years, $p = 0.03$), as was FVC (% of predicted) (67%, 68%, and 66% vs 62%, 56%, and 51%, $p < 0.0001$). Both FEV1% and FVC% increased sharply to 1 year. For double lung transplantation, these values persisted, with minimal decline to 5 years; but for single lung transplantation, they continuously declined to 5 years. Values for double lung transplantation remained higher than for single lung transplantation at all time points but never approached twice the value. Patients undergoing double lung transplantation for emphysema had the highest postoperative FEV1% and FVC%, but also the lowest values for single lung transplantation; the benefit of double lung transplantation was between these values for other diagnoses.

Conclusions. Spirometry weakly favors double lung over single lung transplantation. The advantage of spirometry values alone may not justify double lung transplantation.

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The advantage of double lung transplantation (LTx) over single LTx remains debated [1]. Data suggest a survival advantage for patients undergoing double LTx for emphysema, although this advantage has not been well demonstrated for other transplant indications [2–4]. Although some studies have focused on predictors of postoperative lung function after LTx and the impact of single vs double LTx, they have been limited to patients who have received a transplant for emphysema or the relative impact of bronchiolitis obliterans syndrome (BOS) [5–10].

In this study, we examined spirometry of a large cohort of patients with multiple longitudinal pulmonary function tests to assess temporal trends and compare outcomes of single and double lung LTx for all transplant indications and regardless of BOS. This seems particularly important in determining the incremental value of double LTx compared with single LTx and for the purpose of organ allocation. For all patients who received a LTx at the Cleveland Clinic Lung Transplant Program, we analyzed spirometry performed uniformly in our pulmonary function laboratory. Our goal was to determine how much double LTx provides improved pulmonary function vs single LTx and to identify predictors of post-LTx pulmonary function.

Patients and Methods

Patients

From February 1990 to November 2005, 463 patients older than age 18 years underwent primary LTx for end-stage lung disease at Cleveland Clinic, exclusive of heart–lung transplantation. Recipient, donor, and surgical data were extracted from the Unified Transplant Database, which has been approved for use in research by the Institutional Review Board (IRB), with patient consent waived.

Results of spirometry performed in the Cleveland Clinic's certified pulmonary function laboratory, which conforms to the standards of the American Thoracic Society, were retrieved from the Pulmonary Function Test database [11]. The IRB approved supplemental review of medical records, also with patient consent waived. The mean age of patients at LTx was 48 ± 12 years (range, 18 to 71 years), and 50% were men (Table 1).

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Table 1. Recipient, Donor, and Transplant Details: Single Versus Double Lung Transplant

Characteristic	Double LTx (n = 194)		Single LTx (n = 269)		*p* Value
	n[a]	No. (%) or Mean ± SD	n[a]	No. (%) or Mean ± SD	
Recipient					
Pulmonary function					
FEV1 (% of predicted)	148	30 ± 19	191	25 ± 14	0.02
FVC (% of predicted)	148	46 ± 18	191	51 ± 15	0.001
FEV1/FVC	147	0.68 ± 0.36	191	0.54 ± 0.34	<0.0001
Pulmonary artery pressures, mm Hg[b]					
Systolic	69	51 ± 29	165	38 ± 14	0.006
Diastolic	68	26 ± 16	164	19 ± 7.8	0.01
Mean	56	34 ± 19	140	26 ± 10	0.07
Demography	194		269		
Women		96 (49)		133 (49)	1.0
Race					
Caucasian		172 (89)		252 (94)	0.06
African American		16 (8.2)		14 (5.2)	0.2
Age, years		39 ± 12		55 ± 7.7	<0.0001
Height, cm		170 ± 10		170 ± 11	1.0
Weight, kg		65 ± 18		71 ± 16	<0.0001
Body mass index, kg/m^2		23 ± 5.2		25 ± 5.3	<0.0001
Comorbidities					
Hypertension	184	14 (7.6)	242	32 (13)	0.06
History of smoking	140	61 (44)	178	155 (87)	<0.0001
Serum creatinine	182	0.79 ± 0.34	240	0.73 ± 0.25	0.1
Serology/immunology					
PRA	193	1.6 ± 5.8	268	2.1 ± 8.6	0.8
Blood type A	194	83 (43)	269	112 (42)	0.8
Blood type AB	194	7 (3.6)	269	12 (4.5)	0.6
Blood type B	194	27 (14)	269	27 (10)	0.2
Blood type O	194	77 (40)	269	118 (44)	0.4
Rh+	194	159 (82)	266	228 (86)	0.3
Indication for transplant	194		269		
α-1 antitrypsin deficiency		10 (5.2)		32 (12)	0.01
Bronchiectasis		11 (5.7)		0 (0)	<0.0001
COPD		29 (15)		154 (57)	<0.0001
Cystic fibrosis		76 (39)		0 (0)	<0.0001
Eisenmenger disease		2 (1)		4 (1.5)	0.7
IPF		31 (16)		50 (19)	0.5
PPH		14 (7.2)		8 (3)	0.03
Sarcoidosis		9 (4.6)		7 (2.6)	0.2
Donor					
Demography					
Women	191	97 (51)	267	130 (49)	0.7
Race					
Caucasian	194	162 (84)	269	244 (91)	0.02
African American	194	28 (14)	269	21 (7.8)	0.02
Age, years	185	35 ± 15	251	37 ± 14	0.3
Height, cm	194	170 ± 11	269	170 ± 11	0.9
Weight, kg	194	71 ± 18	268	72 ± 20	0.9
Body mass index, k/m^2	194	25 ± 5.9	268	25 ± 5.8	0.7
Serology/immunology					
Blood type A	194	61 (31)	269	84 (31)	1.0
Blood type AB	194	1 (0.52)	269	3 (1.1)	0.5
Blood type B	194	23 (12)	269	19 (7.1)	0.08