

# 320e Lung Transplantation

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Lung transplantation is a therapeutic consideration for many patients with nonmalignant end-stage lung disease, and it prolongs survival and improves quality of life in appropriately selected recipients. Since 1985 almost 40,000 procedures have been recorded worldwide, and since 2009 more than 3000 transplants have been reported annually.

## INDICATIONS

The indications span the gamut of lung diseases, but in some respects the distribution of indications differs among countries. According to aggregate international data, the most common indications in the last few years have been chronic obstructive pulmonary disease (COPD), ~29%; idiopathic pulmonary fibrosis (IPF), ~28%; cystic fibrosis (CF), ~16%;  $\alpha_1$ -antitrypsin deficiency emphysema, ~3.5%; and idiopathic pulmonary arterial hypertension (IPAH), ~3%. Other diseases have made up the balance of primary indications, and retransplantation has accounted for ~3% of procedures.

## RECIPIENT SELECTION

Transplantation should be considered when other therapeutic options have been exhausted and when the patient's prognosis is expected to improve as a result of the procedure. Survival rates after transplantation can be compared with predictive indices for the patient's disease, but each patient's clinical course must be integrated into the assessment as well. Moreover, quality of life is a primary motive for transplantation for many patients, and the prospect of improved quality-adjusted survival is often attractive even if the survival advantage itself may be marginal.

Disease-specific consensus guidelines for referring patients for evaluation and for proceeding with transplantation are summarized in Table 320e-1 and are linked to clinical, physiologic, radiographic, and pathologic features that influence the prognosis of the respective diseases. Candidates for lung transplantation are also thoroughly screened for comorbidities that might affect the outcome adversely. Conditions such as systemic hypertension, diabetes mellitus, gastroesophageal reflux, and osteoporosis are not unusual; however, if uncomplicated and adequately managed, they do not disqualify patients from transplantation. The upper age limit is ~70 years at most centers, but the median age of recipients has been increasing steadily over the last decade. In the United States in 2009, 22% of recipients were  $\geq 65$  years old.

Standard exclusions include HIV infection, chronic active hepatitis B or C infection, uncontrolled or untreatable pulmonary or extrapulmonary infection, uncured malignancy, active cigarette smoking, drug or alcohol dependency, irreversible physical deconditioning, chronic nonadherence with medical care, significant disease of another vital organ (e.g., heart, liver, or kidney), and psychiatric or psychosocial situations that could substantially interfere with post-transplantation management. Other problems that may compromise outcome constitute relative contraindications. Some typical issues are ventilator-dependent respiratory failure, previous thoracic surgical procedures, obesity, and coronary artery disease. Chronic infection with antibiotic-resistant *Pseudomonas* species, *Burkholderia* species, *Aspergillus* species, or nontuberculous mycobacteria is a unique concern in some patients with CF. The potential impact of these and other factors must be judged in the clinical context to determine an individual candidate's suitability for transplantation.

## WAITING LIST AND ORGAN ALLOCATION

Organ allocation policies are influenced by medical, ethical, geographic, and political factors, with systems varying from country to country. Regardless of the system, potential recipients are placed on a waiting list and must be matched for blood group compatibility and, with some latitude, for lung size with an acceptable donor. Most lungs are procured from deceased donors after total brain failure ("brain

TABLE 320e-1 DISEASE-SPECIFIC GUIDELINES FOR REFERRAL AND TRANSPLANTATION

### Chronic Obstructive Pulmonary Disease

#### Referral

BODE index  $>5$

#### Transplantation

BODE index 7–10

or

Any of the following criteria:

Hospitalization for exacerbation, with  $Pa_{CO_2} >50$  mmHg

Pulmonary hypertension or cor pulmonale, despite oxygen therapy

$FEV_1 <20\%$  with either  $DL_{CO} <20\%$  or diffuse emphysema

### Cystic Fibrosis / Bronchiectasis

#### Referral

$FEV_1 <30\%$  or rapidly declining  $FEV_1$

Hospitalization in ICU for exacerbation

Increasing frequency of exacerbations

Refractory or recurrent pneumothorax

Recurrent hemoptysis not controlled by bronchial artery embolization

#### Transplantation

Oxygen-dependent respiratory failure

Hypercapnia

Pulmonary hypertension

### Idiopathic Pulmonary Fibrosis

#### Referral

Pathologic or radiographic evidence of UIP, regardless of vital capacity

#### Transplantation

Pathologic or radiographic evidence of UIP

and

Any of the following criteria:

$DL_{CO} <39\%$

Decrement in FVC  $\geq 10\%$  during 6 months of follow-up

Decrease in  $Sp_{O_2}$  to  $<88\%$  during a 6-min walk test

Honeycombing on HRCT (fibrosis score  $>2$ )

### Idiopathic Pulmonary Arterial Hypertension

#### Referral

NYHA functional class III or IV, regardless of therapy

Rapidly progressive disease

#### Transplantation

Failure of therapy with IV epoprostenol (or equivalent drug)

Persistent NYHA functional class III or IV during maximal medical therapy

Low ( $<350$  m) or declining 6-min walk test

Cardiac index  $<2$  L/min per  $m^2$

Right atrial pressure  $>15$  mmHg

**Abbreviations:** BODE, body mass index (B), airflow obstruction (O), dyspnea (D), exercise capacity (E);  $DL_{CO}$ , diffusing capacity for carbon monoxide;  $FEV_1$ , forced expiratory volume in 1 s; FVC, forced vital capacity; HRCT, high-resolution computed tomography; ICU, intensive care unit; NYHA, New York Heart Association;  $Pa_{CO_2}$ , partial pressure of carbon dioxide in arterial blood;  $Sp_{O_2}$ , arterial oxygen saturation by pulse oximetry; UIP, usual interstitial pneumonitis.

**Source:** Summarized from JB Orens et al: J Heart Lung Transplant 25:745, 2006. For BODE index, BR Celli et al: N Engl J Med 350:1005, 2004.

death"), but only ~15–20% of brain-death organ donors yield either one or two lungs suitable for transplantation. Lungs from donors after cardiac death have been utilized to a limited extent (~2% of lung donors in the United States in 2009). Recently, ex vivo lung perfusion has been used by some centers to assess donor lungs that are marginal or high-risk for implantation by standard criteria; if the results of ex vivo testing are satisfactory, these lungs have been transplanted successfully.

In the United States, a lung allocation scoring system is used to prioritize patients on the waiting list. The lung allocation score (LAS) for a patient is based on the patient's risk of death during 1 year on