Imaging in Lung Transplantation

Surgical Considerations of Donor and Recipient

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KEYWORDS

• Lung transplant • Transplant evaluation • Transplant surgery • Computed tomography

KEY POINTS

- Imaging is an essential part of the evaluation process for potential lung transplant donors and recipients.
- Extended lung donor criteria and emerging techniques in donor management have become more common as a means of increasing the donor pool.
- Radiologists must be knowledgeable in identifying anatomic abnormalities and medical conditions with implications for surgical techniques in transplantation.

INTRODUCTION

The first lung transplant was performed in 1963 by Hardy and coworkers.[1] Since then, lung transplantation has advanced to become an effective treatment for patients with end-stage lung disease. The medical and ethical complexities and resource use involved in organ transplantation require thorough clinical work-up to ensure maximal benefit for each transplant performed. Imaging plays a critical role in pretransplant assessment for lung transplant recipients and donors. In the recipient, imaging can identify clinical features that require modifications in surgical technique. In the donor, imaging is useful to identify conditions associated with poor clinical outcomes. This article describes the interpretation of radiologic studies in the assessment of lung transplant donors and recipients and implications for work-up and management.

DONOR EVALUATION

Despite the rise in number of lung transplants performed in the United States, availability of suitable donors is the main limitation for continued growth. The number of lungs transplanted per deceased donor has increased from 0.25 in 2000 to 0.39 in 2012, yet 75% of all lung offers are not accepted for transplantation.[2–5] Many potential donors are excluded from donation based on radiographic examinations. Twelve percent of potential lung donors are rejected for findings on chest radiograph alone (**Table 1**).[6] The most common imaging

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Table 1
Reasons for declining potential lung donors

Low Pao_2/Fio_2 ratio	11%
Abnormal chest radiograph	12%
Abnormal bronchoscopy	16%
Abnormal intraoperative examination	18%
Postharvest assessment	2%

Abbreviation: Fio_2, fraction of inspired oxygen.
From Alvarez A, Moreno P, Espinosa D, et al. Assessment of lungs for transplantation: a stepwise analysis of 476 donors. Eur J Cardiothorac Surg 2010;37(2):435.

findings for rejection are pulmonary consolidation or contusion (**Table 2**). It is estimated that many more organs might be suitable for transplant with a missed opportunity rate of 200 organs per year. Many of these missed opportunities represent donors who fail to meet strict donation. As such, extended donor criteria have been developed to liberalize selection without compromising clinical outcomes (**Table 3**).[2,7–9]

Table 3
Lung donor criteria

Standard Donor Criteria	Extended Donor Criteria
Age >55 y	Age >55 y
Pao_2/Fio_2 (Fio_2, 1.0; PEEP, 5 cm H_2O) >300 mm Hg	Pao_2/Fio_2 (Fio_2, 1.0; PEEP, 5 cm H_2O) <300 mm Hg
Clear chest radiograph	Abnormalities on chest radiograph
Smoking history <20 pack-years	Smoking history >20 pack-years
Absence of aspiration	Aspiration
Absence of chest trauma	Chest trauma
Absence of overt lung infection	Donation after circulatory death
—	Ischemic time >6 h (single lung transplant)

Abbreviations: Fio_2, fraction of inspired oxygen; PEEP, positive end-expiratory pressure.

Donor Management

Protocols that address clinical conditions associated with worse outcomes following lung transplant show promise for increasing the organ donor pool. Lung management protocols in brain-dead donors using protective ventilation strategies, fluid restriction, and hormonal resuscitation have been shown to increase the rate of donor use.[10,11] Although not yet universal, new ventilation modes have also been developed with the goal of resuscitating marginal organs and have yielded lung retrieval rates four times higher than historic controls.[12] The newest, innovative tool for optimizing marginal donors for lung transplant is the ex vivo lung perfusion system. This technique was originally developed to assess donors after circulatory death and has since been used in clinical trials to extend cold ischemic time and resuscitation of marginal donors. Results from the ex vivo system demonstrate safety, high rates of successful transplantation, and short-term recipient outcomes similar to recipients from conventional donors.[13–16]

Table 2
Chest radiograph findings for rejected lung donors

Normal	82%
Infiltrate/contusion	9%
Pleural effusion/ pneumothorax	4%
Extensive atelectasis	3%
Pulmonary edema	1%
Not available	1%

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Pulmonary Complications Following Brain Death

Brain-deceased donors comprise 99% of all lung transplant donors.[17] Brain death is associated with major systemic changes with direct impact on suitability for organ donation. The most common physiologic changes associated with brain death include need for vasopressor support (97%), coagulopathy (55%), thrombocytopenia (54%), diabetes insipidus (46%), cardiac ischemia (30%), lactic acidosis (25%), and renal failure (20%).[18] Neurogenic pulmonary edema is a common complication of significant central nervous system injury. Development of pulmonary edema after neurologic insult is abrupt, but the cause is incompletely understood. Blast injury, which results in a catecholamine-induced capillary leak, is one proposed mechanism for its development.[19,20] Pulmonary edema leads to poor gas exchange, resulting in low Pao_2/fraction of inspired oxygen ratios and