Imaging the Complications of Lung Transplantation

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KEYWORDS

• Lung transplant • Computed tomography • Anastomotic complications • Pleural complications • Rejection • Infection

KEY POINTS

- Radiography and computed tomography (CT) are considered workhorse imaging modalities as they are widely available and can detect and characterize most posttransplant complications.
- Within reason, the increased radiation exposure related to CT should be less of a concern in lung transplant patients given their limited long-term survival.
- Anastomotic complications are important but are becoming less common because of improvements in graft preservation, surgical technique, and immunosuppression.
- Grouping complications by their predominant imaging finding and along a timeline including the early, intermediate, and late posttransplant periods can help when generating a differential diagnosis.

INTRODUCTION

With advances in surgical technique and immunosuppressive drug regimens, lung transplantation has become the sole treatment option for patients with a variety of end-stage lung disease. The International Society for Heart and Lung Transplantation (ISHLT) reports that through 2013 nearly 50,000 lung transplants have been performed worldwide.[1] However, long-term survival remains disappointing with only a 5.3-year median survival after transplant, primarily due to complications.[2] Detecting and treating complications are crucial to improving patient outcomes. The goal of this article is to explore the role of imaging in the diagnosis of lung transplant complications.

IMAGING MODALITIES AND TECHNIQUES

A variety of imaging modalities are available for evaluating lung transplant complications, each having its own unique strengths and weaknesses, which are covered in **Table 1**. Radiography and computed tomography serve (CT) as the workhorse modalities. Although these modalities use ionizing radiation, the risks of radiation-induced malignancy are minimal in this population with limited long-term survival.[3]

SURGICAL TECHNIQUE

Single lung transplant (SLT) is performed through a lateral thoracotomy. The lung to be removed is deflated and mobilized; the hilar structures are transected; the donor lung replaces the lung. The graft is implanted with 3 anastomoses, which are performed in their posterior-to-anterior anatomic sequence: bronchus, pulmonary artery, and pulmonary veins-left atrium. The surgical technique used for double lung transplants (DLTs) is the bilateral sequential operation, which is done through a

Disclosure: The authors of this article do not have any relevant financial disclosures.
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Radiol Clin N Am 54 (2016) 355–373
http://dx.doi.org/10.1016/j.rcl.2015.09.014
0033-8389/16/$ – see front matter

Table 1
Imaging modalities: strengths and weaknesses

Imaging Modality	Indications	Strengths	Weaknesses
Chest radiography	• Evaluation of lines/tubes • Evaluation of effusion, pneumothorax • Limited evaluation of interstitial and airspace disease	• Inexpensive • Quick • Can be done portably	• Subtle findings of infection and rejection not well evaluated • Only secondary signs of vascular complications visible
CT and CT angiography	• Evaluation of lung parenchyma, interstitium, airways, and pleura • Evaluation of vessels with addition of intravenous contrast	• Excellent resolution • Short examination time • Exhalation images can evaluate air trapping, bronchomalacia • Direct evaluation of vascular structures	• Expensive (relative to CXR) • Cannot be performed portably
MR imaging and MR angiography	• Evaluation of vascular complications • Evaluation of fluid collections	• No radiation • Superior tissue characterization	• Expensive • Long examination times • Inability to image patients with claustrophobia and certain implantable devices
Ventilation/perfusion scintigraphy	• Evaluation of quantitative lung function • Evaluation for pulmonary embolism	• Can obtain split pulmonary functional analysis	• Time consuming • Interpretation can be difficult, especially in the early posttransplant period
PET CT	• Diagnosis and staging PTLD and other malignancies	• Helpful in staging and monitoring response to treatment	• Expensive • Limited availability • Long examination times
Ultrasound	• Evaluation of pleural fluid, fluid collections	• Inexpensive • Can be done portably	• Has a limited role, aside from evaluating pleural fluid

Abbreviations: CT, computed tomography; MR, magnetic resonance; PTLD, posttransplant lymphoproliferative disorder.

clamshell incision with transverse sternotomy; it otherwise uses the same technique as SLT, just applied to both lungs sequentially.[4,5]

The bronchial anastomosis is most prone to complications due to disruption of bronchial arterial blood supply. A variety of modifications have been performed in an attempt to reduce complications. One of the more common is the telescoping anastomosis.[6] With improving surgical techniques and immunosuppression, many surgeons now favor the end-to-end anastomosis with a tissue wrap.[7] Telescoping anastomosis is still used at some centers, especially when there is size discrepancy between the native bronchus and the allograft bronchus.[6]

RELEVANT ANATOMY

Most serious posttransplant complications occur within the graft.[2] Knowledge of relevant pulmonary anatomy helps the radiologist understand the imaging findings. The authors break pulmonary anatomy down into 3 compartments: airways, airspaces, and interstitium.

Airways

Airways within the graft constitute the conducting zone, which conveys gas to and from the airspaces. They are made up of bronchi, bronchioles, and terminal bronchioles.[8] Common findings directly visible on imaging include bronchiectasis and bronchial wall thickening. Bronchiolar disease can be inferred based on the presence of air trapping.

Airspaces

Airspaces make up the respiratory zone where gas exchange takes place. They contain respiratory