CT images after Lung Transplantation

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Introduction

• Nearly 50,000 lung transplantation have been performed until 2013 in the world.

• In our hospital, 51 cases have undergone lung transplantation during 2000-2016.

• Complications may follow after lung transplantation
  - early (~1 week)
  - intermediate (1 week ~ 2 months)
  - late (2 months ~)

And we also show radiographs cases that we have experienced.
Early Posttransplant Period (~1 week)

- Surgical complications
  - Pulmonary vein thrombosis
  - Pulmonary thromboembolism
  - Phrenic nerve paralysis

- Pleural complications
  - Pleural effusion
  - Pneumothorax
  - Hemothorax

- Airspace & interstitial disease
  - Hyperacute rejection
  - Graft size mismatch
  - Primary graft dysfunction
  - Lobar torsion
  - Pulmonary edema
Surgical complications

Pulmonary vein thrombosis

Thrombi are formed at the pulmonary venous/left atrial anatomic suture line. They may carry the risk of systemic embolization and cerebrovascular accident, and obstruct pulmonary venous outflow and cause severe pulmonary edema.

Clinical features include hypoxemia, decreased lung compliance, and diffuse radiographic opacities in the allograft. But some cases were detected incidentally by transesophageal echocardiography without any symptoms.

Surgical complications

**Pulmonary thromboembolism (PE)**

PE can occur at any time after lung transplantation but is most common in the early period. Postoperative immobility and hypercoagulability are important risk factors.

**Imaging findings**

On CXR, Westermark sign (focal peripheral hyperlucency and central pulmonary vessels may also be dilated), secondary findings of infraction: Hampton hump sign (a dome shaped, pleural-based opacification) and unilateral pulmonary oligemia are seen.

On CT, a centralized pulmonary artery filling defect with a rim of surrounding contrast is seen.

Pleural complications

◆ Pleural effusions

Pleural effusions are very common in early posttransplant period. The contributing factors are increased alveolar capillary permeability, because of allograft ischemia, denervation and subsequent reperfusion, disruption of lymphatic flow, pulmonary venous stenosis and thrombosis.

Pleural complications

◆ **Pneumothorax**

Pneumothorax is a common complication after transplantation.

It may occur in a variety of settings: undersized donor lung for recipient, anastomotic leak, iatrogenic complications, infection, and disease in the native lung.

Most pneumothoraces subside by themselves within a few days; however, 10% of cases last more than 2 weeks or recur.

38y.o. male underwent heart and lung transplantation (6 days after surgery).

CT shows pneumothorax in the right lung.
Pleural complications

♦ Hemothorax

Hemothorax occurs in up to 15% of transplants. Dissection of vascular adhesions is needed to remove the native lung, resulting in surface oozing. Patients with sarcoidosis, retransplantation, and dense pleural adhesions are at high risk.

On CXR, hemothorax is difficult to distinguish from pleural effusion. On CT, acute hemothorax increases attenuation, 35-70 Hounsfield units (HU).

38y.o. female underwent left lung transplantation (3 days after surgery). CT shows pneumothorax in the right lung.
Airspace & interstitial disease

◆ Hyper acute rejection (HAR)

HAR is associated with humoral rejection: the presence of preformed antibodies in the recipient against major histocompatibility complex (MHC) of the donor.

It occurs within 24 hours (most cases occur few hours after transplant).

◆ Imaging findings

CXR shows diffuse homogeneous infiltration of the entire allograft.

◆ Graft size mismatch

Size differences of 10%–25% between a donor lung and a recipient thoracic cage have been reported to be acceptable.

◆ Imaging findings

CXR & CT show areas of atelectasis that manifest as linear areas of consolidation.

Airspace & interstitial disease

◆ Primary graft dysfunction (PGD)

PGD is a severe, acute lung injury syndrome occurring in the first 72 hours after lung transplantation.

A number of factors are considered: donor’s age, donor’s smoking history, donor’s fat embolism and thromboembolism, recipient’s pulmonary hypertension, and preformed antibodies to intercellular antigens.

The severity of PGD is graded:

- Grade 0: \( \frac{\text{PaO}_2}{\text{FiO}_2} > 300 \) and normal chest radiograph
- Grade 1: \( \frac{\text{PaO}_2}{\text{FiO}_2} > 300 \) and diffuse allograft infiltrates on chest radiograph
- Grade 2: \( 200 \leq \frac{\text{PaO}_2}{\text{FiO}_2} \leq 300 \)
- Grade 3: \( \frac{\text{PaO}_2}{\text{FiO}_2} < 200 \)

It increases the risk of subsequent bronchiolitis obliterans syndrome (BOS)

Airspace & interstitial disease

◆ **Lobar torsion**

Lobar torsion is rare and result in ischemia and infraction of the affected lobe.

The risk factors postulated are the normal division of the pulmonary ligament during allograft procurement, size discrepancy, and the presence of a complete major fissure.

**Imaging findings**

CXR shows abnormal opacity of the hilum and increased opacity of the involved lobe.

CT shows tapering of the pulmonary artery and adjacent bronchus to the involved lobe with increased soft tissue density at the hilum. The torsioned lobe may show areas of ground glass opacity, consolidation, and interlobular septal thickening.
◆ Pulmonary edema

Pulmonary edema develops in over 50% of patients after lung transplantation.

It consists of morphologic, functional, and roentgenographic changes that occur in the allograft in the early posttransplantation period.

CXR shows upper lobe pulmonary venous diversion, cardiac enlargement, peri-bronchial cuffing, Kerley lines, bat wing pulmonary opacities, and pleural effusions.

CT shows ground-glass opacities with smooth interlobular septal thickening and pleural effusions.

22y.o. male underwent heart and lung transplantation (6 days after surgery). CXR showed bilateral consolidation and ground-glass opacities. CT showed ground-glass opacities and septal thickening and pleural effusion.
Intermediate Posttransplant Period (1 week ~ 2 months)

- Surgical complications
  - Bronchial dehiscence
  - Pulmonary artery stenosis
- Pleural complications
  - Chylothorax
  - Empyema
- Airspace and interstitial disease
  - Acute rejection
  - Infection
  - Pulmonary infarction
  - Acute fibrinous and organizing pneumonia
Surgical complications

**Bronchial dehiscence**

Bronchial dehiscence typically occurs within the first 1-5 weeks. The reported incidence is between 1-10%. Most cases with complete dehiscence lead to sepsis.

**Imaging findings**

CXR are unreliable. On CT, dehiscence can be identified by the presence of bronchial wall irregularities, external air around the anastomosis, or a combination of these features.

Bronchial wall defects of 4mm or less have been shown to have excellent clinical outcomes, whereas, the outcome of larger defects is unpredictable.
Surgical complications

- **Pulmonary artery stenosis**

Pulmonary artery stenosis has been reported early and late complication of lung transplantation. Causes include excessive length of donor and recipient segments. Stenosis usually results from excessive length at the anastomotic site, leading to pulmonary hypertension and right heart failure.

CT angiography shows a narrowing at the anastomotic site.

47y.o. male underwent right lung transplantation (2 months after surgery). CT showed right pulmonary artery narrowing at the anatomic site.

Pleural complications

♦ Chylothorax
Chylothorax occurs when the thoracic duct is damaged. It is common in cases with pleural adhesion or lymphangioleiomyomatosis.
It is difficult to distinguish chylothorax from other causes of effusion by images.

♦ Empyema
Empyema complicates 4~7% of transplants.
Emphyema should be suspected when a new effusion develops within 4 weeks of transplant, especially if the effusion appears loculated.

On CXR, pleural fluid is typically unilateral or markedly asymmetric.
The lenticular shape is also suggestive.
On CT, a fluid density collection in the pleural space are seen, sometimes with locules of gas. At the margins of the empyema, the pleura can be seen dividing into parietal and visceral layers, the so-called split pleura sign.

Airspace and interstitial disease

**Acute rejection**

Acute rejection is a significant problem in lung transplantation. It occurs most likely in the first 6 months following lung transplantation. It is responsible for 4% of deaths in the first 30 days.

Acute rejection is more related to acute cellular rejection than humoral rejection.

Risk factors are HLA mismatching, genetic factors (IL-10, CCL4L, TLR4 etc.), immunosuppression regimen, age (18~34 years), Vit. D deficiency.

**Imaging findings**

CXR may demonstrate perihilar opacities and interstitial edema with/without pleural effusion, but the sensitivity and specificity are low.

CT may show ground-glass opacities, septal thickening, volume loss and pleural effusion, but it is difficult to distinguish rejection from infection.

42-year-old female underwent right lung transplantation (12 days after surgery). CXR showed diffused right lung ground-glass opacities. CT showed broad consolidation, ground-glass opacities, and septal thickening in the right lung. She was confirmed as acute rejection because of increasing lymphocytes in BAL.
Airspace and interstitial disease

◆ Infection

Infection occurs at any period, but intermediate period is the most risky. Bacterial infections are most common in the 1st week. It is said that *P. aeruginosa*, *S. aureus* and *Acinetobacter* are the most common in bacterial infections. In fungal infections, *Aspergillus* and *candida* are most likely to occur. PJP is also likely to occur in this period. But most important organism in this period is CMV because it influences the prognosis.

1 week 2 week 1st month 2nd month

1st year

*CMV: cytomegalovirus
*PJP: *Pneumocystis jiroveci* pneumonia

CMV infection

- CXR findings are non-specific.
- The classic CT finding is ground-glass opacities, small centrilobular nodules, consolidation and bronchiectasis.
- Some cases detected only by transbronchial lung biopsy (TBLB).

39y.o. female underwent left lung transplantation (1.5 months after surgery). CT showed ground-glass opacities and small centrilobular nodules. She was confirmed CMV infection by TBLB.
Airspace and interstitial disease

◆ Acute fibrinous and organizing pneumonia (AFOP)

AFOP was proposed by B. Beasley in 2002. Predominant symptom is progressive dyspnea, others are cough, fever and chest pain.

Histologically, AFOP is characterized by prominent intra-alveolar fibrin deposition resulting in a morphological pattern that may represent an underreported variant of DAD, COP and EP.

On CXR, most common pattern is bilateral basilar infiltrates. CT shows nonspecific patchy or diffuse consolidation and ground-glass opacities (OPpattern).

19y.o. Male underwent double lung transplantation (2 months after surgery). CT showed consolidation in both lower lungs.

Imaging findings

Late Posttransplant Period (2 months ~)

- Surgical complications
  - Bronchial stenosis
  - Bronchomalacia

- Plural complications
  - Pleural fibrosis
  - Empyema

- Airspace & interstitial disease
  - Infection
  - Pulmonary infraction
  - Acute fibrinous and organizing pneumonia
  - Chronic lung allograft dysfunction
  - Posttransplant lymphoproliferative disorder
Surgical complications

- **Bronchial stenosis**
  Bronchial stenosis is the most common airway complication and often occurs in patients who have experienced anastomotic necrosis, dehiscence or infection. It occurs months after surgery.

- **Bronchomalacia**
  Blonchomalasia is a dynamic narrowing of the airway that increases during exhalation. Both focal and diffuse forms can be seen.

Paired end-inspiratory and dynamic-expiratory CT images are useful to diagnose: airway collapse or transient narrowing of the anastomosis or other airway segments may be detected with expiratory CT.

14y.o. Female who was undergone both lung transplantation. This CT was taken 1 year after surgery. CT showed bronchial stenosis at the anastomosis site.

14y.o. Female underwent double lung transplantation (1 year after surgery). CT showed bronchial stenosis at the anastomosis site.

Airspace & interstitial disease

Infection

Community-acquired bacterial and viral pneumonias can develop in the late posttransplant period. Fungal infection including *Aspergillus* is less common in this period. Mycobacterial infection is rare. But over the last 10 years, multiple cases of *M. abscessus* have been reported with pleuropulmonary and disseminated disease. In addition, there is an increase in mortality.

A 42-year-old female underwent double lung transplantation. She had fever and cough 7 years after transplantation. CT showed nodules and centrilobular micronodules in both lungs, ground-glass opacities, linear shadow, and pleural thickening. She was confirmed with *M. abscessus* infection by TBLB. Her respiratory function had declined and she went into an artificial respirator.
Airspace & interstitial disease

**Chronic lung allograft dysfunction (CLAD)**

CLAD is a term that was first introduced in the lung transplant literature in 2010.

CLAD is defined as a persistent decrease in $\text{FEV}_{1.0}$ and/or $\text{FVC}$ of at least 20%, compared to the baseline values at least 3 weeks. But this method, it is difficult to distinguish from other causes of chronic diseases. CLAD includes many phenotypes of dysfunction: bronchiolitis obliterans syndrome (BOS), reactive allograft syndrome (RAS) and other dysfunction including unknown dysfunction.

Transpl Int. 2015 Oct;28(10):1131-9
Bronchiolitis obliterans syndrome (BOS)

BOS is defined as a 20% drop in FEV$_{1.0}$ from the post transplant baseline. BOS is graded only by FEV$_{1.0}$ and FEF$_{25-75}$. It is known that early-onset BOS (within 2 years) and high grade onset BOS is predictive of significantly worse survival. Patients with BOS have a mean survival postdiagnosis of 4 years.

Risk factors are acute rejection, lymphocytic broncholitis, infection, autoimmunity and gastroesophageal reflux and so on.

Histologically, BOS shows fibrosis and scarring around bronchioles.

Imaging findings

CT shows mosaic attenuation, mild bronchiectasis, bronchial wall thickening and expiratory air trapping. CT is more useful to distinct BOS from other airflow obstruction diseases.

Bronchiolitis obliterans syndrome (BOS)

51y.o. male underwent left lung transplantation (3 years after surgery). CT showed mosaic attenuation.
Restrictive allograft syndrome (RAS)

RAS is defined as a TLC or FVC 20% drop from post transplant baseline more than 3 weeks. But it may be inaccurate in cases of single lung transplantation.

Patients with RAS have a mean survival postdiagnosis of only 1.5 years. Histologically, RAS shows spread of inflammation from pleura and interlobular septa to lung parenchyma. It results in pleuroparenchymal fibroelastosis (PPFE) finally.

**Imaging findings**

CT shows findings of fibrosis, including reticulation, traction bronchiectasis, and volume loss with architectural distortion and pleural scarring with an upper-lung prediction.

Restrictive allograft syndrome (RAS)

40y.o. male underwent left lung transplantation (3 years after surgery). CT showed upper lobe fibrosis and pleural thickening. He died 20 days after getting this CT.
Airspace & interstitial disease

- Posttransplant lymphoproliferative disorder (PTLD)

The diverse lymphoproliferative disease that arise after transplantation are referred to collectively as PTLD. They comprise a morphologically and clonally heterogeneous group of abnormal B-cell proliferative responses that have been associated with Epstein-Barr virus (EBV) infection. It tend to progress rapidly.

PTLD occurs in 5% of lung transplant patients.

Risk factors: higher in children, young adults, cystic fibrosis patients and patients with greater intensity of immunosuppression.

Imaging findings

Common imaging manifestations of PTLD are pulmonary nodules, masses, lymphoadenopathy and pleural effusions. PET-CT allows for more accurate initial staging of PTLD and can be used to monitor response to therapy.

Aris RM et al: Am J Respir Crit Care Med 1996;154:1712
Saueressig MG et al: Clin Transplant 2011;25:E430
36y.o. female underwent double-lung transplantation. 4 months after the procedure, she suffered from anorexia and pharyngodynia. CT showed nodules and consolidation in both lung, anterior mediastinum mass and mild mediastinal and hilar lymphoadenopathy. PET-CT showed abnormal uptake generalized lymph nodes, anterior mediastinum mass. She was diagnosed with PTLD by lymph node biopsy.
Conclusion

• Many complications can occur after lung transplantation, and they are important prognosticator.

• Complications vary by period after transplantation.

• To know susceptible complications in every period and their image findings, we can make an early diagnosis and contribute to improve prognosis.