Imaging Following Lung/Airway Surgery
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Objectives
• To understand the various lung surgeries
• To recognize post operative findings of the various surgeries
• To be familiar with the complications and their imaging characteristics

Classification of chest surgeries

Basics of pulmonary resection
• Performed most often for resection of tumor or focus of infection
• For anatomical resection, branches of bronchi, pulmonary arteries and pulmonary veins supplying the resected lung need to be ligated, and accompanying lymph nodes are removed
• For non-anatomical resection, large staplers are used to excise geographic portions of the lung

Wedge resection
DEFINITION:
A non-anatomical “wedge” of lung is resected

INDICATION:
• Excisional biopsy of indeterminate lesions, which if benign, may require no treatment
• For single or multiple pulmonary metastases
• When used for primary lung cancer, it is a salvage procedure when lobectomy cannot be performed

CT APPEARANCE:
Thin or thick suture line with or without associated soft tissue thickening

COMPLICATIONS:
Early (P.O.D. 1-30): Hemorrhage, pneumonia, empyema, bronchopleural fistula, lung herniation
Late (≥ P.O.D. 30): Bronchopleural fistula, empyema, pneumonia, recurrent tumor
Lung volume reduction surgery (LVR S)

**DEFINITION:**
Resection of approximately 2/3 of both upper lobes at the maximal site of emphysema

**INDICATION:**
For patients disabled by emphysema despite maximal medical therapy

**CT APPEARANCE:**
Remaining portions of upper lobes are smaller in size; long resection sutures

**COMPLICATIONS:**
Persistent air leak, pneumonia

Bullectomy

**DEFINITION:**
Resection of a large cyst or bulla, usually followed by mechanical pleurodesis

**INDICATION:**
When a large cyst(s) in an emphysematous lung causes significant surrounding atelectasis, dyspnea can be alleviated by bullectomy.

**CT APPEARANCE:**
Removal of bulla; reexpansion of previously atelectatic lung

**COMPLICATIONS:**
Persistent air leak, pneumonia

Segmentectomy

**DEFINITION:**
Any anatomic resection less than a lobe; accompanying lymph nodes are also resected

**INDICATION:**
- For tumor resection when lobectomy is not feasible due to poor lung function
- For resection of bronchiectasis, benign tumor and metastases

**TYPES:**
- Single segment resection, e.g. RUL apical segmentectomy
- Basal segmentectomy (all basal segments in a lower lobe)
- Lingulectomy
- Upper division left upper lobectomy (lingular sparing)

**CT APPEARANCE:**
Main lobar bronchus is patent, however a distal bronchus is resected

**COMPLICATIONS:**
Early (P.O.D. 1-30): Hemorrhage, pneumonia, edema, empyema, dehiscence, bronchopleural fistula, lung herniation
Late (> P.O.D. 30): Recurrent tumor, bronchopleural fistula, empyema, pneumonia

Closure flaps at bronchial stump

**DEFINITION:**
Wrapping vascularized tissue around bronchial stump to augment vascular supply, promote healing, and prevent dehiscence

**INDICATION:**
Primarily: At time of original surgery, when there is concern for anastomotic healing due to
- Infected field
- Post radiation therapy
- Zealous resection of lung and lymph nodes; compromising blood supply
Secondarily:
- To treat a bronchopleural fistula that has occurred postoperatively.
- To reduce the volume of post resection space

**TYPES:**
Muscles- Intercostal, Latissimus dorsi, Pectoralis are common muscle flaps
Fat- Omental, Pericardial fat pad are common fat flaps

**COMPLICATIONS:**
Failure of flap to prevent dehiscence, bronchopleural fistula or empyema, flap necrosis

Lobectomy

**DEFINITION:**
Resection of one lobe along with regional lymph nodes

**INDICATION:**
This is the definitive pulmonary resection for most lung cancers

**TYPES:**
- Right upper lobe (RUL)
- Right middle lobe (RML)
- Right lower lobe
- Bilobectomy (RUL & RML)

**CT APPEARANCE:**
To identify resected lobe, follow the bronchial tree from the carina, and look for bronchial stump. Displacement of fissures

**COMPLICATIONS:**
Early (P.O.D. 1-30): Hemorrhage, pneumonia, edema, empyema, dehiscence, bronchopleural fistula, lung herniation, lobar torsion, atelectasis
Late (> P.O.D. 30): Bronchopleural fistula, empyema, pneumonia, recurrent tumor, anastomotic stricture

Pneumonectomy

**DEFINITION:**
Resection of either lung with mediastinal lymph nodes

**INDICATION:**
Necessary when there is proximal pulmonary arterial, pulmonary venous or bronchial involvement. Procedure of last resort due to higher mortality rate of 6-7% compared to 1-2% for lesser resections

**CT APPEARANCE:**
Initially air/liquid in pneumonectomy space. After 30 days, only fluid is seen. Fluid demonstrates a concave medial margin and a smooth rind

**COMPLICATIONS:**
Early (P.O.D. 1-30): Hemorrhage, pneumonia, edema, empyema, stump dehiscence, bronchopleural fistula
Late (> P.O.D. 30): Bronchopleural fistula, empyema, pneumonia, recurrent tumor
**Intrapericardial pneumonectomy**

**DEFINITION:**
Resection of lung with ligation of intrapericardial portion of pulmonary artery and/or pulmonary vein(s). Also excision of any involved portion of pericardium and closure of any pericardial defect with mesh.

**INDICATION:**
When tumor encroaches upon the hilum necessitating incision of the pericardium to remove proximal extent of tumor and/or involved portion of pericardium.

**COMPLICATIONS:**
In addition to complications of standard pneumonectomy, cardiac herniation with torsion may occur as an early complication, occurring more often with right intrapericardial pneumonectomy.

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**Extrapleural pneumonectomy**

**DEFINITION:**
Removal of lung with investing envelope of parietal pleura, and involved portion of ipsilateral hemidiaphragm and pericardium, followed by reconstruction with graft.

**INDICATION:**
- In highly selected cases of malignant mesothelioma
- For tuberculous empyema
- For recurrent tumor

**COMPLICATIONS:**
Early (P.O.D. 1-30): Hemorrhage, pneumonia, edema, dehiscence, infection in pleuropneumonectomy space
Late (> P.O.D. 30): Infection in pleuropneumonectomy space, pneumonia, recurrent tumor

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**Tracheal and carinal resection**

**DEFINITION:**
Resection and reconstruction of portion of trachea or carina.

**INDICATION:**
- For tumors: usually either squamous cell carcinoma or adenoid cystic carcinoma
- For stricture, usually at site of tracheostomy or endotracheal cuff

**CT APPEARANCE:**
Shortened trachea, alteration in carinal branching pattern

**COMPLICATIONS:**
- Early: Airway obstruction (edema), air leak, anastomotic dehiscence, bleeding, infection
- Late: Stenosis/stricture, tumor recurrence, tracheoesophageal fistula

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**Sleeve resection**

**DEFINITION:**
Resection of a lobe with involved adjacent airway segment followed by reanastomosis of remaining airway.

**INDICATION:**
- For endobronchial tumors that involve the main or proximal bronchi, particularly squamous cell carcinoma and low-grade malignancy
- Most feasible for RUL tumor that extends into junction of upper lobe bronchus with main and intermediate bronchus because of sufficient length of bronchus intermedius

**CT APPEARANCE:**
Findings of lobectomy; transition in caliber of airway at anastomosis

**COMPLICATIONS:**
- Early (P.O.D. 1-30): Intrabronchial bleeding/aspiration, pneumonia, empyema, bronchopleural fistula
- Late (> P.O.D. 30): Tumor recurrence, anastomotic stricture/dehiscence, bronchopleural fistula, bronchovascular fistula

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**Pleurodesis**

**DEFINITION:**
Production of sterile adhesive pleuritis and obliteration of potential pleural space following complete evacuation of fluid.

**INDICATION:**
For recurrent pleural effusion, particularly malignant atelectasis
For recurrent pneumothorax

**TYPES:**
- Sclerosant: Talc (poudrage), bleomycin, doxycycline
- Cytotabetic: Carboplatin
- Mechanical: Abrasion with bovie scratch pads. Used in young patients with benign disease

**IMAGING APPEARANCE:**
Talc is visualized as hyperdense foci in the pleural space on CT, and may be FDG-avid on PET

**COMPLICATIONS:**
Failure to prevent recurrent pleural effusion, pneumothorax and ARDS

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**Decortication and pleurectomy**

**DEFINITION:**
Decortication: Removal of thick peel off the visceral pleura
Partial pleurectomy: Resection of parietal pleura
Total pleurectomy: Resection of visceral and parietal pleura

**INDICATION:**
Decortication: For empyema, organized hemothorax, fibrothorax, tumor (in conjunction with pleurectomy)
Pleurectomy: For malignant mesothelioma, trapped lung secondary to empyema, organized hemothorax

**COMPLICATIONS:**
Infection, tumor recurrence, hemorrhage
Thoracoplasty

**DEFINITION:**
Collapse of lung is produced by surgically altering framework of chest

**INDICATION:**
- Once the standard surgical treatment to close tuberculosis cavities in the upper lobes
- Now used to obliterate persistent rigid pleural space, in chronic infection and bronchopleural fistula

**TYPES:**
- Extrapleural: Resection of multiple contiguous ribs
- Intrapleural: Resection of ribs, intercostal muscles and thickened pleura
- Plombage: Placement of inert substances (such as lucite balls) extrapleurally

**CT APPEARANCE:**
Small upper hemithorax

**COMPLICATIONS:**
Scoliosis

Open drainage ("Bliesser flap")

**DEFINITION:**
Exteriorized iatrogenic fistula between skin and pleural space, via a chest wall defect created from resection of two or more ribs

**INDICATION:**
To achieve long-term drainage of chronic empyema, without an indwelling chest tube

Superior sulcus tumor resection

**DEFINITION:**
Resection of 1st-3rd ribs, apical lung resection, usually upper lobectomy, portion of brachial plexus/sympathetic chain, and possibly portions of vertebrae

**INDICATION:**
For removal of superior sulcus tumor which is an apical lung cancer that invades the thoracic inlet. When this tumor causes symptomatic invasion of the brachial plexus, vasculature and sympathetic ganglia, it is known as Pancoast tumor

VATS: Video assisted thoroscopic surgery

**DEFINITION:**
Percutaneous insertion of thoracoscope without thoracotomy

**INDICATION:**
- Biopsy/ excision of lesions in lung/pleura/mediastinum
- Biopsy of aortopulmonary and bilateral hilar nodes
- Wedge resection, lung volume reduction surgery
- Lobectomy
- Pleurodesis

**PROCEDURE:**
- Videothoracoscope enters in the 7th, 8th, or 9th intercostal space
- Two other trocars for grasping and cutting inserted

**AVANTAGES:**
- Minimally invasive procedure
- can be performed on older, sicker patients

**COMPLICATIONS:**
Persistent air leak, tumor implantation, hemorrhage

References

- Eun A Kim et al. Radiographic and CT findings in Complications Following Pulmonary Resection, Radiographics 2002; 22:67-86
- Eun Jin Chae et al. Radiographic and CT findings of Thoracic Complications after Pneumonectomy, Radiographics 2006; 26:1449-1467