Thoracic Surgery

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Anatomy

Veins	Nerves	Thoracic duct
Azygous vein runs along the right side and drains into superior vena cava	Phrenic nerve runs anterior to hilum Vagus nerve runs posterior to hilum	Thoracic duct runs along the right side, crosses midline at T4–5 and dumps into left SCV at the junction with IJV (laterality of effusion indicates level of thoracic duct injury)

Muscles of respiration	
Primary muscles	Diaphragm and intercostal muscles (external, internal, and transverse intercostal muscles)
Accessory muscles	SCM, levators, serratus posterior, scalenes

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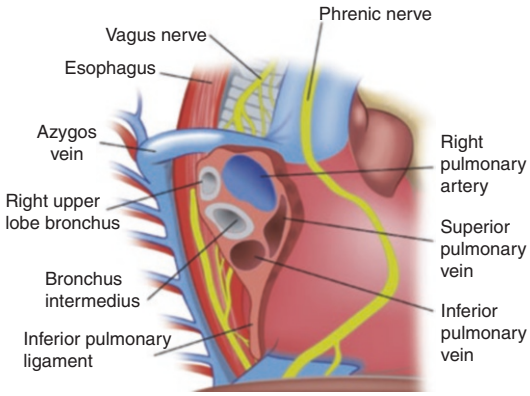
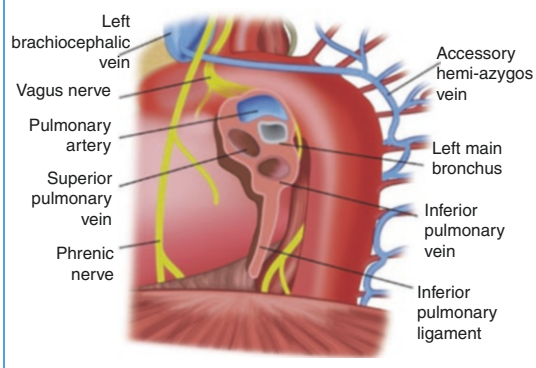
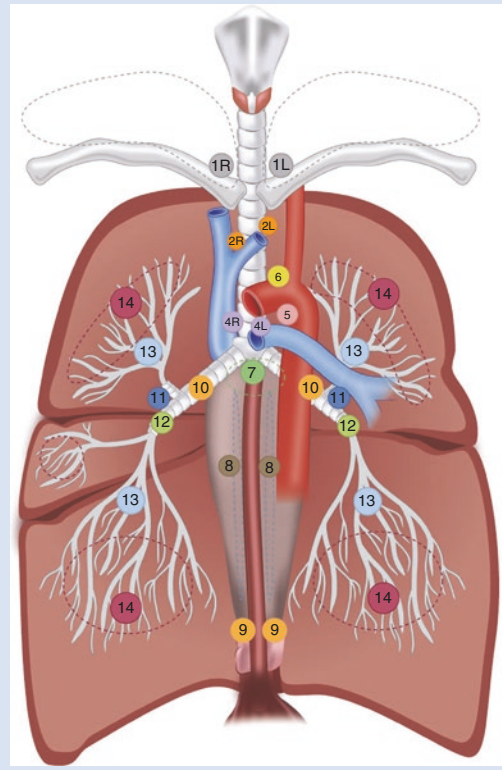
Right lung hilar structures	Left lung hilar structures
From anterior to posterior: **Superior pulmonary vein ➔ pulmonary artery ➔ right bronchus** Superior pulmonary vein ➔ most anterior structure Most inferior structure: Inferior pulmonary vein	From anterior to posterior: **Superior pulmonary vein ➔ left bronchus ➔ pulmonary artery** Superior pulmonary vein ➔ most anterior structure Most inferior structure: Inferior pulmonary vein
	

Lymph nodes



N3

Supraclavicular Nodes
Level 1: Low cervical, supraclavicular, and sternal notch nodes

N2

Superior Mediastinal Nodes
Level 2: Upper paratracheal nodes
Level 3: Prevascular or prevertebral
Level 4: Lower paratracheal nodes

Aortic Nodes
Level 5: Between aortic arch and pulmonary artery
Level 6: Anterior to aortic arch

Inferior Mediastinal Nodes
Level 7: Subcarinal
Level 8: Paraesophageal
Level 9: Pulmonary ligaments

N1

Level 10: Hilar
Level 11: Interlobar
Level 12: Lobar
Level 13: Segmental
Level 14: Subsegmental

Double digit ipsilateral: N1
Single digit nodes: N2
Any contralateral node: N3

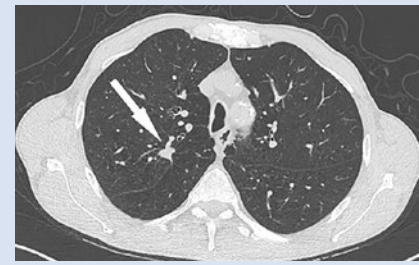
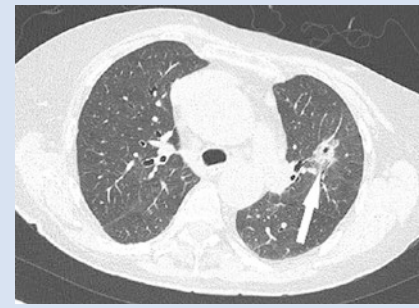
Bronchoscopy

- Tracheobronchial tree contains 23 generations of branches.
- First 6 generations are purely conductive.
- Trachea has 17–21 incomplete anterior cartilaginous rings and posterior membranous part.

Bronchoalveolar lavage	
Indications	Used to diagnose and guide antibiotic treatment of ventilator-associated pneumonia Diagnosis of atypical pneumonia in immunocompromised patients, interstitial lung disease, pulmonary malignancy Evaluation of alveolar hemorrhage
Key steps	Sites of new or evolving infiltrates on CXR should be sampled If diffuse infiltrates or no infiltrates ➔ specimens should be obtained from RML or Lingula Specimen should be collected from the most distal airway that can be sampled
Diagnosis	100,000 CFU/mL ➔ diagnostic threshold for pneumonia 10,000 CFU/mL ➔ diagnostic threshold in critically injured trauma patients with possible Acinetobacter or pseudomonas

	Right lung	**Left lung**
Mainstem bronchus	More cephalad-caudad oriented than the left	Horizontally oriented
Segments	10 segments **RUL:** Apical, anterior, and posterior **RML:** Medial and lateral **RLL:** Superior, anterior basal, posterior basal, medial basal and lateral segments	8 segments **LUL:** Apicoposterior, anterior, superior Lingular, and inferior Lingular **LLL:** Superior, anteromedial basal, posterior basal, and lateral basal segments
Divisions of main bronchus	First branch is the takeoff of **RUL bronchus** (3 o'clock) **Bronchus intermedius** is a continuation of right mainstem bronchus, followed by the takeoff of the **RML bronchus** (9 o'clock), and the takeoff of **RLL superior segmental bronchus** (3 o'clock) and **basilar segments** (12 o'clock)	**LUL bronchus** (9 o'clock) **LLL bronchus** (6 o'clock)

Pulmonary Nodules

<table>
<tr><th colspan="4">Solitary pulmonary nodule</th></tr>
<tr><td>Definition</td><td colspan="3">Rounded lesion with well- demarcated margins</td></tr>
<tr><td>Characteristics</td><td colspan="3">Doubling time: <10 days or > 450 days ➔ most likely benign
Stable nodules on serial imaging over 2 years or entirely calcified lesions➔ most likely benign</td></tr>
<tr><td rowspan="4">Radiologic findings</td><td>Benign patterns</td><td>Diffuse, central, laminated, or popcorn calcifications</td><td> 
</td></tr>
<tr><td rowspan="3">Malignant patterns</td><td>Ill-defined borders, speculation</td><td rowspan="2">  </td></tr>
<tr><td>Involvement of bronchi suggests malignancy</td></tr>
<tr><td>Air bronchogram is more commonly seen in malignant pulmonary nodules</td><td>  </td></tr>
<tr><td>Diagnosis</td><td colspan="3">• Biopsy: CT guided biopsy (diagnosis in 82% of cases)
• Bronchoscopic biopsy
• PET scan: Distinguish benign from malignant lesions (90% sensitivity) in nodules >1 cm in size</td></tr>
<tr><td>Treatment</td><td colspan="3">• Indications for wedge resection:
– Nodule >10 mm with malignant characteristic
– Indeterminate nodules
– Enlarging in size
• If frozen pathology is positive for carcinoma ➔ oncologic resection (lobectomy)</td></tr>
</table>

Primary Tumors of Lung

Screening for lung cancer	
National Lung Screening Trial (NLST)	Low-dose CT can significantly reduce lung cancer and all-cause mortality in high-risk patients
US preventive services task force (USPSTF)	Annual low-dose CT for individuals **55–80 years** of age who are current or former smokers (at least **30 pack-years** of smoking history or quitting within the **past 15 years**)

Lung cancer		
Epidemiology	• Most common cause of cancer related death in USA • Incidence and mortality of lung cancer is decreasing • More cases are diagnosed because of increased screening • Increased incidence in nonsmokers	
Risk factors	Smoking, radon gas, asbestos, arsenic, pollutants	
Symptoms	• **Symptoms depend on location and size of tumor** • Pulmonary symptoms: Cough, dyspnea, hemoptysis, pneumonia, pain • Most present in late-stage disease • Direct invasion or nodal involvement may lead to **SVC syndrome**	
	Tumor causes	**Symptoms**
	Invasion of the RLN	➔ Hoarseness
	Invasion of brachial plexus	➔ **Pancoast syndrome**
	Invasion of superior cervical ganglion	➔ **Horner syndrome** (unilateral facial anhidrosis, ptosis, and miosis)
	• 10% NSCLC patients present with paraneoplastic syndrome (clubbing, endocrine symptoms such as hypercalcemia, Cushing syndrome, SIADH) • **Paraneoplastic syndromes** are more common with SCLC and SCC	
Diagnosis	• Imaging + tissue diagnosis • If malignancy is suspected ➔ histological confirmation mandatory (since benign conditions and metastasis can mimic lung cancer)	
Metastasis	• Spreads hematogenously (brain, adrenal, bone, and lungs) and to lymphatics • **Brain** ➔ single most common site for hematogenous metastasis sites • Adrenal metastasis ➔ in 7% of lung cancer patients • **SCLC and Pancoast tumor ➔ high rate of occult intracranial metastases ➔ MRI brain always**	

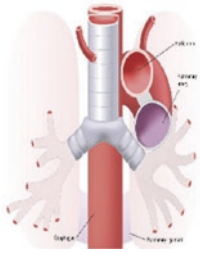
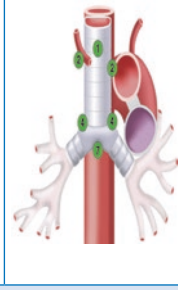
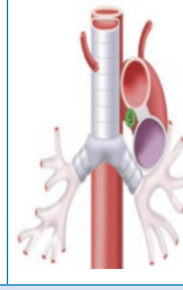
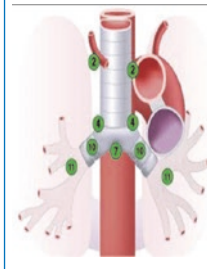
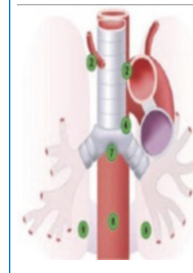
Genetic changes associated with progression to Lung cancer	
Oncogenes	**K-RAS** Oncogene Epithelial growth factor receptor **(EGFR)** Oncogene
Tumor suppressor genes	**P53, p16**

Lung cancer types	Subtype	Characteristic	Management
Small cell lung cancer (20%)		Neuroendocrine in origin Usually, a hilar or perihilar mass Usually metastatic at diagnosis	Usually not amenable to surgery because of early metastasis ➔ **chemotherapy and mediastinal radiotherapy** + locoregional and prophylactic cranial radiotherapy
Non-small cell lung cancer (NSCLC) (80%)	**Adenocarcinoma**	• Most common type of NSCLC (45%) • **Peripherally** distributed • Malignant epithelial tumor with glandular differentiation or mucin production	Need to be staged ➔ and managed according to stage
	Squamous cell carcinoma	• Dose–response relationship to smoking • Usually more **central** • Associated with necrosis and cavitary lesions • Keratin pearls on histology From bronchial epithelium	
	Large cell carcinoma	Poorly differentiated epithelial tumor Large **peripheral** mass	

<table>
<tr><th colspan="6">Staging</th></tr>
<tr><td>T</td><td colspan="5">Determine T stage from CT scan of chest</td></tr>
<tr><td rowspan="4">N</td><td colspan="5">For lymph node staging: CT and PET scan are used to identify suspicious lymph nodes

Mediastinal lymph nodes >1 cm or hypermetabolic lymph nodes on PET (max SUV > 2.5) are abnormal

Palpable supraclavicular or cervical lymph nodes ➔ N3 ➔ poor prognosis if positive

If positive lymph nodes in the mediastinum on PET/CT or very large lymph nodes or central primary tumor ➔ access lymph nodes</td></tr>
<tr><td>Approach used to access lymph nodes</td><td>Cervical mediastinoscopy</td><td>Anterior mediastinoscopy/ chamberlain procedure</td><td>EBUS- TBNA</td><td>EUS-FNA via esophagus</td></tr>
<tr><td>Lymph node station</td><td>Level 1, 2, 3, 4, and 7</td><td>Level 5–6</td><td>Level 2,3,4,7,10,11</td><td>Level 2, 4 L,7, 8 and 9</td></tr>
<tr><td></td><td>  </td><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>M</td><td colspan="5">PET/CT to identify metastatic disease

Pleural effusion ➔ thoracentesis (if malignant pleural effusion ➔ M1 ➔ chemoradiotherapy)
Brain MRI to detect metastatic lesions to the brain (for stage I and II ➔if they have neurological symptoms, and for all stage III and IV)</td></tr>
</table>

TNM staging for lung cancer		
T	**N**	**M**
T1 ≤ 3 cm in diameter	**N1** Ipsilateral hilar nodes	**M1** Distant metastasis or malignant pleural effusion
T2 3–5 cm in diameter	**N2** Ipsilateral mediastinal or subcarinal lymph nodes	
T3 5–7 cm in diameter *OR* Invading parietal pleural/chest wall, phrenic nerve, or pericardium *OR* **Two tumors in the same lobe**	**N3** Contralateral mediastinal or hilar lymph nodes *OR* Scalene or supraclavicular LNs	

TNM staging for lung cancer		
T	**N**	**M**
T4 7 cm in diameter *OR* Invading mediastinum, diaphragm, heart, great vessels, trachea/carina, esophagus, RLN, or spine *OR* Separate nodules within the same lung but separate lobes		

Stage		Management	5- year survival
I	**T1–2, N0**	May be completely resected Stereotactic radiotherapy alone ➔if cannot tolerate surgery Surgery provides better overall survival compared with radiation for local disease	45–50%
II	**T1–2, N1** **T3, N0**	Surgery + adjuvant chemotherapy	30%
III	**IIIA: T1–2, N2** **T3–4, N1** **T4, N3**	**Can be resected if they involve resectable mediastinal structures or N2 ipsilateral LN disease after neoadjuvant chemoradiotherapy**	5–14%
	IIIB: **T1–2, N3** **T3–4, N2**	T4 that involves nonresectable structures or N3 contralateral LNs ➔ chemoradiation	
	IIIC: T3–4, N3	Chemoradiation	
IV	**M1**	All other stage IV cancer ➔ not resectable Metastatic spread to brain or adrenals ➔ resection of primary lung cancer + oligometastasis control (radiation or resection) Radiotherapy for palliation of symptoms (SVC obstruction, hemoptysis, neurologic symptoms, and bone pain) and to reduce or eliminate *paraneoplastic syndromes*	<5%

Long term follow-up for lung cancer
Chest CT every 4–6 months for 2–3 years Noncontrast chest CT yearly thereafter

Superior Vena Cava Syndrome

Superior vena cava syndrome		
Anatomy	SVC and its intrathoracic venous tributaries are located within superior mediastinum to the right and anterior to the trachea and the right mainstem bronchus and to the right of aortic arch	
Etiology	**Malignant masses**	• Most common cause (60%) • SCLC, lymphoma, germ cell tumor, esophageal cancer, malignant thymoma
	Nonmalignant causes	**Intravascular devices** ➔ most common cause of benign SVC syndrome
		Vascular anomalies
		Infectious ➔fibrosing mediastinitis from infectious process (histoplasmosis, tuberculosis, or fungal infection)
		Others: Sarcoidosis, substernal goiter, teratoma
Pathophysiology	Extrinsic compression on SVC or thrombosis from venous stasis ➔ venous return obstruction from head, neck, and upper extremity **Rapid progression** of SVC obstruction ➔ **life threatening symptoms** (laryngeal or tracheobronchial edema and cerebral edema) **Slow progression** of SVC obstruction ➔ **blood flow redirected to collaterals (azygous or IVC)** ➔ gradual progression of dilation of head, neck, and arm veins Children have smaller and more compact thoracic compartment ➔ obstruction ➔ medical emergency ➔ airway compromise or cerebral edema	

Superior vena cava syndrome		
Presentation	Swelling of the face, neck, arms, and upper chest (most common symptom) Dilated neck and chest veins and trunk Tearing, proptosis, and conjunctival edema	
	Tumor causes	**Symptoms**
	Retinal vein thrombosis	➔ Blindness
	Invasion of phrenic nerve	➔ Ipsilateral diaphragm dysfunction
	Compression of RLN	➔ Hoarseness
	Compression of sympathetic chain	➔ Horner syndrome (ptosis, miosis, and anhidrosis)
	Laryngeal or tracheobronchial edema ➔ poor prognosis	➔ Cough and dyspnea
	Increasing ICP and edema (cerebral edema➔ poor prognosis)	➔ Headache, dizziness, and tinnitus
Diagnosis	Clinical findings + imaging + biopsy CXR: Right mediastinal or upper lobe mass **Contrast-enhanced CT chest: Non-opacification of the SVC inferior to the site of obstruction and opacification of collateral structures in the chest (azygous and right intercostal vein)**	
Management	Supplemental oxygen Measures to reduce edema and lower ICP (head elevation and diuretics) +/− steroid therapy using dexamethasone or prednisolone +/− systemic anticoagulation ➔ to address the risk of thrombosis +/− endovascular therapies (thrombectomy, thrombolytic therapy, balloon angioplasty, and stent) to achieve and maintain patency	
	Etiology of SVC	**Management**
	Malignant disease	Chemoradiation +/− anticoagulation
	Substernal goiter	Surgical resection
	Fibrosing mediastinitis	Mediastinal irradiation + antifungal therapy
	SVC caused by intravascular device	Remove device +/− PTC balloon dilation and stent placement

Superior Pulmonary Sulcus (Pancoast) Tumors

Superior pulmonary sulcus (Pancoast) tumors	
Characteristic	Pulmonary sulcus comprises the thoracic costovertebral gutter on either side of the vertebral column and is limited by the first rib superiorly
Presentation	**Pancoast syndrome:** Shoulder or arm pain, atrophy of intrinsic hand muscles, and Horner's syndrome (ptosis, myosis, and anhidrosis)
Diagnosis	**Histologic diagnosis is mandatory prior to treatment**

Superior pulmonary sulcus (Pancoast) tumors	
Management	Resection based on clinical symptoms and preoperative imaging Horner syndrome (ptosis, miosis, and anhidrosis) ➔ invasion of sympathetic chain Contraindication to resection: N2 or greater disease, involvement of brachial plexus beyond C8-T1, and invasion of the spinal cord Resect if there are no contraindications to resection otherwise chemotherapy and radiation

Pulmonary Resections

Different surgical approaches for pulmonary resections and chest trauma	
Posterolateral thoracotomy	Most common approach Excellent exposure to hilum On right exposes ➔ trachea, mainstem bronchi, proximal/midesophagus On left exposes ➔ left ventricle, descending aorta, distal esophagus
Anterior thoracotomy	Access to heart, pericardium, lung Usually used in penetrating trauma Or Used as muscle sparing incision for anatomic resection Left anterolateral thoracotomy ➔ resuscitative thoracotomy
Median sternotomy	Good exposure to anterior mediastinal, heart, and great vessels
Clamshell approach (B/L anterior thoracotomy)	Good exposure to bilateral pleura
Hemiclamshell approach (sternotomy + anterior thoracotomy)	Used for large tumors that require exposure to proximal great vessels

Preoperative pulmonary assessment

Preoperative pulmonary assessment

Predicted postoperative (PPO) pulmonary function calculation is required in all patients (CHEST guidelines)

PPO values can be estimated either by anatomic calculation of functioning lung parenchyma removed, or by mean of quantitative CT scan, ventilation, and perfusion scan

Value	Management
Preoperative FEV1 < 80% and DLCO < 80%	Calculate predicted postoperative (PPO) pulmonary function
PPO FEV1 or DLCO > 60%	Acceptable candidate for pulmonary resection (including pneumonectomy)
PPO FEV1 or DLCO < 40%	Increased perioperative risk of mortality and cardiopulmonary complications
PPO FEV1 or DLCO < 30%	Calculate preop cardiopulmonary exercise testing with measurement of maximal oxygen consumption (VO_2 max)
Resting PCO2 > 50	Contraindication to pneumonectomy
VO2 max 10–15 mL/kg/min	High perioperative risk of mortality and cardiopulmonary complications

Preop DLCO was shown to have a higher correlation with postoperative deaths than FEV1
Most specific predictor of postoperative pulmonary complications ➔ is measurement of VO_2 max

Pulmonary resections

Technical and anatomic considerations

The intercostal neurovascular bundle courses underneath the above rib in the anterior and posterior chest, but posteriorly falls away toward the central intercostal space

Mediastinal lymphadenectomy should be performed during all resections

During an open operation the pulmonary arterial and venous branches can be ligated in any order

During a robotic assisted lobectomy, the order in which vessels are ligated is more defined with the pulmonary arteries often taken first (usual order is artery ➔ vein ➔ bronchus)

Bronchial exposure should not involve stripping the bronchial surface of its adventitia, because aggressive dissection may compromise the vascular supply of the bronchus ➔ lead to bronchial dehiscence

Division of the bronchus should be very close to the carina as to not leave a long bronchial stump ➔ significant risk factor for bronchopleural fistula

Research about surgical management of lung cancer	
Reference	**Findings**
Lung Cancer Study Group: Ginsberg RJ, Rubinstein LV. Randomized trial of lobectomy versus limited resection for T1 N0 non-small cell lung cancer. Lung Cancer Study Group. Ann Thorac Surg. 1995;60:615–622	Lobectomy versus wedge for lung cancer ➔ lobectomy remains the standard surgical treatment for resectable early-stage lung cancer
Dai C, Shen J, Ren Y, Zhong S, Zheng H, he J, Xie D, Fei K, Liang W, Jiang G, Yang P, Petersen RH, ng CS, Liu CC, Rocco G, Brunelli A, Shen Y, Chen C, He J. Choice of surgical procedure for patients with non-small-cell lung cancer ≤ 1 cm or ≥ 1 to 2 cm among lobectomy, segmentectomy, and wedge resection: a population-based study. J Clin Oncol. 2016;34(26):3175–3182	Lobectomy showed better survival than sublobar resection for patients with NSCLC For patients in whom lobectomy is unsuitable (severely compromised pulmonary function, advanced age, or another extensive comorbidity) with NSCLC between 1 and 3 cm ➔ segmentectomy is recommended For patients in whom lobectomy is unsuitable (severely compromised pulmonary function, advanced age, or another extensive comorbidity) with NSCLC ≤1 cm ➔ surgeons could rely on surgical skills and the patient profile to decide between segmentectomy and wedge resection
ACOSOG Z0030 Trial: Darling GE, Allen MS, Decker PA, et al. Randomized trial of mediastinal lymph node sampling versus complete lymphadenectomy during pulmonary resection in the patient with N0 or N1 (less than hilar) non-small cell carcinoma: Results of the American college of surgery oncology group Z0030 trial. J Thorac Cardiovasc Surg. 2011;141(3):662–670	Mediastinal lymph node dissection: For T1–2, N0–1 disease: No increased risk associated with addition of complete nodal resection No difference in local and regional recurrence rate or survival between lymph node sampling and full mediastinal lymph node dissection
Ferguson MK, Lehman AG. Sleeve lobectomy or pneumonectomy: optimal management strategy using decision analysis techniques. Ann Thorac Surg. 2003;76(6):1782–1788	*Sleeve versus pneumonectomy for proximal tumors:* *Sleeve is preferred over pneumonectomy based on equivalent oncologic results, better preservation of pulmonary function, and avoidance of complications of pneumonectomy*

Case	Optimal surgical approach
Early-stage resectable lung cancer	Lobectomy + lymph node dissection
Proximal lung tumor	Sleeve resection > > pneumonectomy
T1 tumor + bad physiologic reserve	Segmentectomy

Postoperative Complications After Pulmonary Resections

Complication	Description	Treatment
Prolonged air leak	Air leak >5–7 days	Majority heal with time if not ➔ pleurodesis or re-exploration If patient tolerate being on water seal without having lung collapse ➔ Heimlich valve or pneumostat
Bronchopleural fistula	Most worrisome after pneumonectomy Seen with large air leaks or after chest tube removal with development of air-fluid levels or empyema	Depending on degree of pleural space contamination, closed or open drainage (Clagett or Eloesser) is required Definitive closure of the fistula may require muscle flap transposition or more proximal closure of the airway if feasible
Chylothorax	High-volume chest tube output + testing pleural fluid for triglycerides	<1 L ➔ manage medically with diet and octreotide/somatostatin >1 L or failed conservative management ➔ thoracic duct ligation/thoracic duct coil embolization
Torsion of RML after RUL lobectomy	Due to lack of tethering of middle lobe once the minor fissure is divided and upper lobe removed	Reoperation + staple middle lobe to lower lobe
Bleeding	Chest tube output >1 L in 1 h or 300 mL/h in 3 h	Return to operating room for control of bleeding
Others	*Atelectasis, pneumonia, respiratory failure, atrial dysrhythmias*	

Pulmonary Metastatic Disease

Pulmonary metastatic disease	
Presentation	Tumors at higher risk of metastasis to the lung **(CRC, sarcoma, melanoma, and RCC)** Tumors usually spread hematogenously to the lung ➔ depositing in small distal vessels
Diagnosis	No radiographic features that distinguish metastatic disease from primary lung cancer **Positive napsin A or thyroid transcription factor 1 (TTF1)** ➔ help differentiate a primary lung carcinoma from a metastatic lesion CT/PET of head, chest, abdomen, and pelvis ➔ to assess for distant primary tumors Colonoscopy ➔ to rule out primary CRC
Criteria for metastasectomy	Adequate control of the primary tumor No extra-thoracic metastatic lesions Patient must be able to tolerate metastasectomy of all lesions (no survival advantage to incomplete metastasectomy)

Pulmonary metastatic disease	
Surgical approach for resection	Complete resection of all lesions suspicious for pulmonary metastases with negative margins Maximal sparing of lung tissue (wedge resections when possible) Staged procedure if bilateral lungs are involved Repeat pulmonary metastasectomy if there are isolated recurrences in the lung
Survival	Most common histology for pulmonary metastasectomy is CRC (35–45% 5-year survival with resection) Sarcoma is second most frequent source of metastases RCC, gynecologic cancers, and head and neck cancers have 20–80% 5-year survival after pulmonary metastasectomy **Strongest predictor of survival is complete resection**

Mediastinal Anatomy

Mediastinal compartment	Borders	Contents
Anterior compartment	Anterior: Sternum Posterior: Great vessels and pericardium	Thymus Internal mammary arteries Adipose tissue
Middle compartment	Anterior: Great vessels and pericardium Posterior: Thoracic spine	Great vessels Heart/pericardium Trachea/bronchi Vagus, phrenic nerve Esophagus, thoracic duct, ascending aorta
Posterior compartment	Potential space that lies laterally along the spine	Sympathetic chain + ganglia Proximal intercostal neurovascular bundles Esophagus, descending aorta

Mediastinal Tumors

Compartment	Tumor	Characteristics	Treatment
Anterior (MC)	**Thymoma**	Most common anterior mediastinal mass 50% are benign (benign thymoma <5 cm, well circumscribed and round) 50% are malignant (> 5 cm, irregular, invade neighboring structures)	Complete excision Thymectomy is indicated in patients with thymic hyperplasia or thymoma If myasthenia gravis ➔ muscle relaxant should be used cautiously to be able to withdraw patient from ventilation as quickly as possible after operation
	Thyroid cancer	See thyroid chapter	See thyroid chapter
	T-cell lymphoma	Tissue diagnosis needed	Chemo/radiotherapy
	Teratoma	Most common type of germ cell tumors Serum tumor marker is negative	Surgical resection
	Seminoma	Most common malignant germ cell tumor Exclusively in males Elevated β-HCG CT: Large, homogenous mass, smooth borders	Radiation
	Non-seminoma: Yolk sac, embryonal, and choriocarcinoma	Elevated β-HCG, AFP, LDH Grow rapidly and compress neighboring tissues ➔ symptomatic Metastatic disease common at presentation	Cisplatin chemotherapy + resection of residual mass
Middle	**Bronchogenic cysts** **Pericardial cysts**	Majority of masses are cysts and are associated with airway Symptoms: Airway or esophageal compression	Surgical resection
Posterior	**Neurogenic tumors**	Schwannomas and neurofibromas Usually benign Present as pain or neurologic dysfunction	Surgical resection
		Ganglion cell tumor from sympathetic chain Neuroblastomas are most common solid extracranial malignancy in children	Localized disease ➔ resection + chemoradiotherapy

Mediastinitis

Types		Characteristics	Diagnosis	Treatment
Acute mediastinitis	**Sternal mediastinitis (post-sternotomy)**	Localized to the sternum Occurs after sternotomy **Most common staphylococcus ➔ pseudomonas and Acinetobacter**	CT of chest and neck with IV and PO contrast Barium or Gastrografin esophageal study to rule out leak CT findings: Pneumomediastinum, mediastinal fluid, and abscesses	Antibiotics + sternal debridement +/− flap closure
	Posterior mediastinal Mediastinitis	Esophageal or tracheal source **Most common polymicrobial**		**Control of esophageal leakage + drainage/ debridement of extraluminal contamination** **Esophageal perforation + mediastinitis ➔Abx + surgical drainage** Drainage alone should be used for perforations of the cervical esophagus which cannot be visualized For infections in the lower mediastinum (below carina) ➔a transthoracic approach to widely drain the mediastinum into the pleural space Posterior mediastinal infections should not be approached trans-sternally **Descending necrotizing mediastinitis ➔ cervical drainage +/− thoracotomy**
	Descending necrotizing Mediastinitis	Oropharyngeal sources ➔ retropharyngeal space ➔ posterior mediastinum **Most common streptococcus**		
Chronic mediastinitis		Characterized by fibrosis Result of an infectious etiology (histoplasma capsulatum), autoimmune process, or malignancy		No curative therapy Surgery in highly selected cases to relieve airway, vascular, and/or esophageal obstruction

Research about Sternal Infection	
Reference	**Findings**
Deo SV, Shah IK, Dunlay SM, et al. Bilateral internal thoracic artery harvest and deep sternal wound infection in diabetic patients. Ann Thorac Surg. 2013;95:862–869	*Use of internal mammary artery graft conduits in CABG in diabetic was traditionally avoided due to decreased sternal blood flow ➔ sternal wound infection* *➔ harvesting technique is the only factor responsible for sternal ischemia and sternal wound complications* *➔ Skeletonization preserve blood flow ➔ minimize sternal infection*

Pleural Disease

Pleural effusion				
Physiology	Fluid production capacity of the pleura is 100 mL/h Fluid absorption capacity of the pleura is 300 mL/h Fluid flux is from parietal pleura capillaries ➔ pleural space ➔ absorption by parietal pleura			
Diagnosis	**CXR:** Blunting of the costophrenic angle; visible effusion represents >300 mL of fluid; fluid in fissures **Ultrasound:** Fluid in pleural space with loss of "sliding" on inspiration **CT chest for empyema:** Loculated, heterogeneous **Light's criteria for exudative effusions:** (distinction between transudative and exudative effusions) Pleural/serum protein ratio > 0.5 *or* Pleural/serum LDH ratio > 0.6 *or* Pleural lactate dehydrogenase >2/3 of normal serum LDH Blood-tinged fluid is suggestive of malignancy (MC mesothelioma, RCC, melanoma)			
Management		**Thoracentesis**	**Drainage alone**	**VATs or thoracotomy**
	Indications	Simple effusion	First-line treatment for hemothorax Large effusions not completely drained by thoracentesis Early empyema (exudative phase) In early fibrinopurulent empyema, add fibrinolytic agents (tPA + DNase)	Organizing phase of empyema (fibrinopurulent stage) If conservative management failed **Retained hemothorax** within first 3 days Early VATS during the acute phase of empyema can prevent fibrothorax and conversion to thoracotomy
	Malignant pleural effusion: • If pleural apposition can be achieved ➔ pleurodesis (talc or doxycycline) • **If the lung does not fully expand or life expectancy < 3 months ➔ tunneled pleural catheter**			

<table>
<tr><th colspan="3">Chylothorax</th></tr>
<tr><td>Physiology</td><td colspan="2">Thoracic duct delivers triglycerides in the form of chylomicrons, lymphocytes, proteins, and fat-soluble vitamins from the intestinal system to the bloodstream

Fatty acids <10 Carbon bypass lymphatics and enter directly into portal system (medium chain triglycerides do not enter thoracic duct)

Cause significant systemic protein loss ➔ lowers oncotic pressure ➔ high-volume pleural effusions</td></tr>
<tr><td>Causes</td><td colspan="2">Malignancy is most common cause of nontraumatic chylothorax (lymphoma is most common)
Other causes: Thoracic duct injury, anastomotic leak, surgical injuries (during esophagectomy) and empyema</td></tr>
<tr><td>Presentation</td><td colspan="2">Present with widened mediastinum and/or pleural effusion
Postsurgical chylothorax presents within a few days (after initiation of oral intake)
Effusion is a milky color but can be serosanguineous or bloody</td></tr>
<tr><td rowspan="5">Diagnosis</td><td colspan="2">Place a pleural drainage catheter to determine the quality of fluid and lung re-expansion</td></tr>
<tr><td>TG level</td><td>Indication</td></tr>
<tr><td>TG > 110 mg/dL</td><td>Strongly suggestive of chylothorax</td></tr>
<tr><td>TG < 50 mg/dL</td><td>Not suggestive of chylothorax</td></tr>
<tr><td>TG between 50 and 110 mg/dL</td><td>Repeat fluid measurements after a high-fat diet</td></tr>
<tr><td colspan="2">Presence of chylomicrons is very specific finding</td></tr>
<tr><td>Management</td><td colspan="2">Conservative therapy is first-line treatment
Drainage of pleural space
NPO + TPN ➔ for high-volume leaks
Diet without long chain triglycerides ➔ for low- volume leaks

Healing often occurs due to obliteration of pleural space rather than vessel closure

Somatostatin ➔ an adjunct therapy to reduce chyle production

Conservative therapy for at least 5–7 days ➔ failure to heal ➔ surgical intervention

Surgical intervention:
• Ligation or clipping area of injury ➔ failed ➔ mass ligation of all tissue lateral to azygous to the vertebral body posteriorly and the aorta medially above diaphragmatic hiatus via right pleural space
• Thoracic duct embolization ➔ for poor surgical candidates

Pleurodesis may be considered especially in malignant fistulas

Lymphatic obstruction by tumor ➔ chemo/radiotherapy</td></tr>
</table>

Pneumothorax	
Types	**Primary pneumothorax** due to rupture of apical subpleural bleb **Secondary pneumothorax:** Arise due to underlying lung disease (COPD, asthma, bullous disease, etc.) **Tension pneumothorax:** Secondary to collapsed segment normally closing off the leaking lung
Presentation	Most common symptom is acute onset of chest pain and dyspnea Tension pneumothorax: JVD, tachycardia, hypotension, decreased breath sounds on the affected side, tracheal deviation away from the affected side
Diagnosis	**CXR:** Visible visceral pleural edge is seen as very thin sharp white line No lung markings are seen peripheral to this line (radiolucent space) **Upright films** are the most accurate way to identify a pneumothorax **Supine films:** Radiolucency along the heart border ("deep sulcus sign")
Management	See tables below
Long term follow-up	Risk factors for recurrence: Tobacco use (only modifiable risk factor to reduce recurrence), increased height in men, and secondary pneumothorax Risk of recurrence with nonoperative treatment is 60% Most cases recur within the first year

ACCP guidelines for pneumothorax management	
Clinically stable + small pneumothorax (apex-to-cupola < 3 cm)	No CT scan Observe for 3–6 h Discharge home if CXR shows stable pneumothorax
Clinically stable + large pneumothorax (apex-to-cupola > 3 cm)	Placement of small-bore pleural catheter or chest tube Hospital admission for observation
Clinically unstable or breathless	Placement of small-bore pleural catheter or chest tube CT scan +admission for observation
Secondary pneumothorax	Associated with greater morbidity and cardiorespiratory compromise ➔ admit to the hospital Tube thoracostomy or needle decompression

	Chest tube	Small-bore pleural catheter
Insertion site	Fourth–fifth intercostal space Mid to anterior axillary line	Second intercostal space Midclavicular line
Advantage	Blunt entry to pleural cavity	Less pain
Disadvantage	Increased pain	Higher frequency of major complications (bleeding, subclavian vein injury)

Surgical therapy	
Indications for surgery	• Persistent air leak **(≥ 4 days)** • Failure of the lung to fully expand with adequate chest tube placement • Recurrent pneumothorax • High-risk profession after first spontaneous pneumothorax • Limited access to hospital care
Approach	Video-assisted thoracoscopy is the standard approach Identify apical blebs ➔ then resect (bullectomy) + pleurodesis (mechanical; chemical: Doxycycline, bleomycin, talc; pleurectomy)