Thoracic Surgery

Samer Kanaan, M.D.

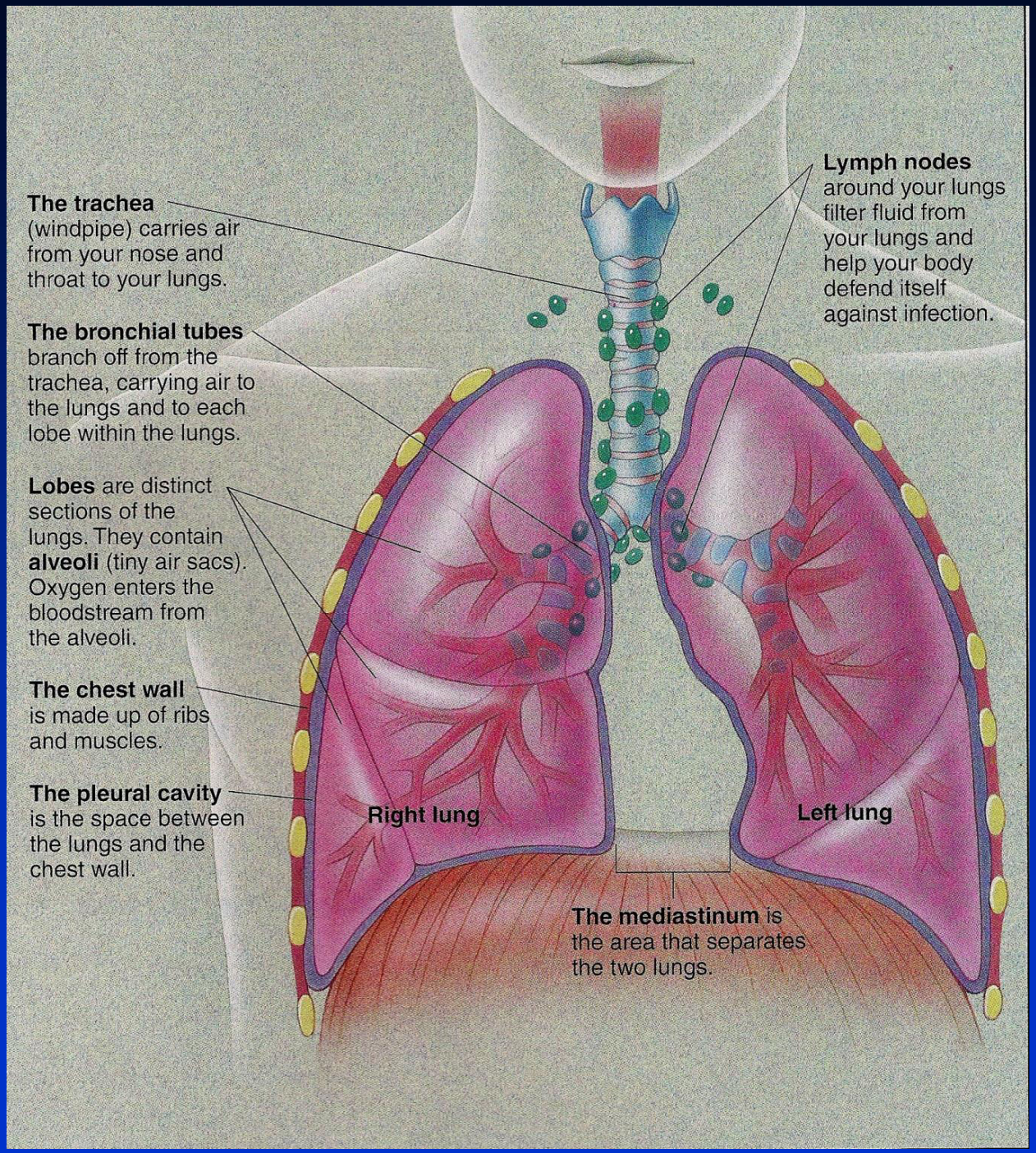
Goals

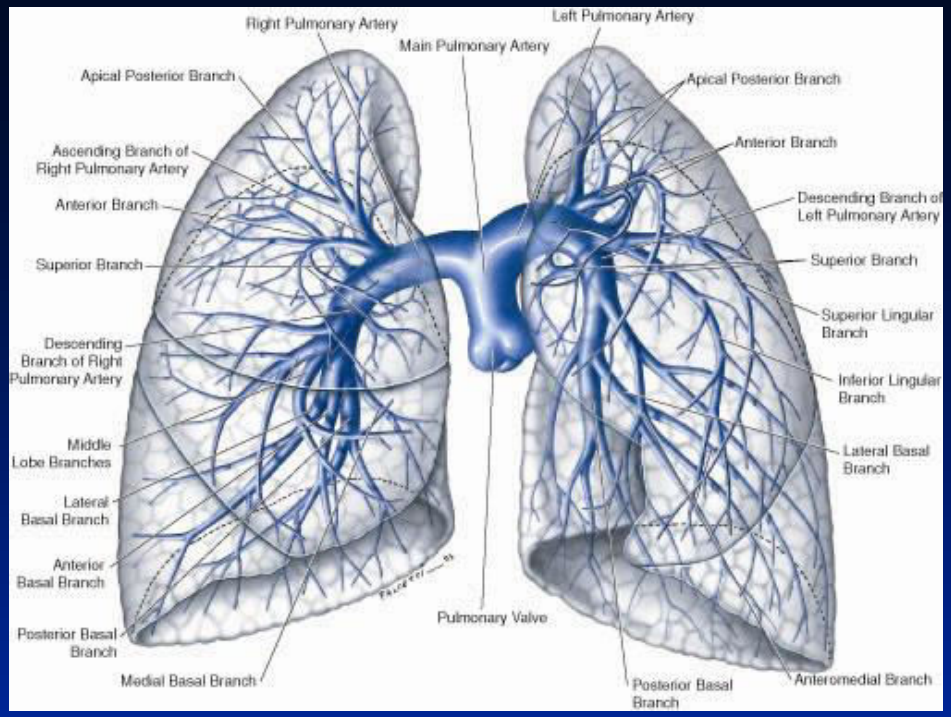
- Review relevant Anatomy of Thoracic Surgery
- Describe Major Thoracic Procedures, their indications and techniques with emphasis on a minimally invasive approach
- Review Instruments / Devices employed in Thoracic Surgery with emphasis on minimally invasive techniques
- Review Case Load, results, and complications since my arrival in July 2008.

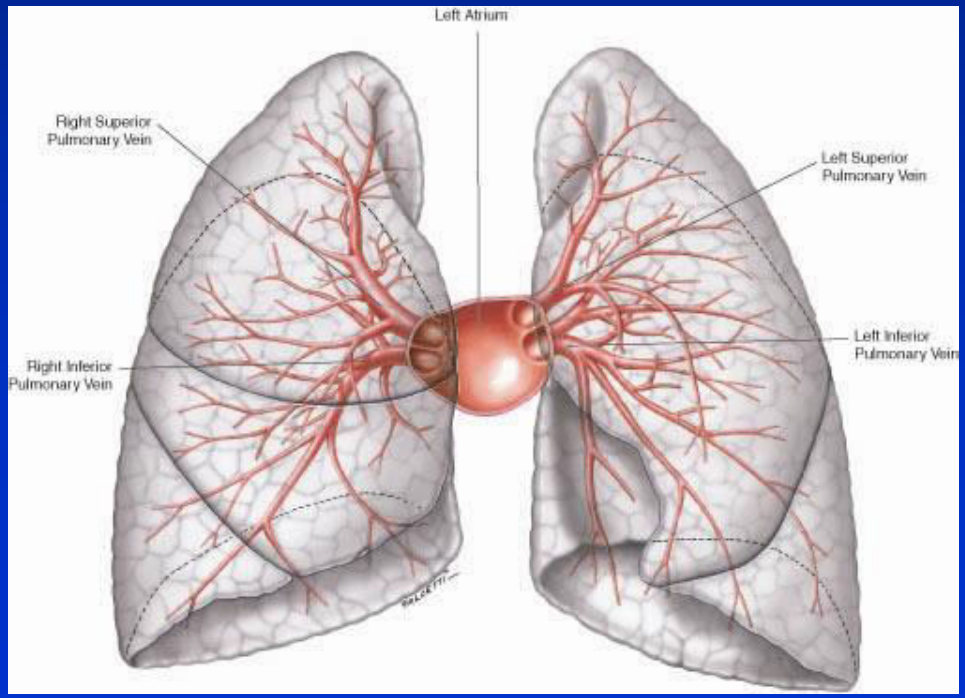
Disclaimer

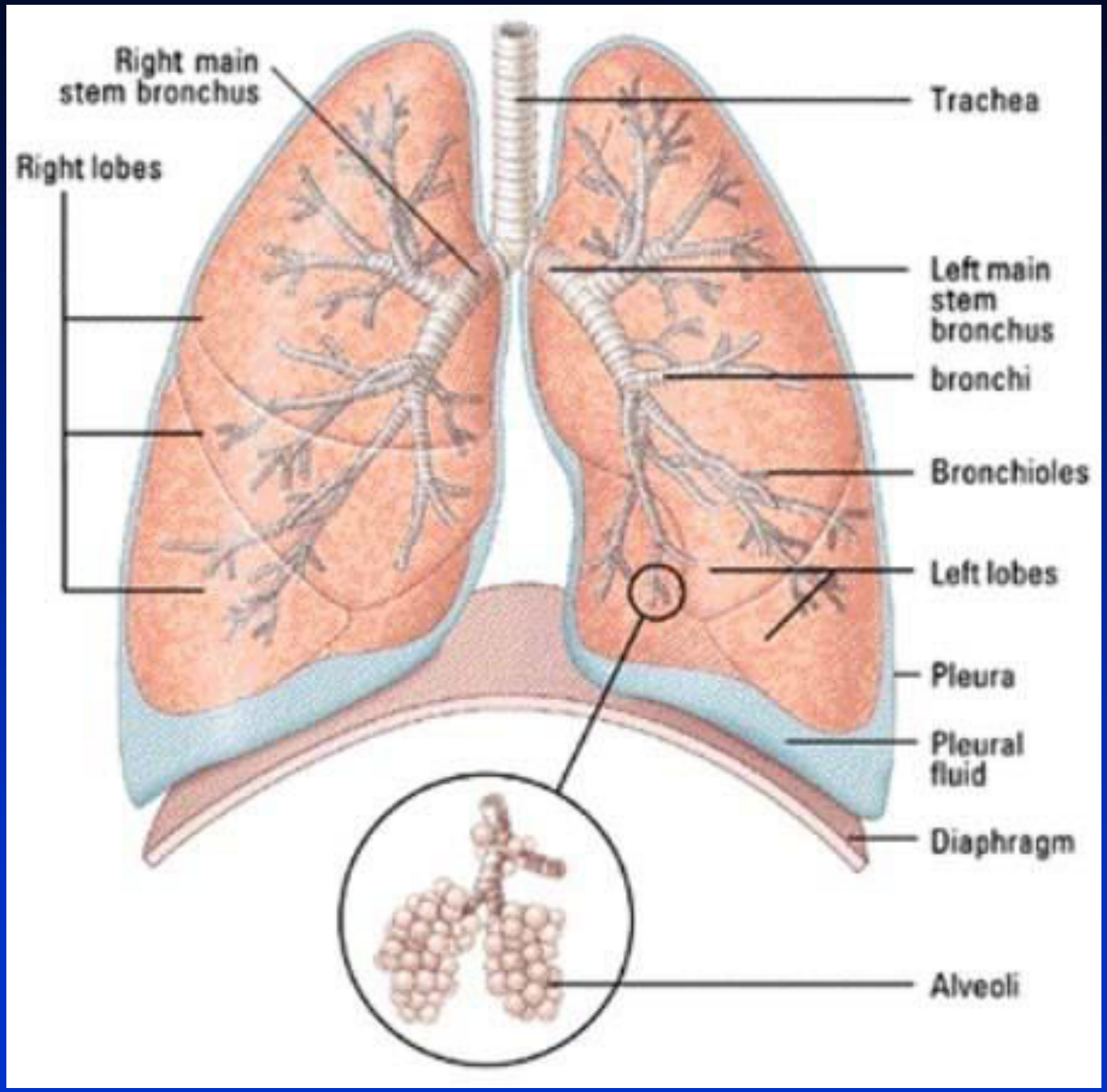
I have NO personal financial relationship with any manufacturer of products or services that will be discussed in this lecture.

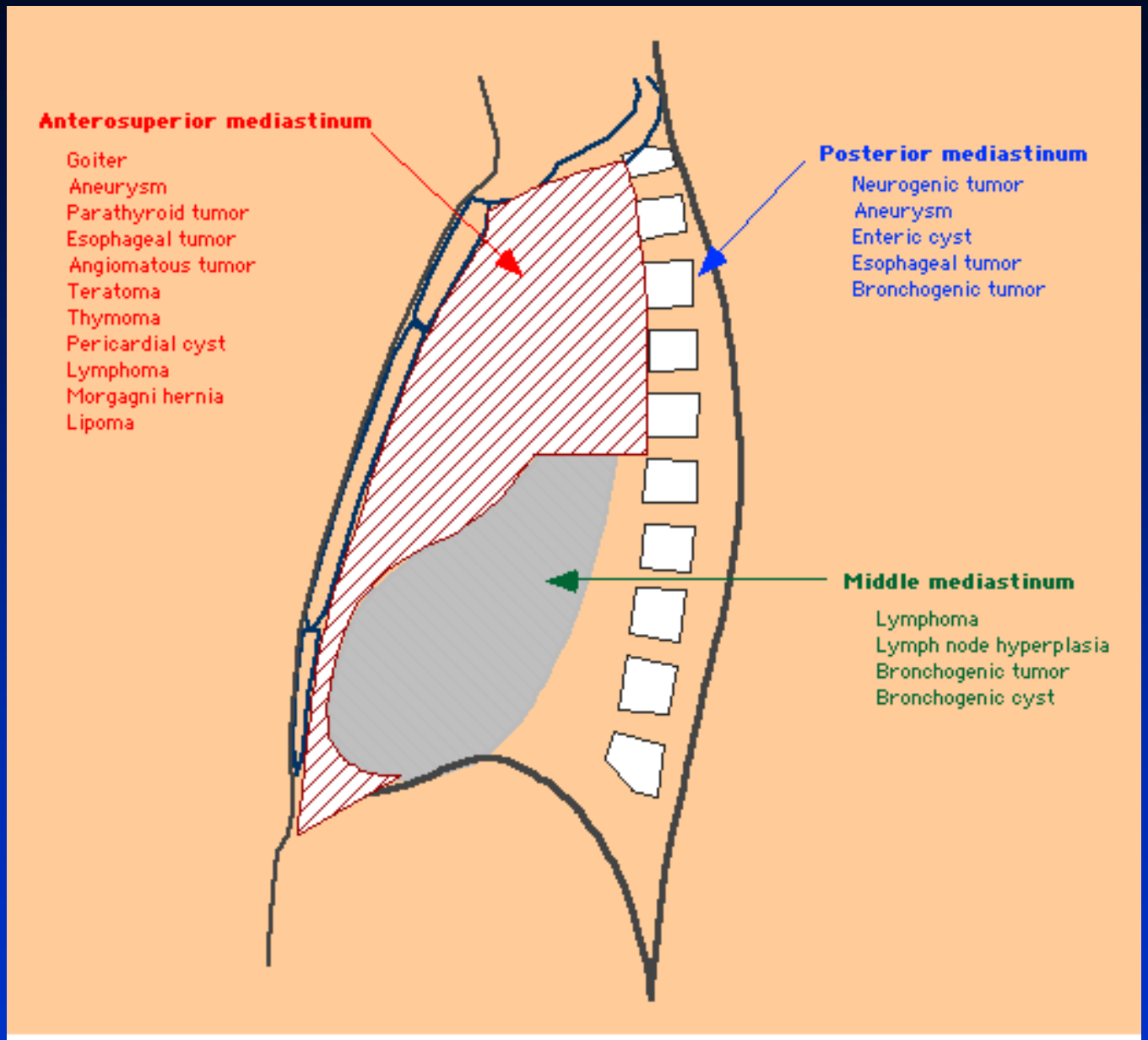
Thoracic Anatomy


The trachea (windpipe) carries air from your nose and throat to your lungs.
The bronchial tubes branch off from the trachea, carrying air to the lungs and to each lobe within the lungs.
Lobes are distinct sections of the lungs. They contain **alveoli** (tiny air sacs). Oxygen enters the bloodstream from the alveoli.
The chest wall is made up of ribs and muscles.
The pleural cavity is the space between the lungs and the chest wall.
Lymph nodes around your lungs filter fluid from your lungs and help your body defend itself against infection.
Right lung
Left lung
The mediastinum is the area that separates the two lungs.

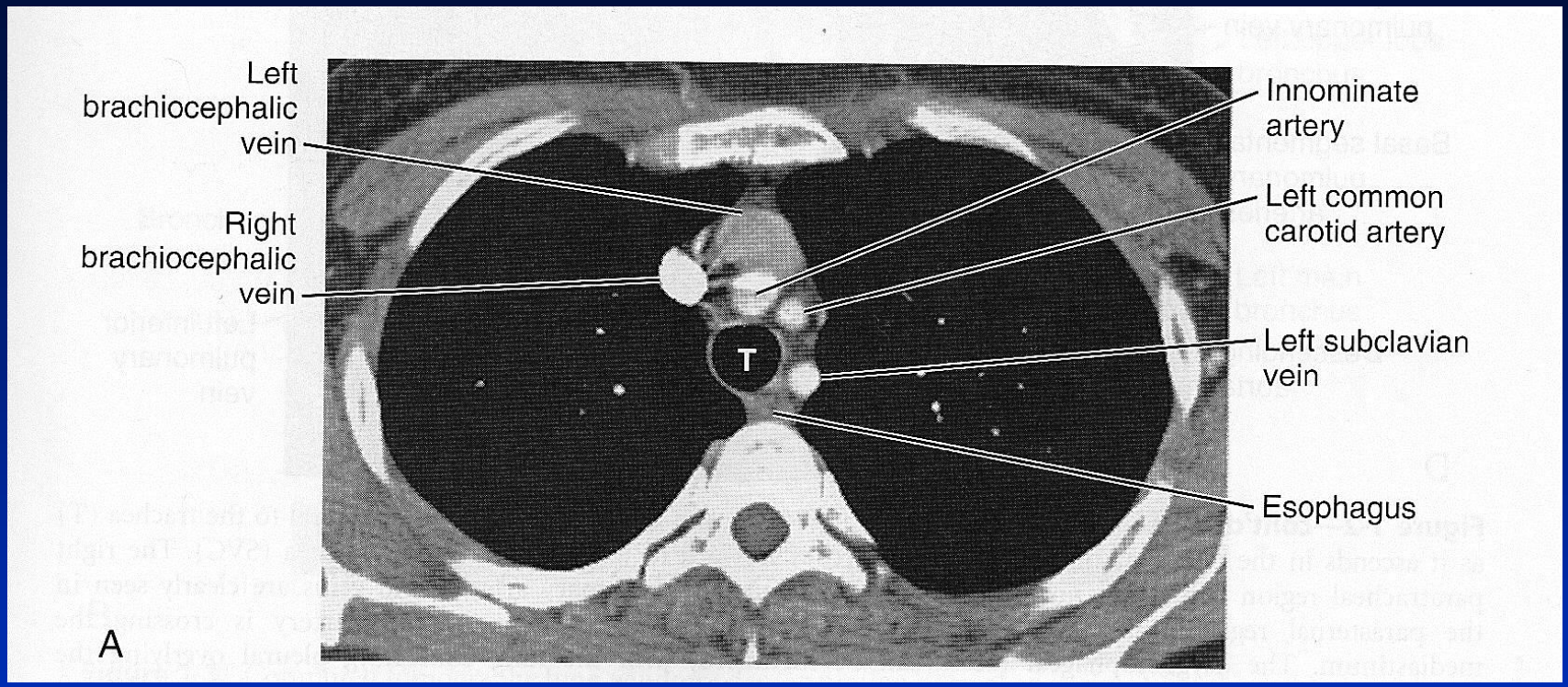

Right Pulmonary Artery
Main Pulmonary Artery
Left Pulmonary Artery
Apical Posterior Branch
Apical Posterior Branch
Ascending Branch of Right Pulmonary Artery
Anterior Branch
Descending Branch of Left Pulmonary Artery
Anterior Branch
Superior Branch
Superior Branch
Superior Lingular Branch
Descending Branch of Right Pulmonary Artery
Inferior Lingular Branch
Middle Lobe Branches
Lateral Basal Branch
Lateral Basal Branch
Anterior Basal Branch
Pulmonary Valve
Posterior Basal Branch
Medial Basal Branch
Posterior Basal Branch
Anteromedial Branch

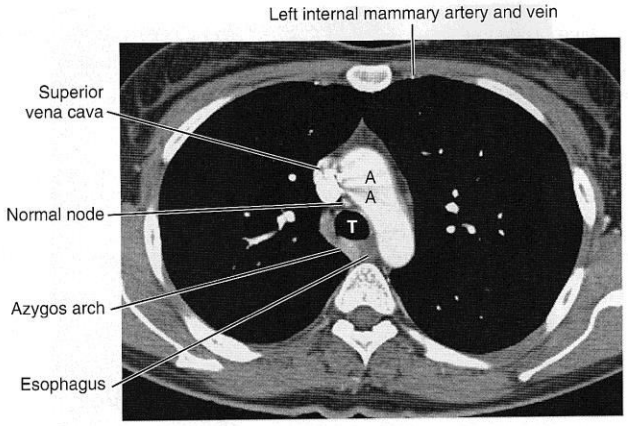

Left Atrium
Right Superior Pulmonary Vein
Left Superior Pulmonary Vein
Left Inferior Pulmonary Vein
Right Inferior Pulmonary Vein


Right main stem bronchus
Right lobes
Trachea
Left main stem bronchus
bronchi
Bronchioles
Left lobes
Pleura
Pleural fluid
Diaphragm
Alveoli

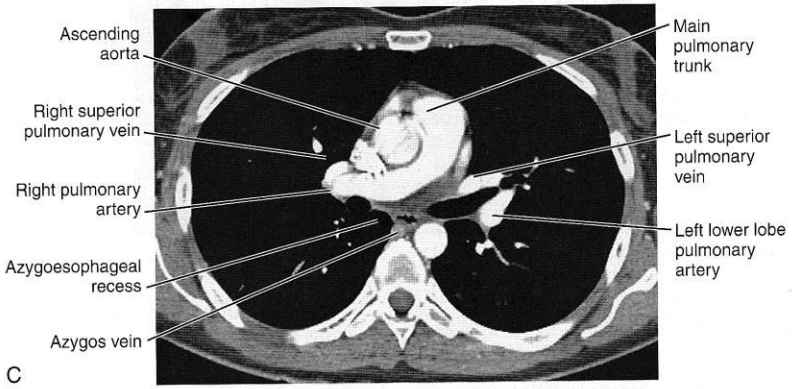


Common diagnostic possibilities of mediastinal masses The differential diagnosis of a mediastinal mass depends upon the anatomic compartment in which it arises. Redrawn from Baue, AE, et al. Glenn's Thoracic and Cardiovascular Surgery. 5th ed. Appleton & Lange, Norwalk, CT,1991.

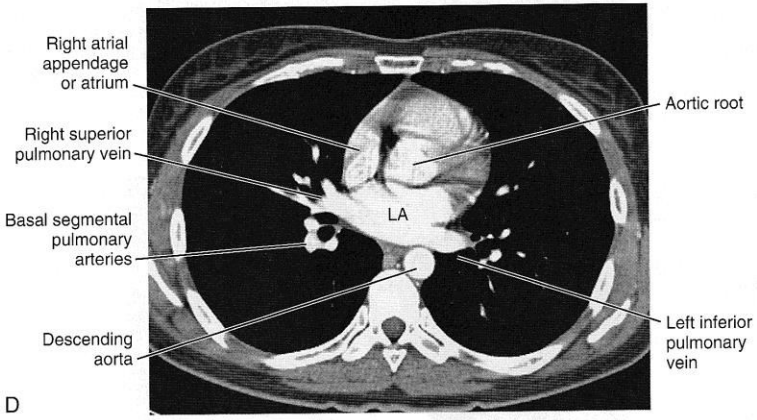

Left brachiocephalic vein
Right brachiocephalic vein
Innominate artery
Left common carotid artery
Left subclavian vein
Esophagus
T
A



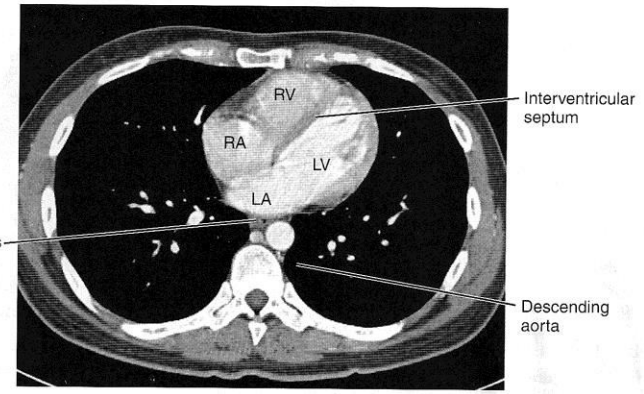
B



C

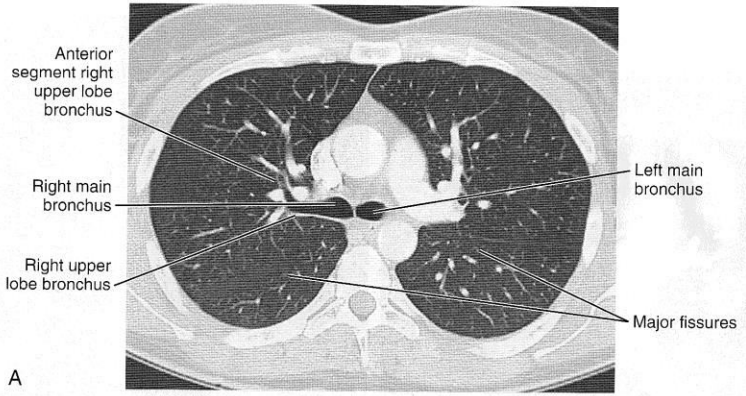


D

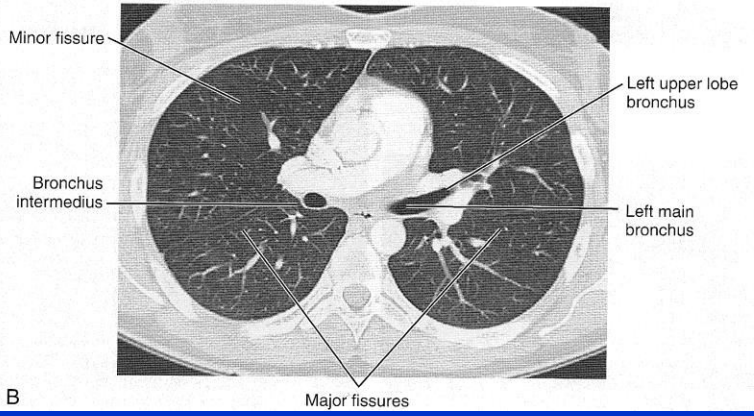


E

Figure 1-2—cont'd: E, At this level, the right ventricle (RV), right atrium (RA), left ventricle (LV) and left atrium (LA) can be clearly identified.



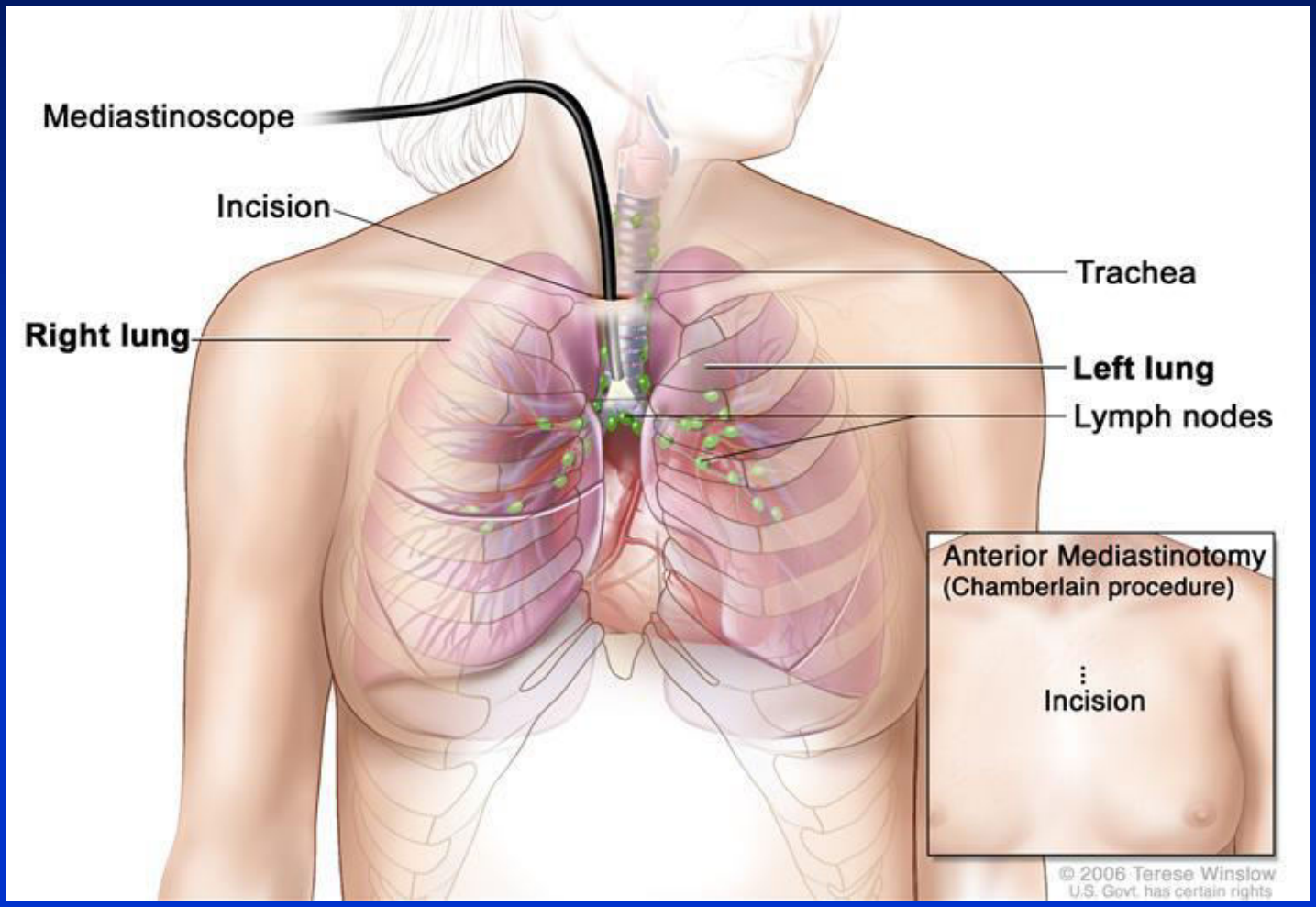
A

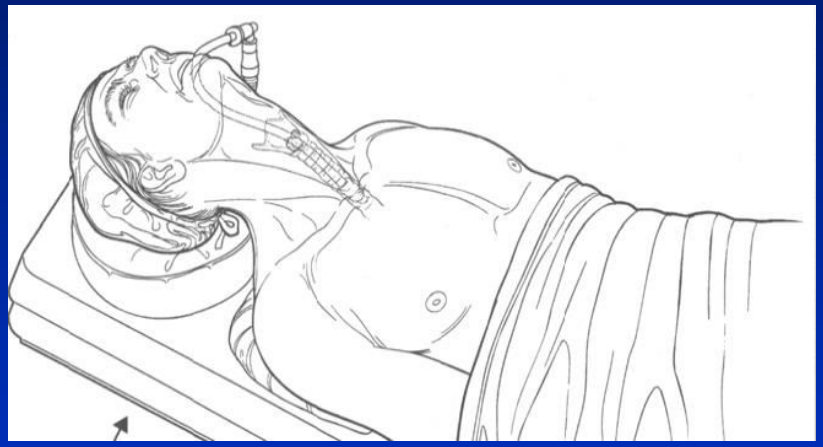


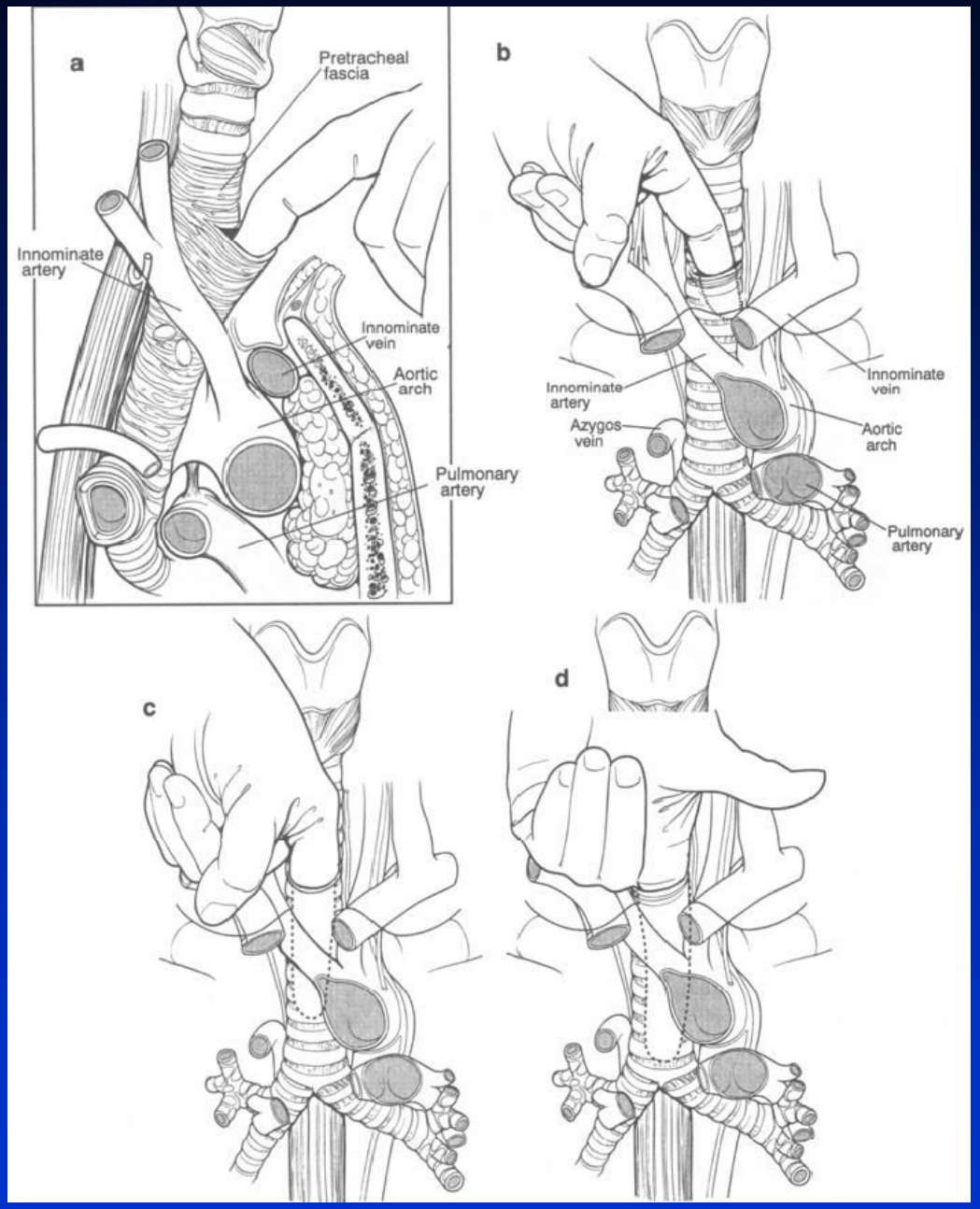
B

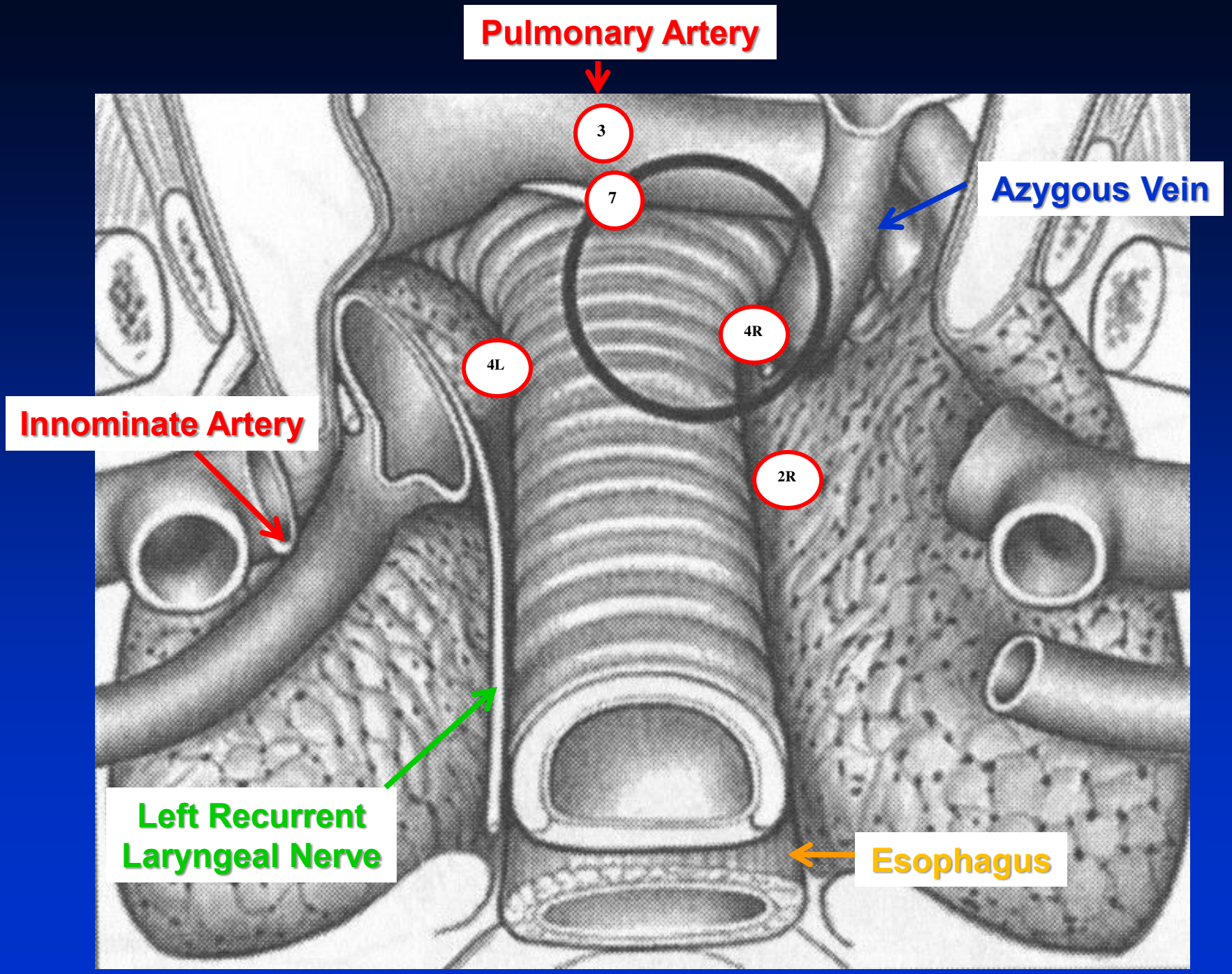
Thoracic Procedures

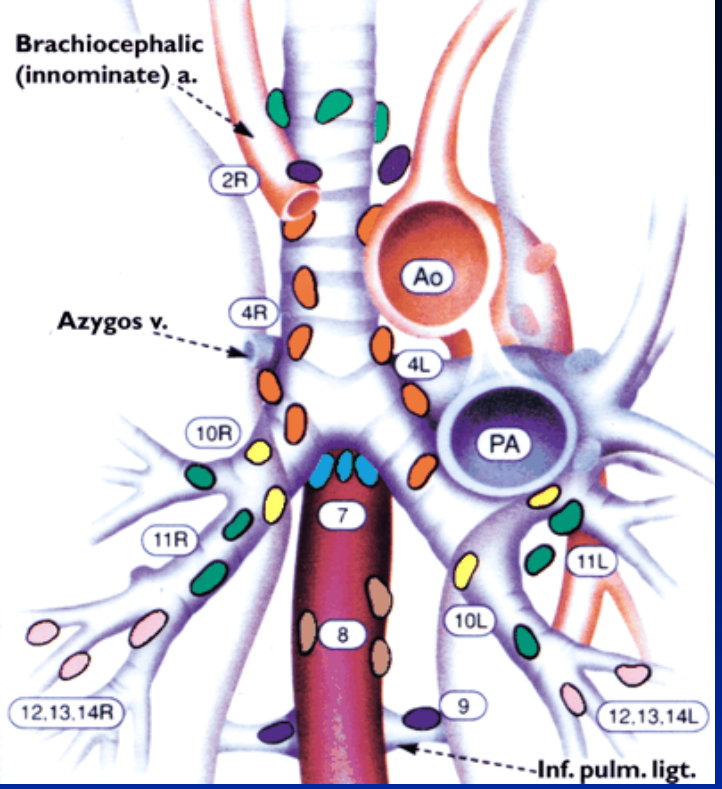
Mediastinoscopy is usually an outpatient procedure performed to sample lymph nodes alongside the trachea in the mediastinum. This is usually done to stage patients with lung cancer and is also useful to diagnose other neoplastic, granulomatous, and inflammatory causes of enlarged mediastinal lymph nodes.






a
Pretracheal fascia
Innominate artery
Innominate vein
Aortic arch
Pulmonary artery
b
Innominate artery
Azygos vein
Innominate vein
Aortic arch
Pulmonary artery
c
d


Pulmonary Artery
3
7
Azygous Vein
4R
4L
Innominate Artery
2R
Left Recurrent
Laryngeal Nerve
Esophagus



Superior Mediastinal Nodes

- 1 Highest Mediastinal
- 2 Upper Paratracheal
- 3 Prevascular and Retrotracheal
- 4 Lower Paratracheal (including azygos nodes)

N_2 = single digit, ipsilateral
N_3 = single digit, contratateral or supraclavicular

Aortic Nodes

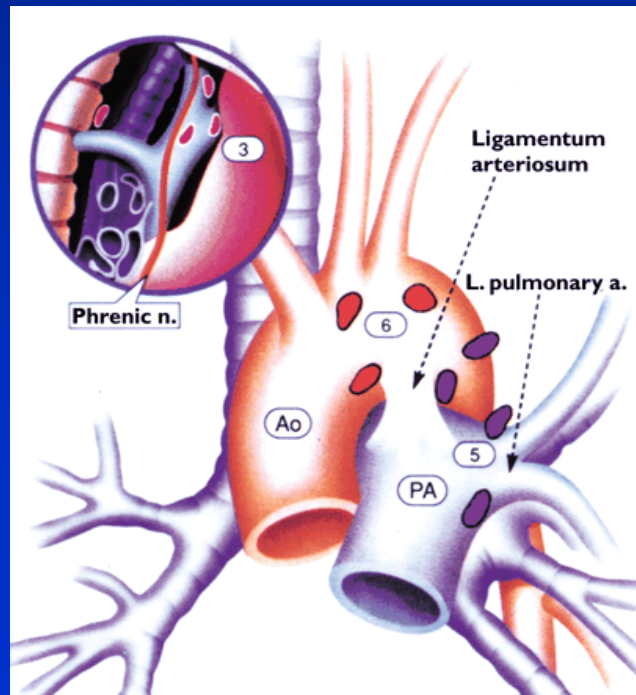
- 5 Subaortic (AP window)
- 6 Para-aortic (Ascending aorta or phrenic)

Inferior Mediastinal Nodes

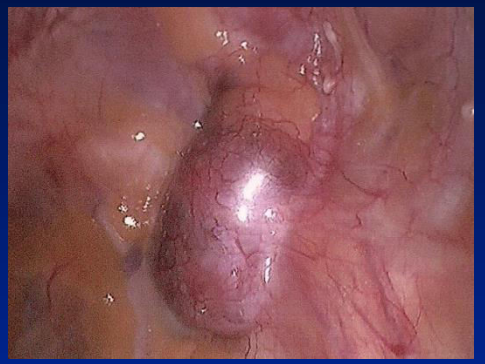
- 7 Inferior Mediastinal Nodes
- 8 Paraesophageal (below carina)
- 9 Pulmonary Ligament

N_1 Nodes

- 10 Hilar
- 11 Interlobar
- 12 Lobar
- 13 Segmental
- 14 Subsegmental



Mediastinal Tumors



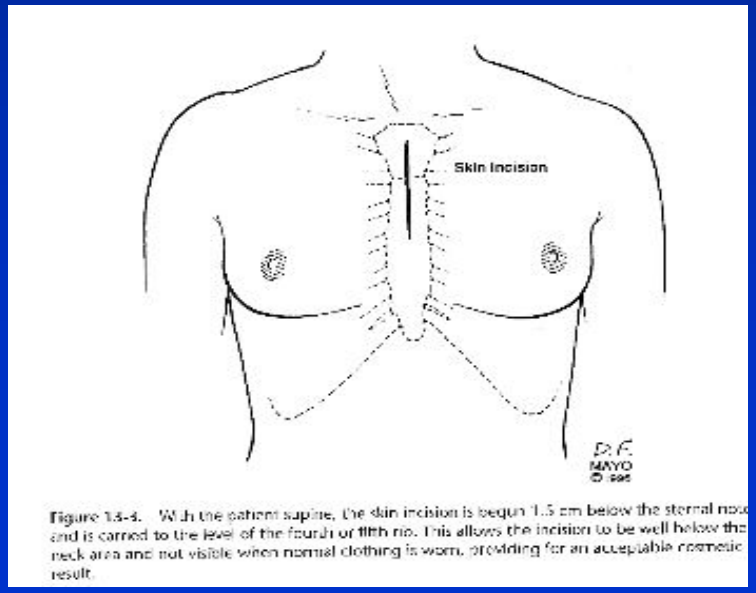
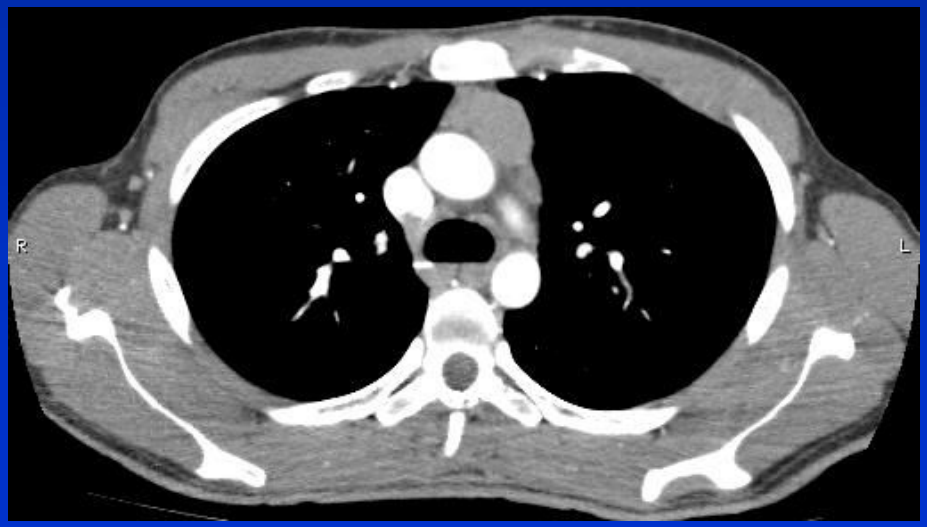


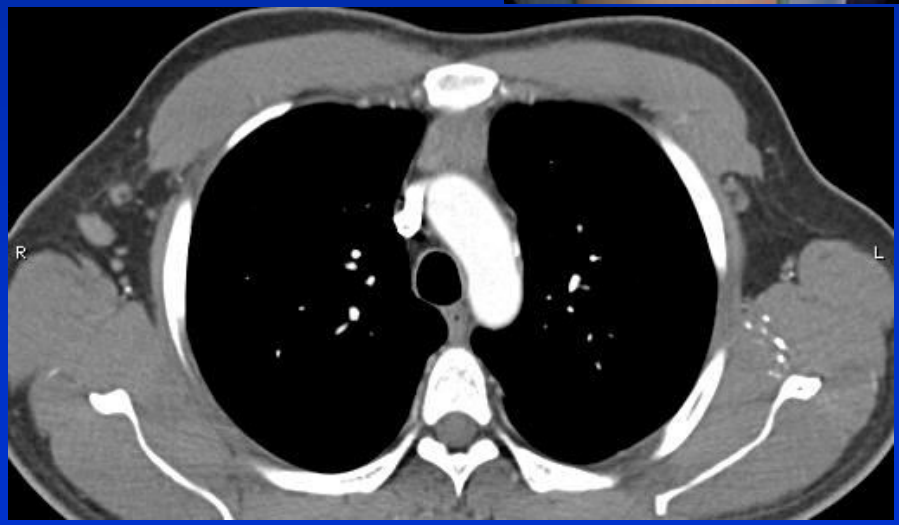
Figure 1.1-4. With the patient supine, the skin incision is begun 1.5 cm below the sternal notch and is carried to the level of the fourth or fifth rib. This allows the incision to be well below the neck area and not visible when normal clothing is worn, providing for an acceptable cosmetic result.

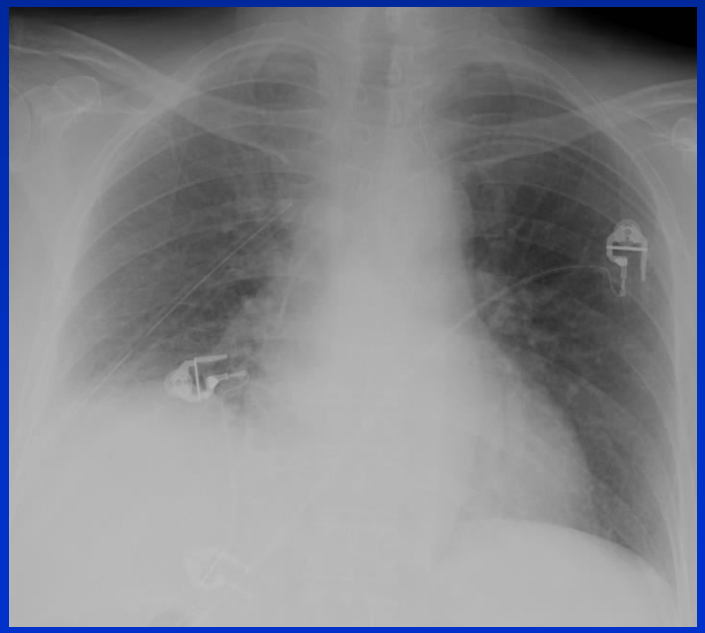
Thymectomy, or removal of the thymus, improves the symptoms in 80-90% of patients with myasthenia gravis. Also, thymectomy is indicated for tumors of the thymus gland and thymic cysts.

For thymomas related to myasthenia gravis, the thymus can be removed minimally invasively with a VATS or Robotic approach. This significantly reduces the hospital stay to 1-2 days, and allows faster recovery and return to work.

For thymic tumors, a median sternotomy approach is recommended and patients usually have a 4-5 day hospital stay.







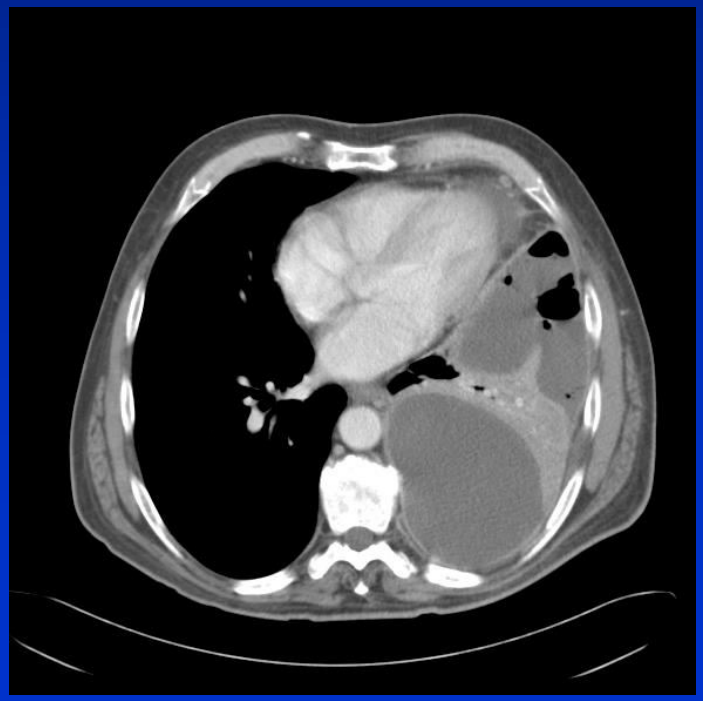
Pleura

Pleural biopsy is performed on patients to make a diagnosis and aid physicians to treat an underlying pleural process. Historically, the pleural biopsy was performed with an open incision, but currently we perform this procedure minimally invasively through VATS. Most patients describe minimal discomfort, and recover from the procedure in a day or two.

Pleural effusion is the accumulation of fluid in the chest or pleural cavity causing progressive compression of the lung and leading to shortness of breath. Malignant effusions are those secondary to lung cancer or metastatic cancers such as breast or ovary for example. The pleural effusion can be drained with a needle (thoracentesis) or chest tube (thoracostomy) but usually recurs and repetitive drainage causes discomfort, and loses efficacy over time.

A minimally invasive approach thru VATS can drain the fluid and instill talc powder to cause the lung to adhere to the chest wall (pleurodesis) and prevent re-accumulation of fluid. **VATS talc pleurodesis** is **90- 95% effective** and patients usually leave the hospital in 2-3 days after surgery.

Decortication

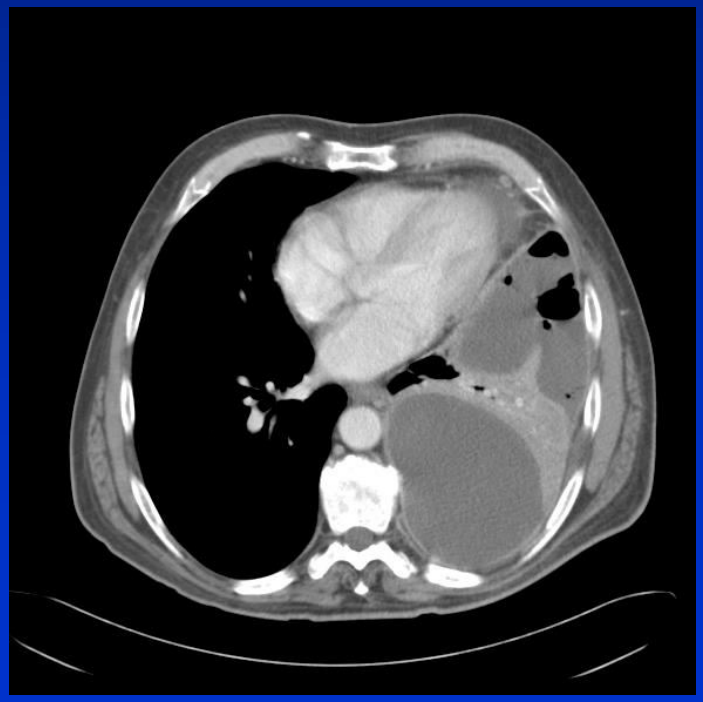


Empyema is pus in the chest or pleural cavity. It is usually the result of a bacterial pneumonia and subsequent parapneumonic effusion becoming secondarily infected. The **mortality rate** associated with empyema can be as high as **25-75%**.

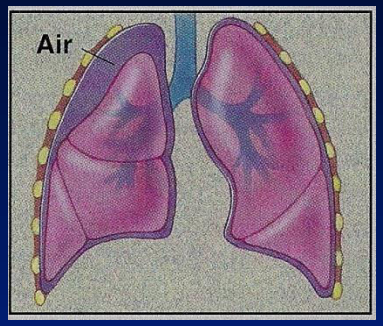
Surgical therapy with drainage of the effusion, removal of the pus and "peel" over the trapped lung is called **decortication** and is the most effective therapy, however it traditionally required a large thoracotomy and was not tolerated by elderly debilitated patients.

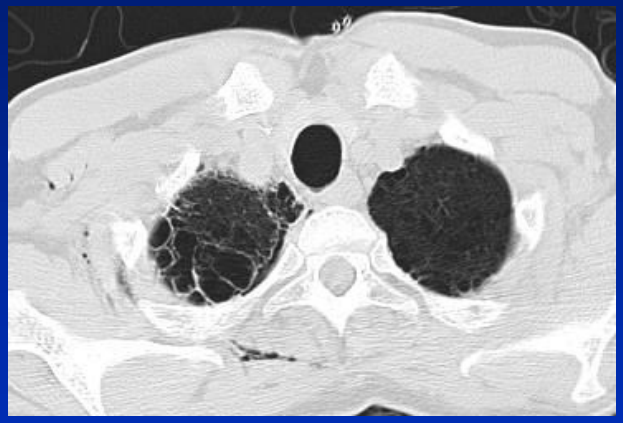
Today, decortication for empyema can be performed successfully using a **minimally invasive approach with VATS**. The VATS approach allows reduced hospital stay, faster recovery, and is an option for older sicker patients who would not otherwise be candidates for the more invasive traditional surgery.

Decortication



Spontaneous Pneumothorax





Spontaneous pneumothorax is an accumulation of air in the chest cavity causing lung collapse. It occurs in patients with no known lung disease and is attributed to rupture of small blebs on the surface of the lung. It usually occurs in thin, young males with cigarette smoking increasing its risk by 20 fold. Patients present with shortness of breath or pain on taking a deep breath.

Treatment varies from observation for a small pneumothorax, to chest tube placement for a larger pneumothorax. After the first episode there is a 30% chance of recurrence and after the second episode the recurrence rate is 70%. For this reason, surgery is recommended for recurrent spontaneous pneumothorax.

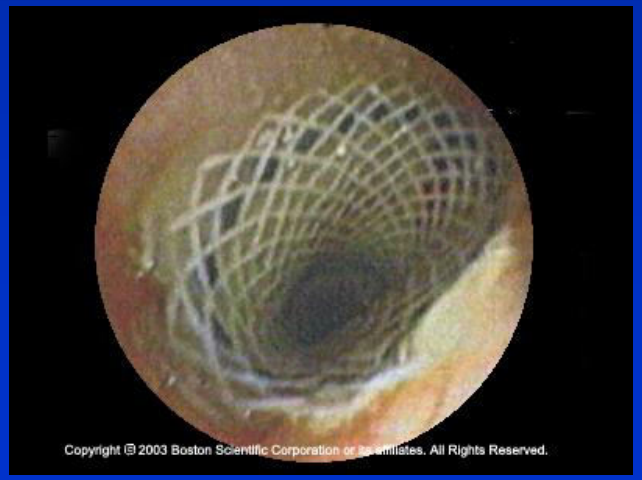
Surgery is done **minimally invasively with VATS** and entails resection of the blebs if present and pleurodesis (abrasion of the chest lining) to facilitate adhesion of the lung to the chest wall to prevent recurrences. Most patients are in the hospital for 2-3 days and return to full activity in a few weeks after surgery.

Airway Stents

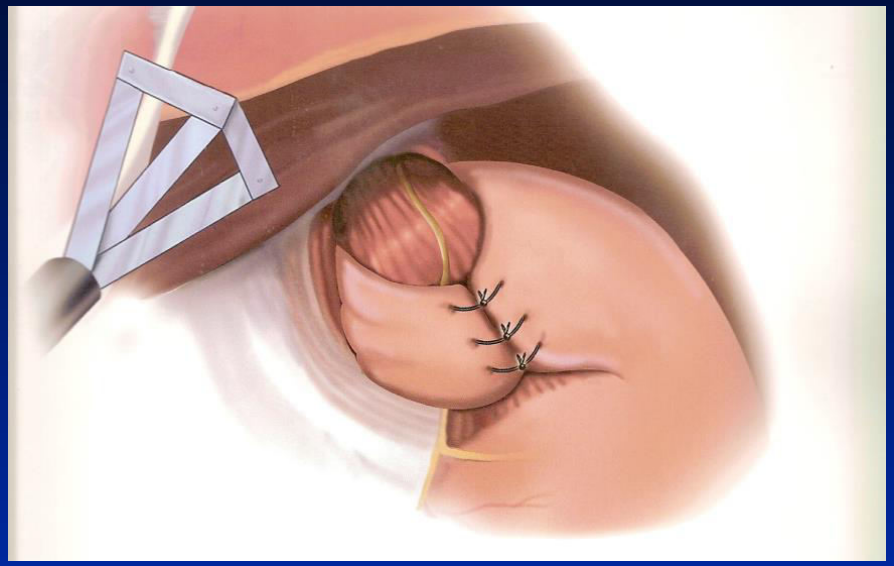
Airway stents are placed for several reasons: extrinsic compression from tumors, intrinsic obstruction from airway tumors, intrinsic stenosis, airway fistula, and tracheomalacia.

The airway stents are either silicone or metal with the metal stents coated or uncoated. Silicone stents can be removed later after placement while the metal stents are usually left in place.

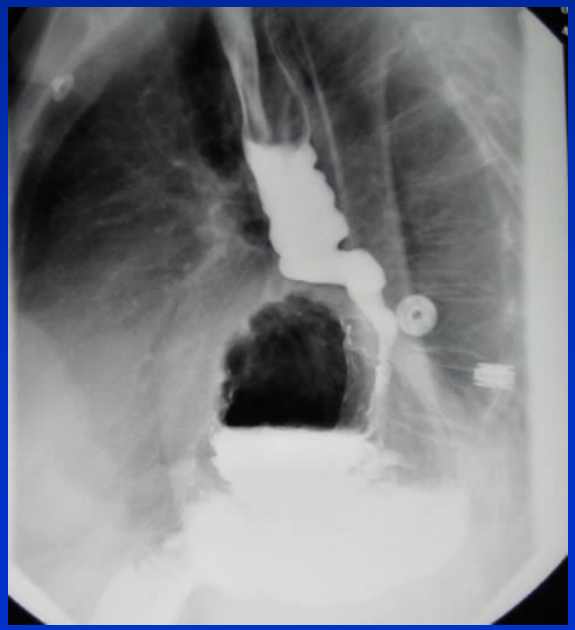
The stents are placed in the airway through a bronchoscope and the procedure usually is short and the patient can be discharged the following day.



Esophageal Surgery



Laparoscopic Nissen repair for GERD involves 5 small incisions, use of a videoscope, and insufflations of CO_2 gas. The repair involves reducing the esophagus into the abdomen, tightening the diaphragmatic crura with stitches, and performing a 360 degree wrap of the stomach around the distal esophagus to prevent acid reflux. Most patients are discharged home in 2-3 days, return to full activity by 6 weeks, and have no or minimal symptoms of reflux after surgery.



Paraesophageal hernias are uncommon and occur when the body of the stomach protrudes into the chest. Many are asymptomatic but can cause severe complications such as bleeding, obstruction, strangulation of the stomach, and perforation which could be lethal.

Surgery is the treatment of choice and was historically approached with either a large chest or abdominal incision. Currently, paraesophageal hernias can be repaired laparoscopically, reducing hospital stay and hospital complication rates. The repair involves reducing the stomach into the abdomen, resecting the hernia sac, closing the defect with mesh if necessary, and then fixing the stomach in the abdomen with either a gastrostomy feeding tube or wrapping the stomach (fundolipication).

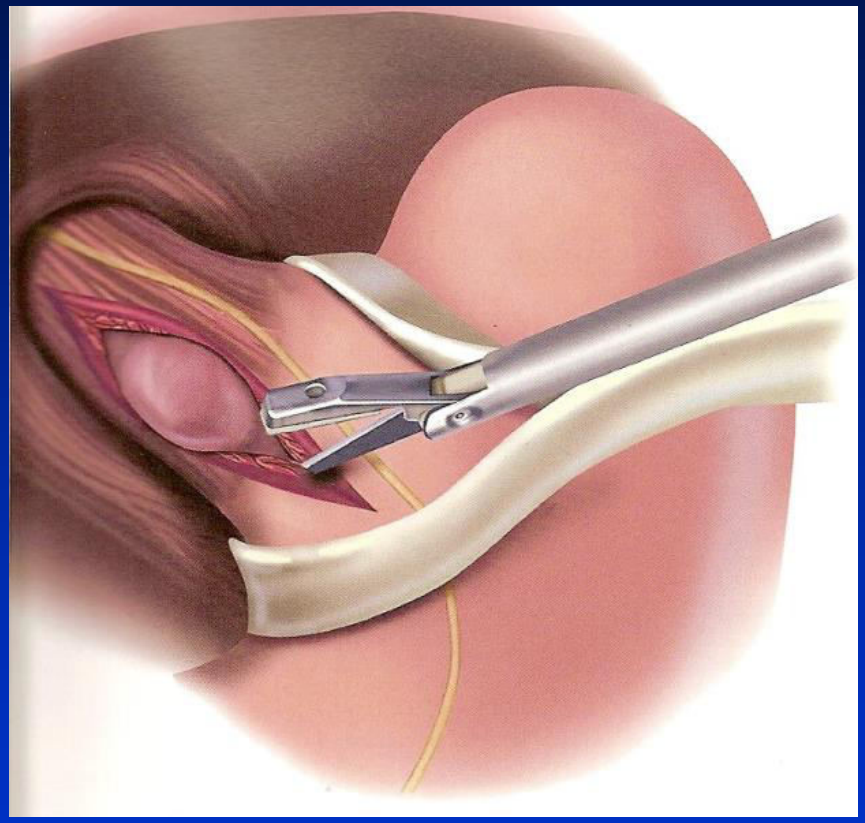
Heller Myotomy

Achalasia is a primary esophageal motility disorder that is characterized by failure of the esophagus to empty normally.

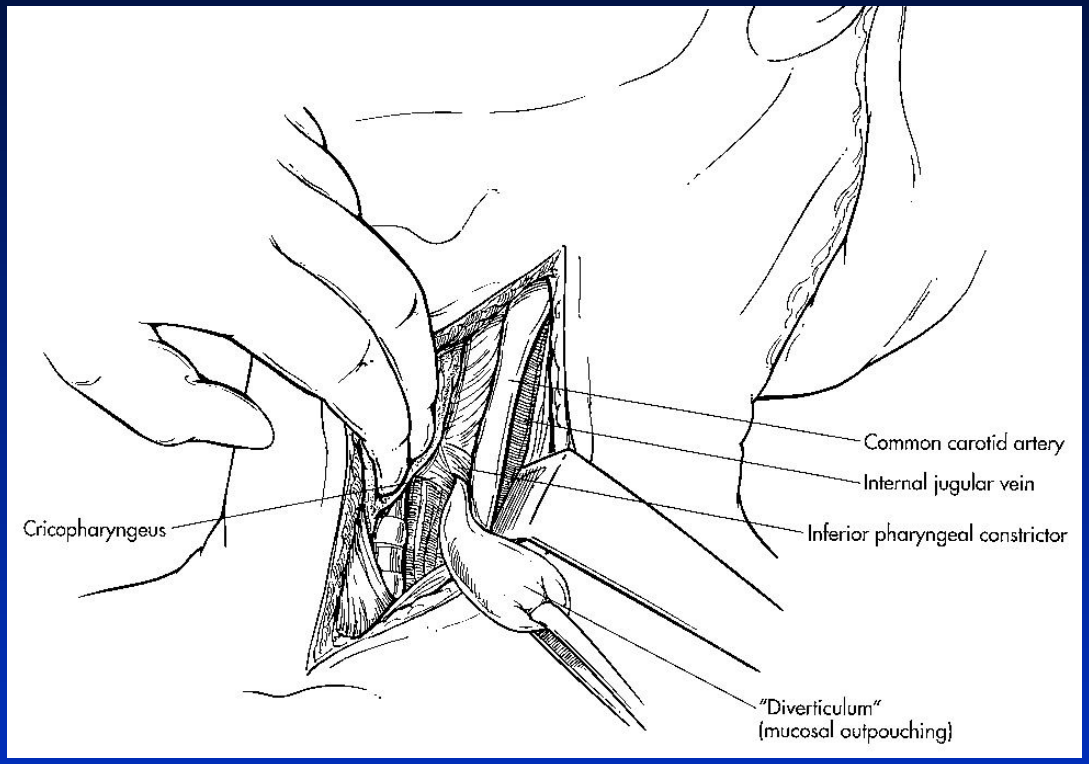
The cause is unknown and treatment is directed at relieving the outflow obstruction caused by failure of the lower esophageal sphincter to relax.

Treatment options include Botox injection, balloon dilation, and surgical myotomy, or dividing the offending esophageal muscle.

Surgical **Heller myotomy** is the gold standard treatment for Achalasia and when done minimally invasively, including robotically, has excellent results with average hospital stays of 1-2 days.



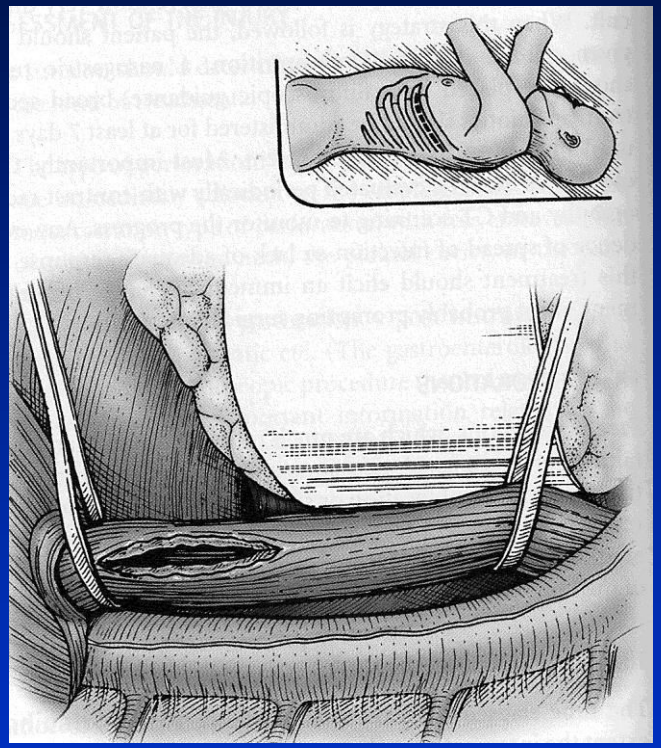
Zenker's Diverticulum



A **Zenker's diverticulum** forms as a result of dysfunction of the pharyngoesophageal junction. This leads to increased pressure that causes an outpouching of the esophagus, usually on the left side. The diverticulum that forms can then lead to food or pills getting stuck, cause bad breath, cause difficulty with swallowing, and lead to aspiration pneumonias. Once detected it should be repaired surgically.

The operation involves an incision in the left neck to divide the offending pharyngoesophageal muscle and then to either resect or suspend the diverticulum to prevent further complications. Most patients are discharged home in 2-3 days and have resolution of their symptoms after surgery.

Esophageal Perforation

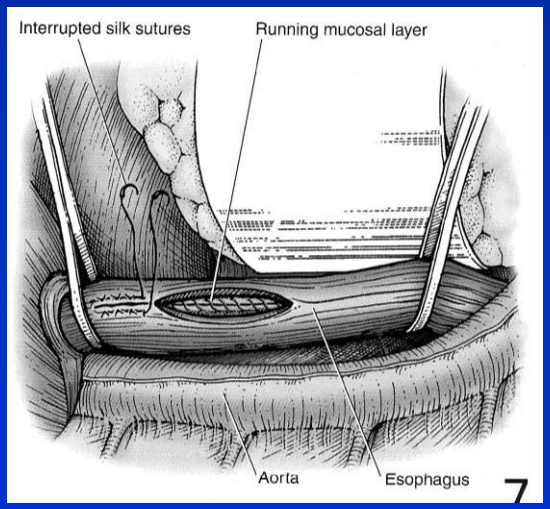


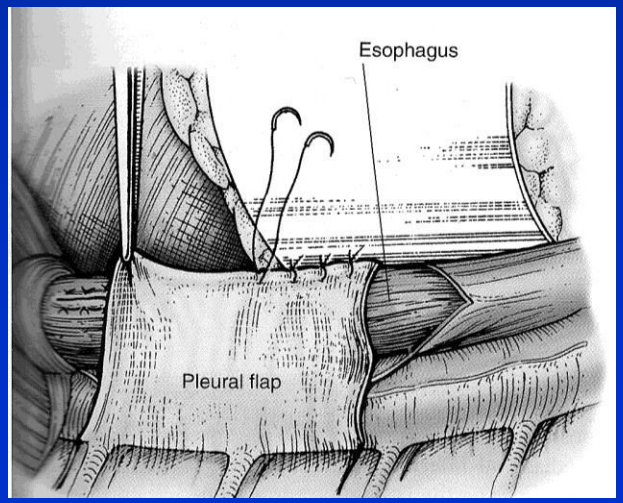
Esophageal perforation is a serious condition that if left untreated is usually fatal. The most common cause is related to esophageal instrumentation with scopes or dilation. Other causes include forceful vomiting, and obstructing esophageal tumors.

The consequence of perforation is the extravasation of oral secretions with bacteria into the mediastinal space leading to a severe inflammatory reaction and eventually septic shock and then death.

The most important factor in survival is the time from perforation to treatment – the sooner it is treated the better.

Treatment includes intravenous antibiotics, drainage with chest tubes and nasogastric tubes, and operative intervention. Surgical options include operative drainage, **repair of the perforation which is preferred** if possible, esophageal resection, and esophageal diversion.





Esophageal Cancer

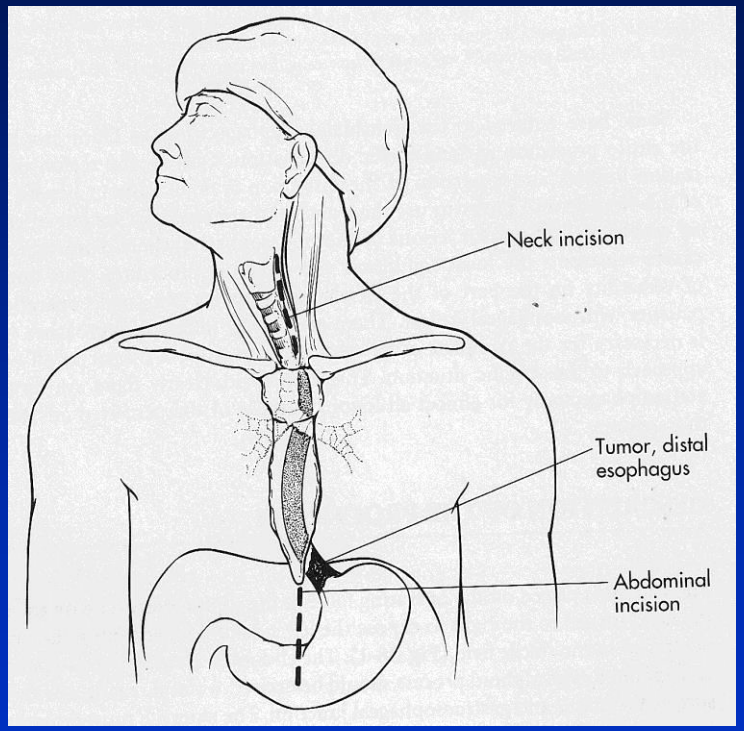
Esophageal cancer affects approximately 14,000 Americans each year with unfortunately an overall poor 5 year survival.

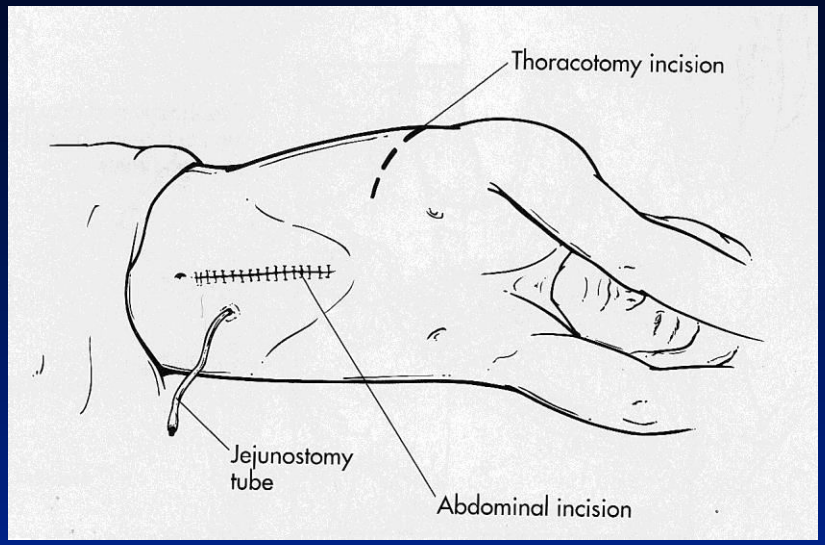
Most patients present with dysphagia, or difficulty swallowing. Diagnosis is usually made with a barium swallow, endoscopy with biopsy, and/or a CT scan.

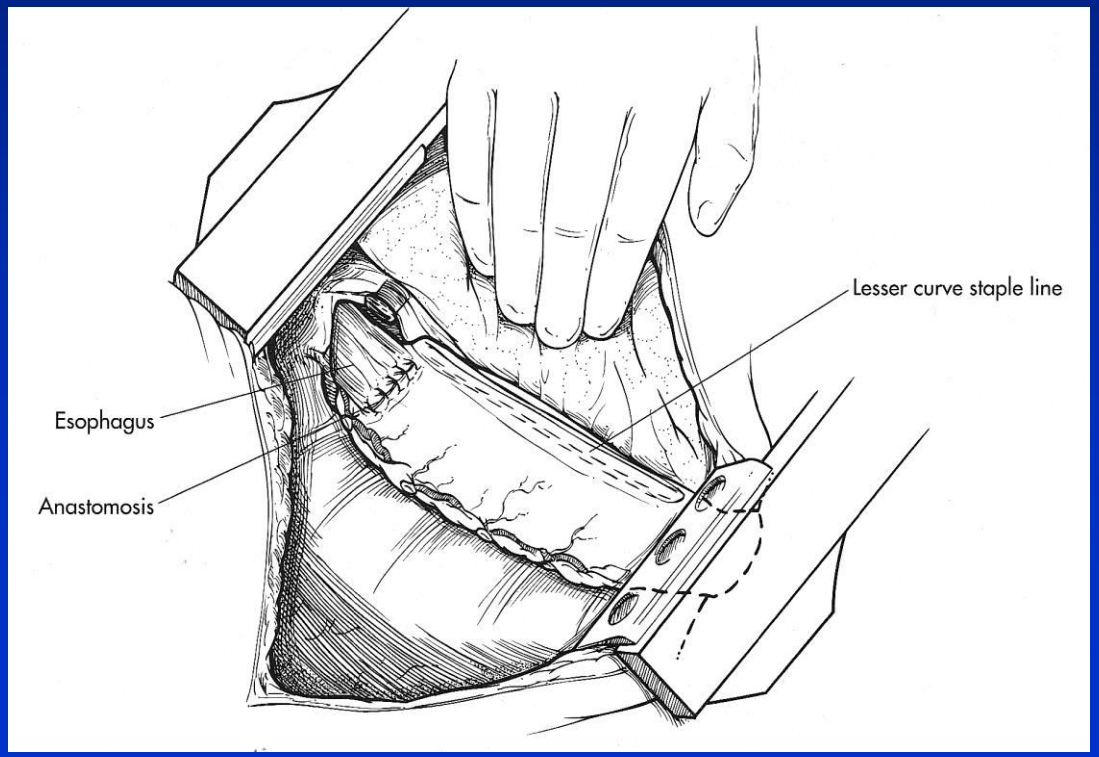
Surgery is directed at removing the esophagus and then replacing it with either the stomach or colon to re-establish gastrointestinal continuity.

Traditionally, surgery involved either a large chest or abdominal incision or both, but now this can be accomplished minimally invasively. Most patients after undergoing an esophagectomy will stay in the hospital 10-14 days. The minimally invasive approach allows less postoperative pain, shorter hospital stays, and faster recovery.

Esophageal Cancer

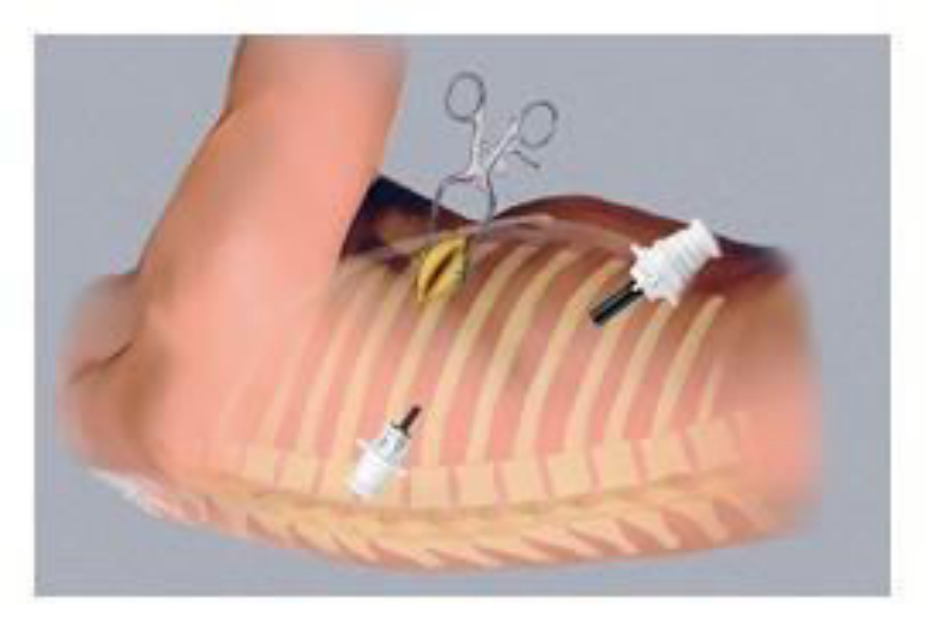


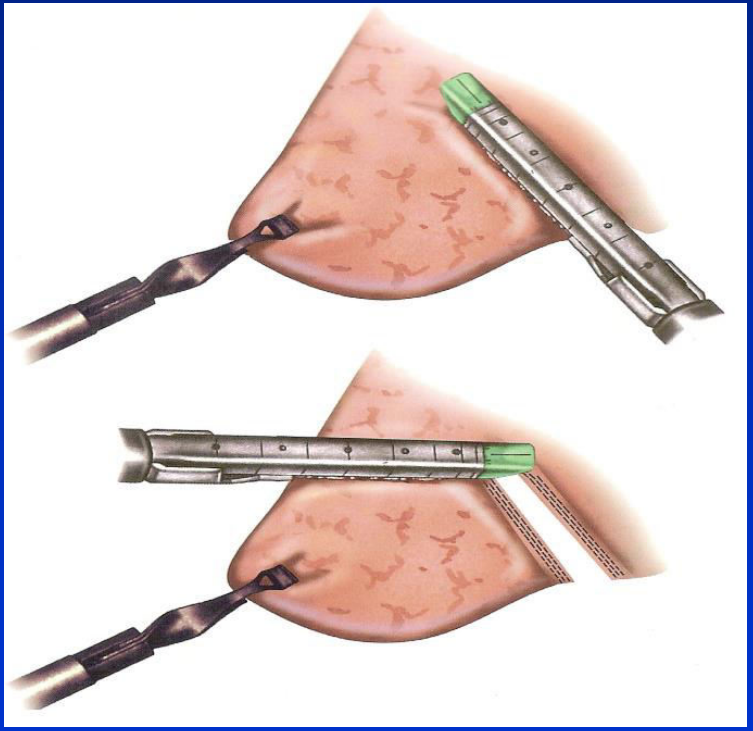




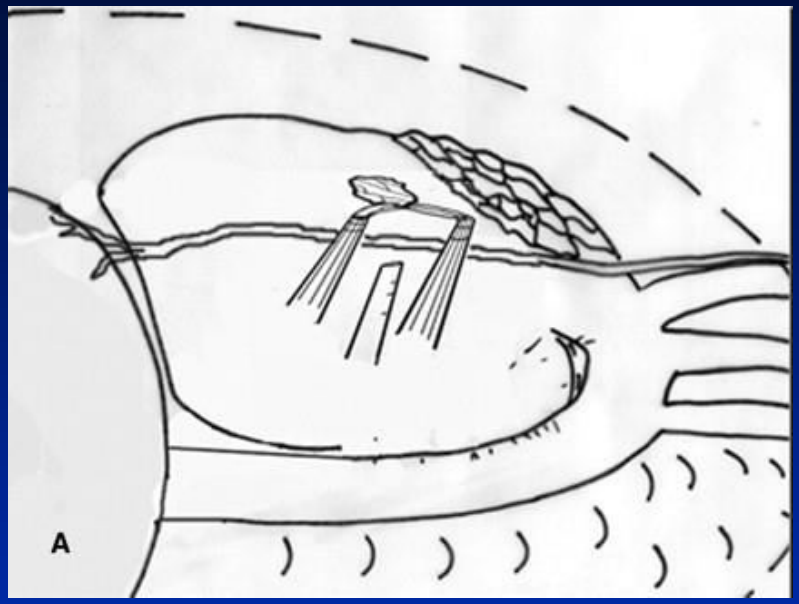
VATS
(Video Assisted Thoracic Surgery)

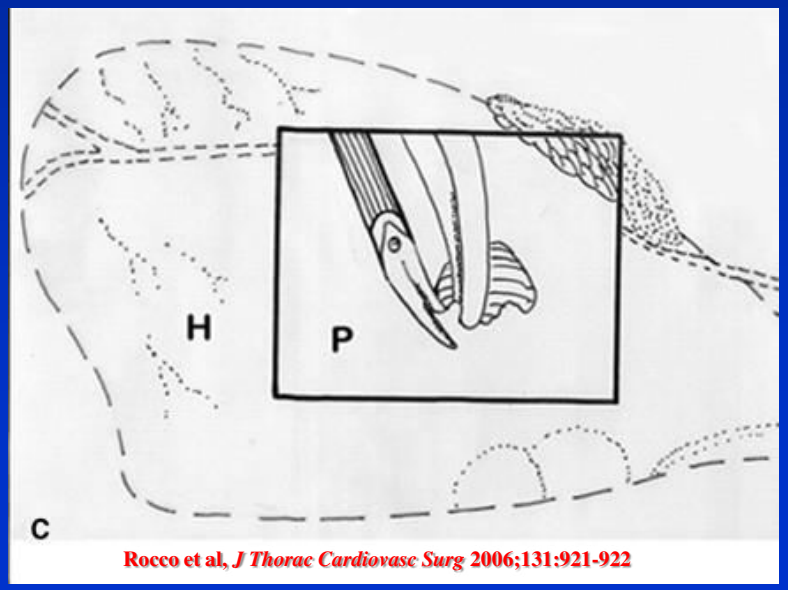

Example of VATS Incisions





Pericardial Window





Rocco et al, *J Thorac Cardiovasc Surg* 2006;131:921-922

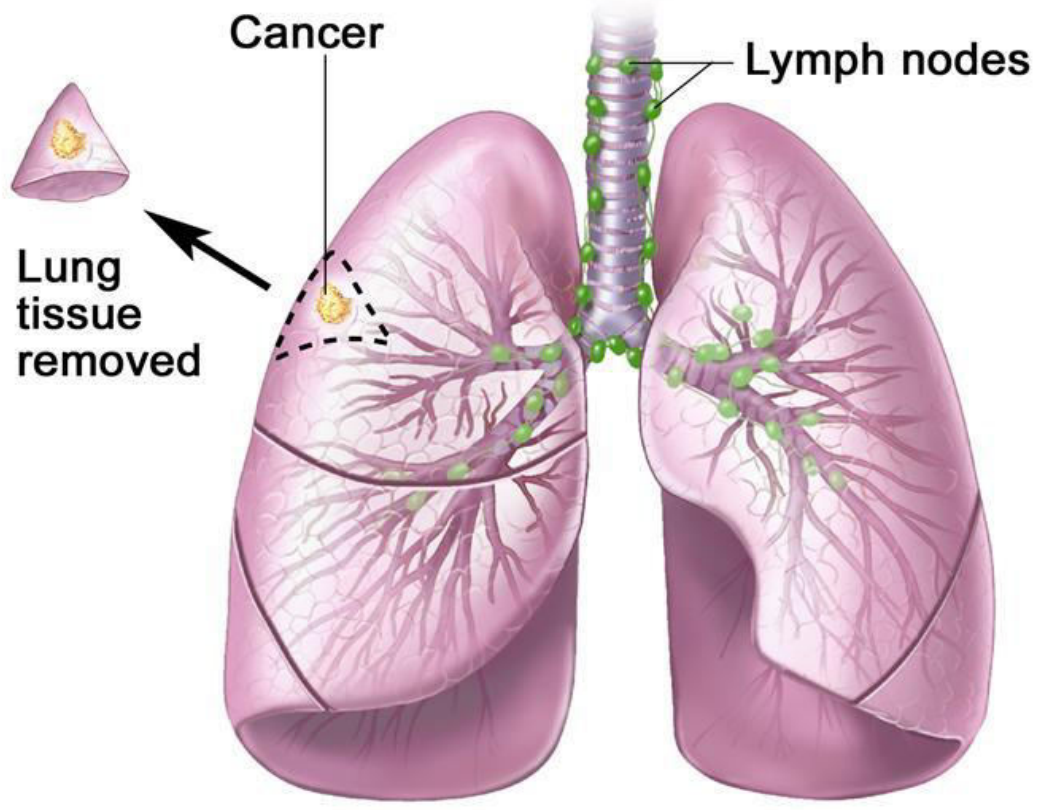
Pericardial effusions if large enough it can cause tamponade, preventing the heart from filling properly and leading to death. The traditional approach of a subxyphoid pericardial window is 80-85% effective.

A **VATS pericardial window** is a minimally invasive video assisted approach that creates a hole in the pericardium to allow the fluid to drain into the chest cavity and is **95% effective** in draining the pericardial effusion and preventing cardiac tamponade.

TABLE 6-4 ■ RATES OF CONTROL FOR PERICARDIAL EFFUSION AFTER THE VARIOUS METHODS FOR TREATMENT[17]

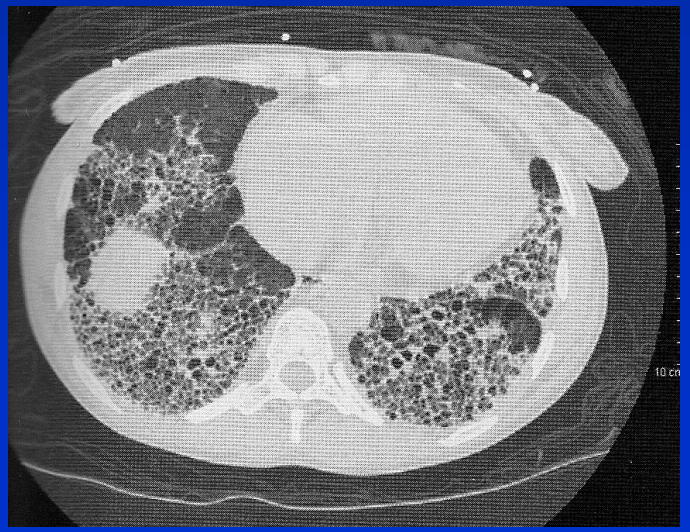
Technique	No Recurrence at 3 Months (%)
Pericardiocentesis	10
Pericardiocentesis plus sclerosis	75
Subxiphoid window	86
Thoracotomy for window	90
VATS window	95

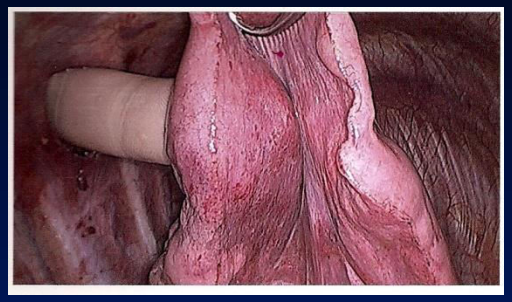
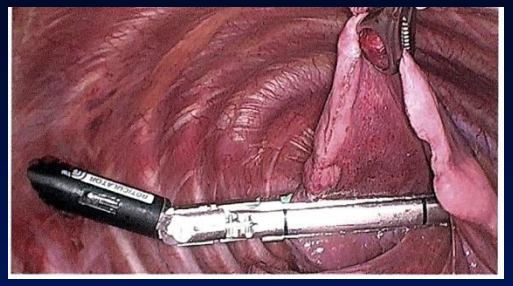
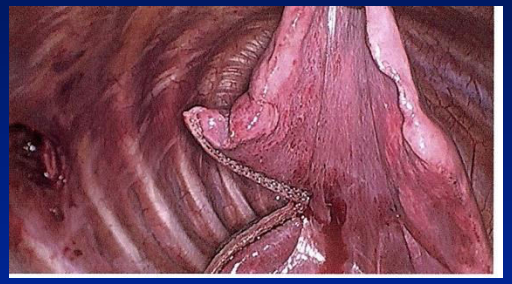
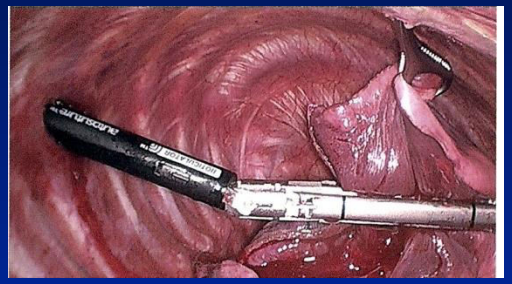
Wedge Resection

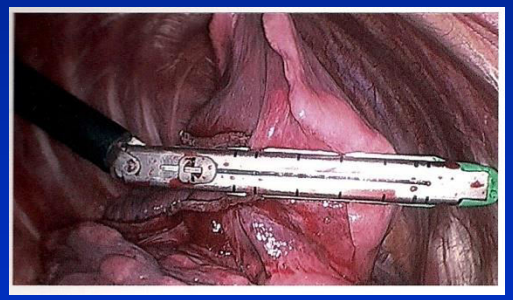


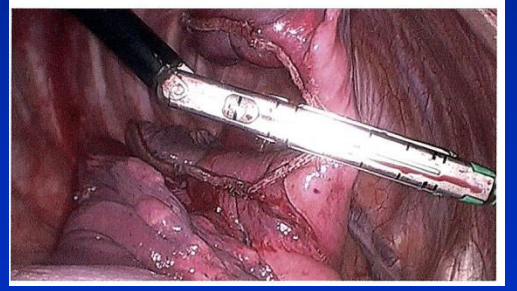
Wedge resection is a nonanatomic resection of a small portion of the lung. This is usually done to make a diagnosis with respect to a lung nodule or mass, and can be done to treat lung cancer in patients whose lung function does not permit a more extensive cancer operation such as lobectomy. It is also used on patients to make a diagnosis to aid in the treatment of an underlying pulmonary condition.

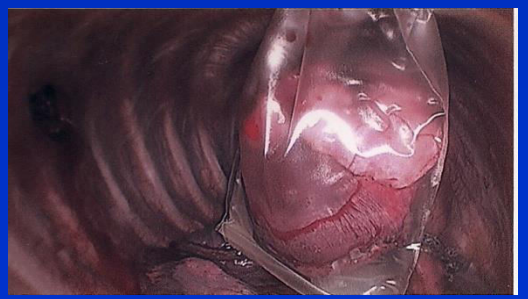
Today, we perform wedge resections **minimally invasively thru a VATS approach**. The advantages include smaller incision, no rib spreading or cutting, less pain, shorter hospital stay, and earlier return to normal activity and work. Also, the minimally invasive technique allows us to offer surgery to higher risk patients who would otherwise not be candidates for traditional surgery.



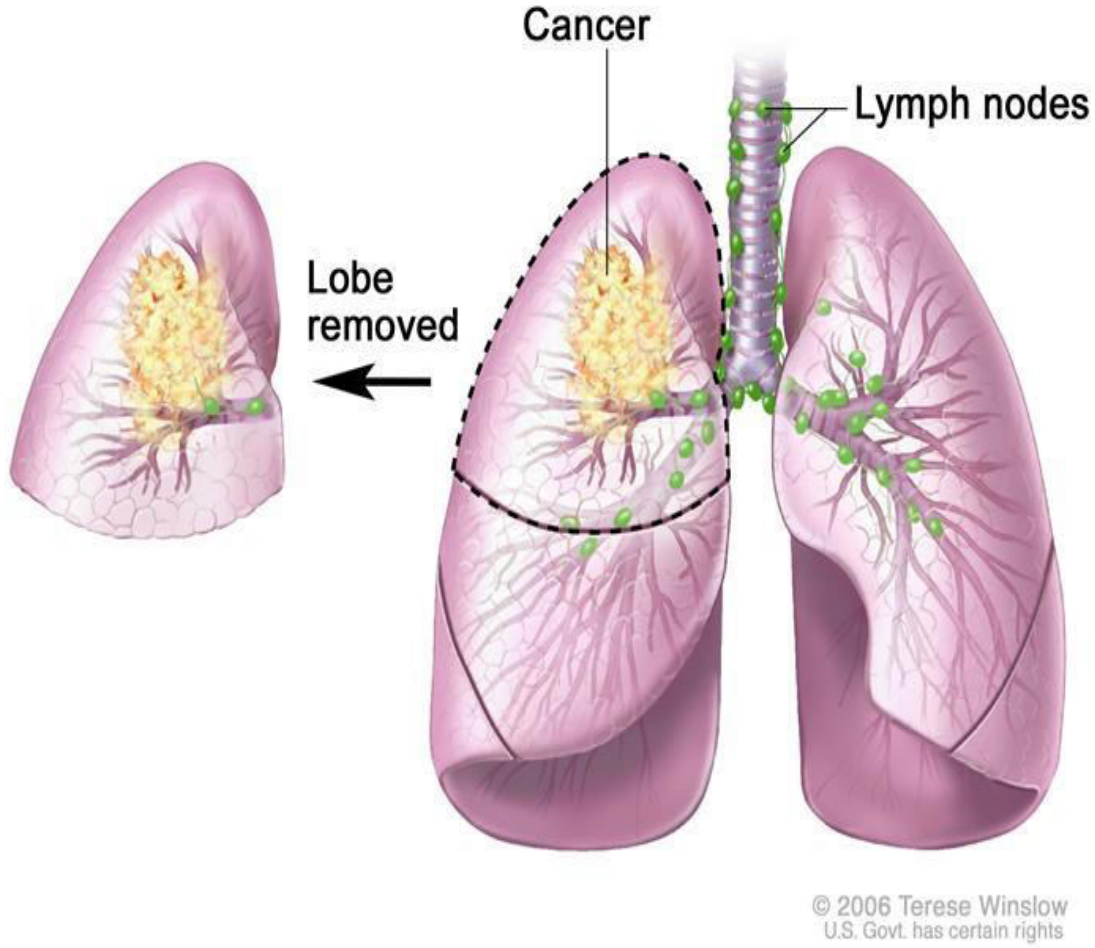










Lobectomy



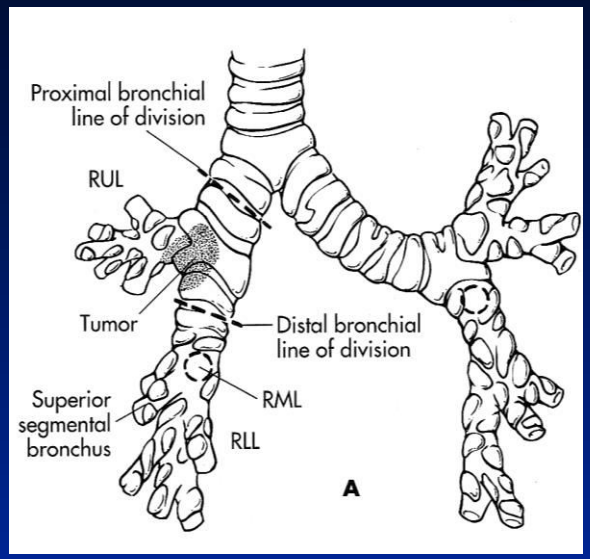
Lobectomy is the removal of a lobe of the lung, usually to treat lung cancer. Traditionally, a thoracotomy was used to accomplish this, but the incision was large, painful, led to many postsurgical complications.

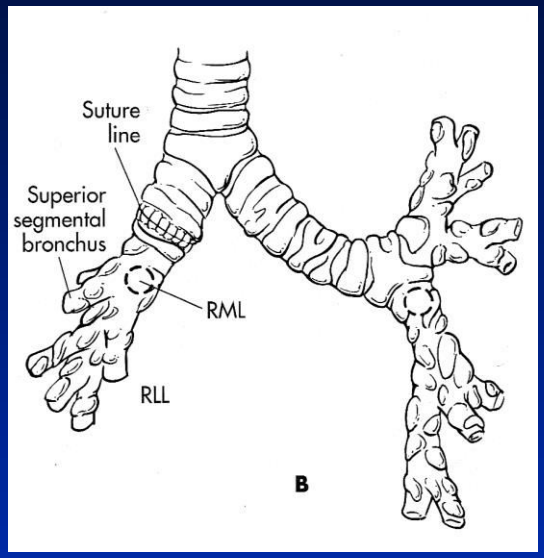
Today, we can perform a lobectomy minimally invasively thru a VATS approach.

The advantages include smaller incision, no rib spreading or cutting, less pain, less pneumonia (3% vs 19% in open lobectomy), less atrial fibrillation (3% vs 20% in open lobectomy), shorter hospital stay (4 days vs 9 days in open lobectomy), and earlier return to normal activity and work.

Also, the minimally invasive technique allows us to offer surgery to higher risk patients who would otherwise not be candidates for traditional surgery.

Sleeve Lobectomy

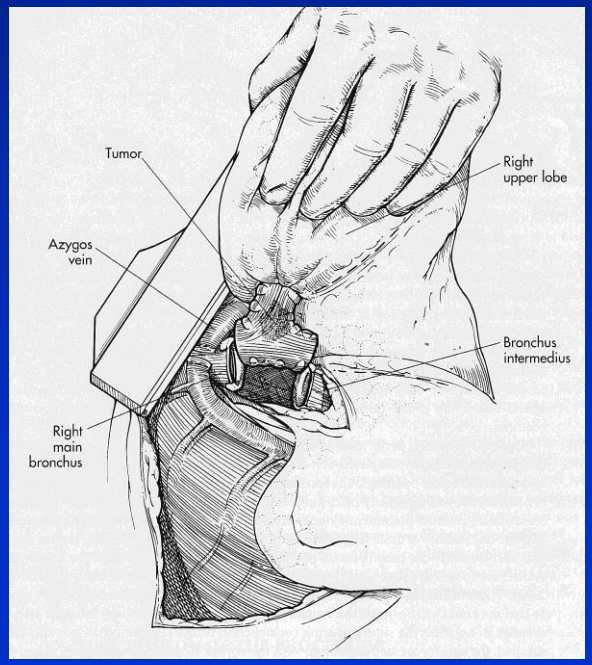


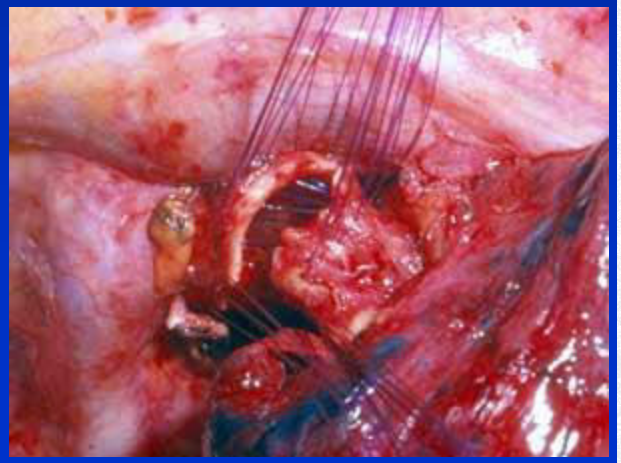


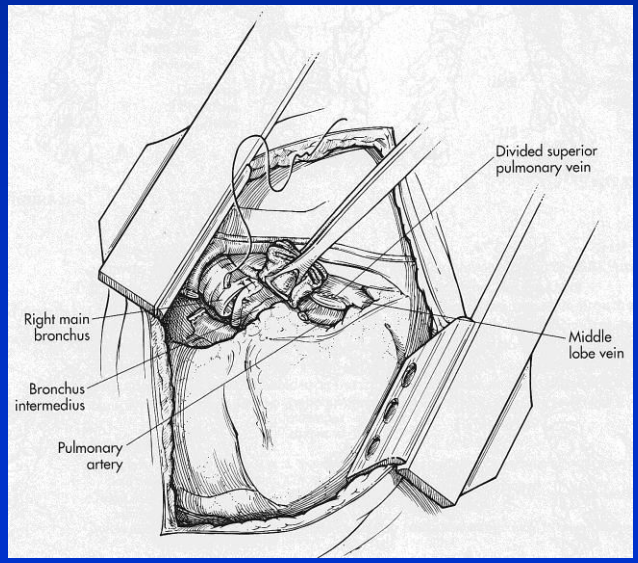
Sleeve lobectomy is an operation used for tumors or diseases that are not amenable to simple lobectomy. This is usually because the tumor or disease involves the origin of a lobar bronchus.

The involved lobe is removed and the ends of the bronchus are rejoined and any remaining lobes are reattached to the bronchus. The sleeve resection therefore, spares uninvolved lung and maintains more respiratory function. The main goal of a sleeve resection is to avoid a pneumonectomy which is the removal of the entire lung.

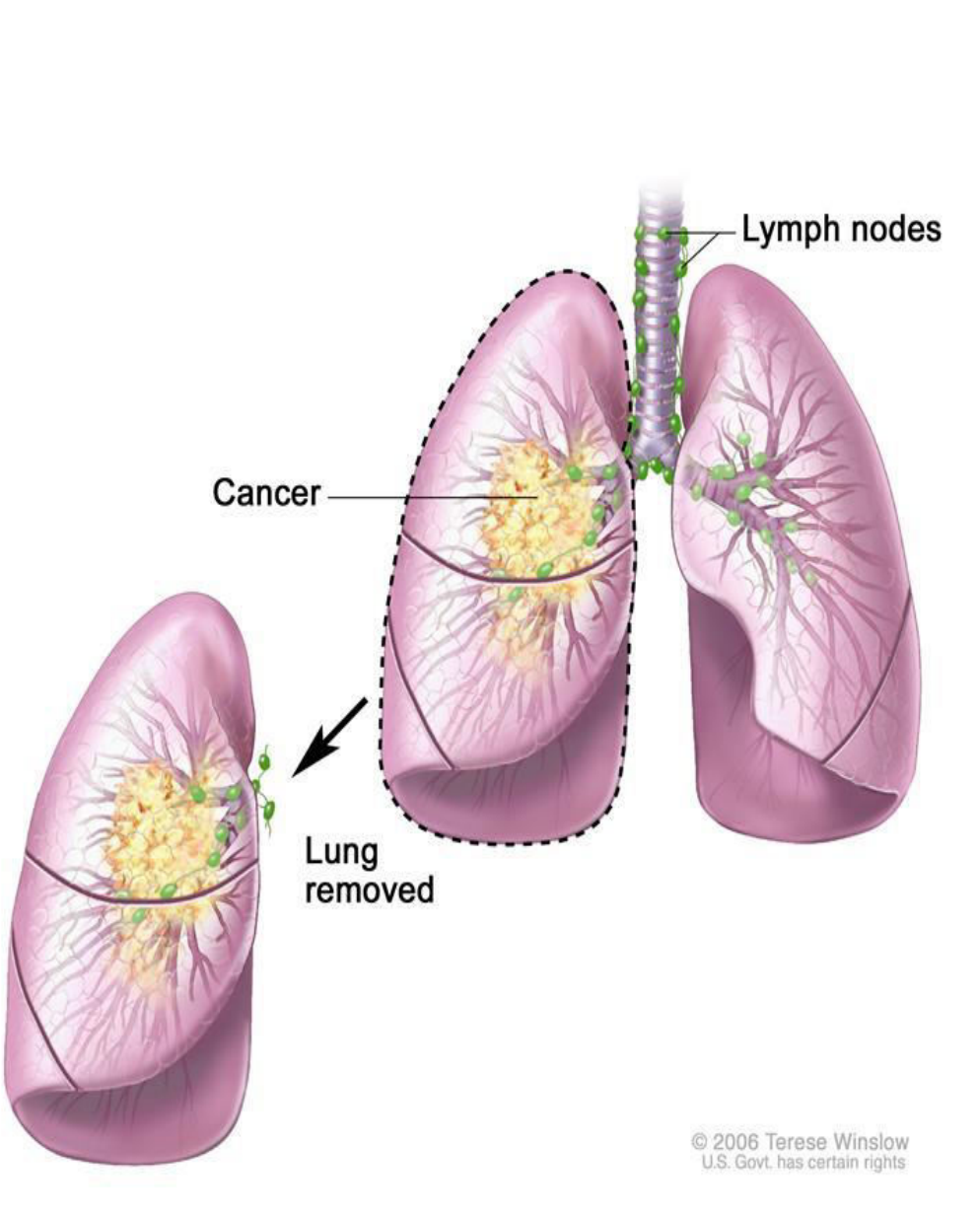
Sleeve resections based upon their complexity require a traditional thoracotomy approach.







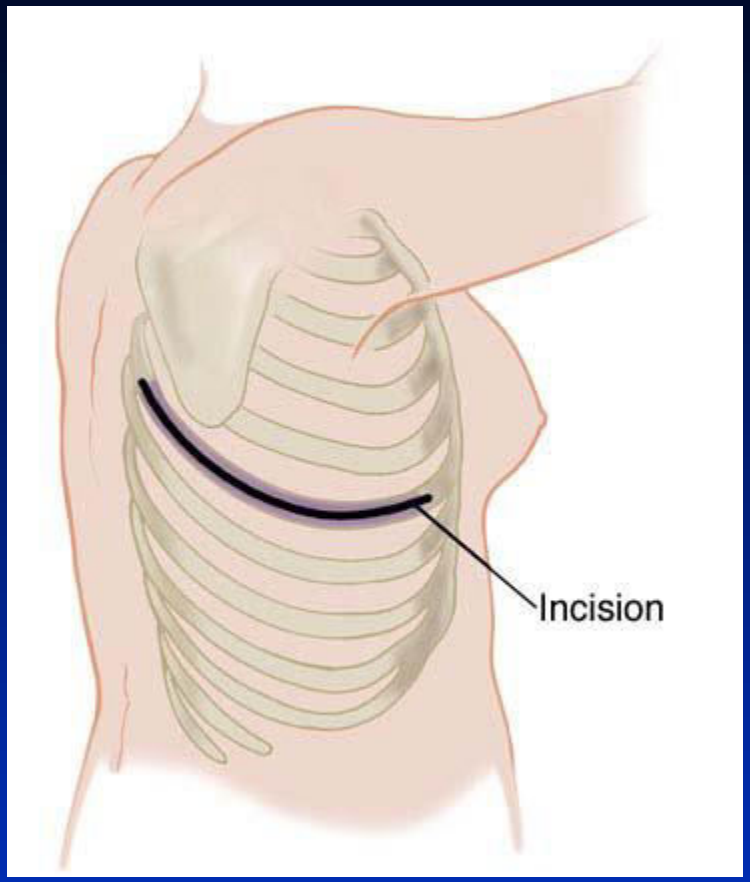
Pneumonectomy

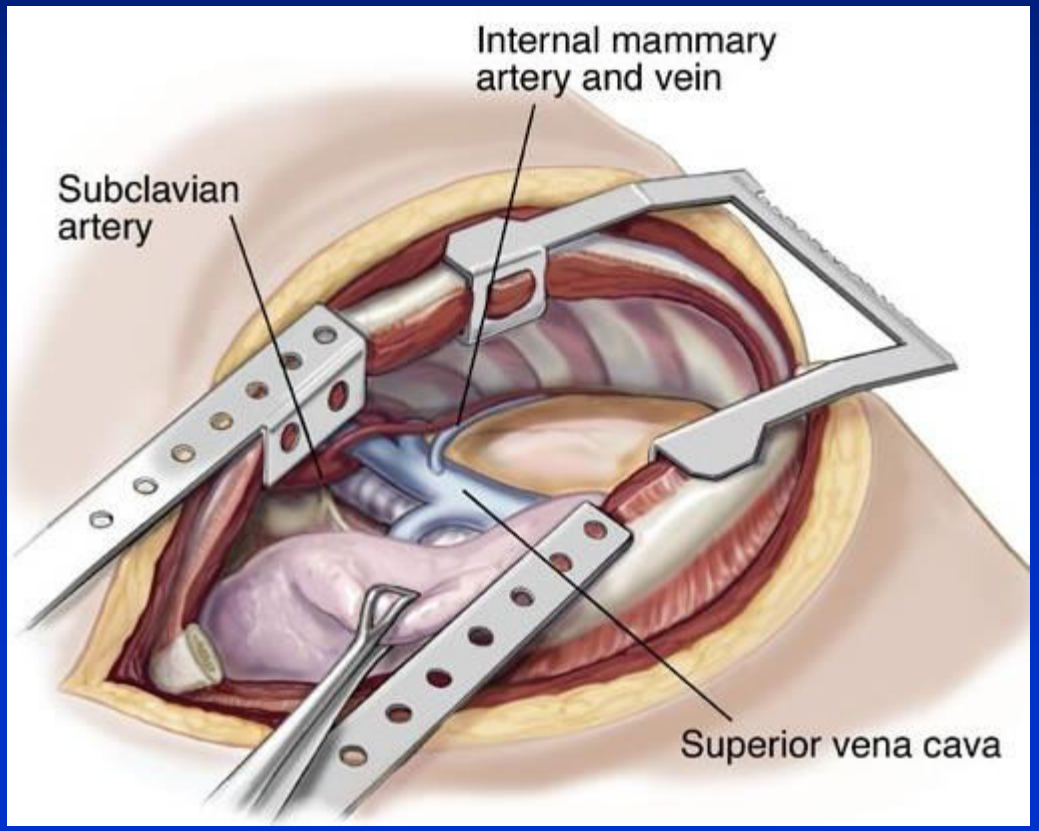


Pneumonectomy is the removal of an entire lung, usually done for lung cancer. Patients can live on only one lung if needed, provided their pulmonary function is adequate.

Pneumonectomy is however an aggressive surgical approach and does have significant risks when compared to lobectomy.

Based upon its complexity, a pneumonectomy requires a traditional thoracotomy approach.


Incision


Internal mammary
artery and vein
Subclavian
artery
Superior vena cava

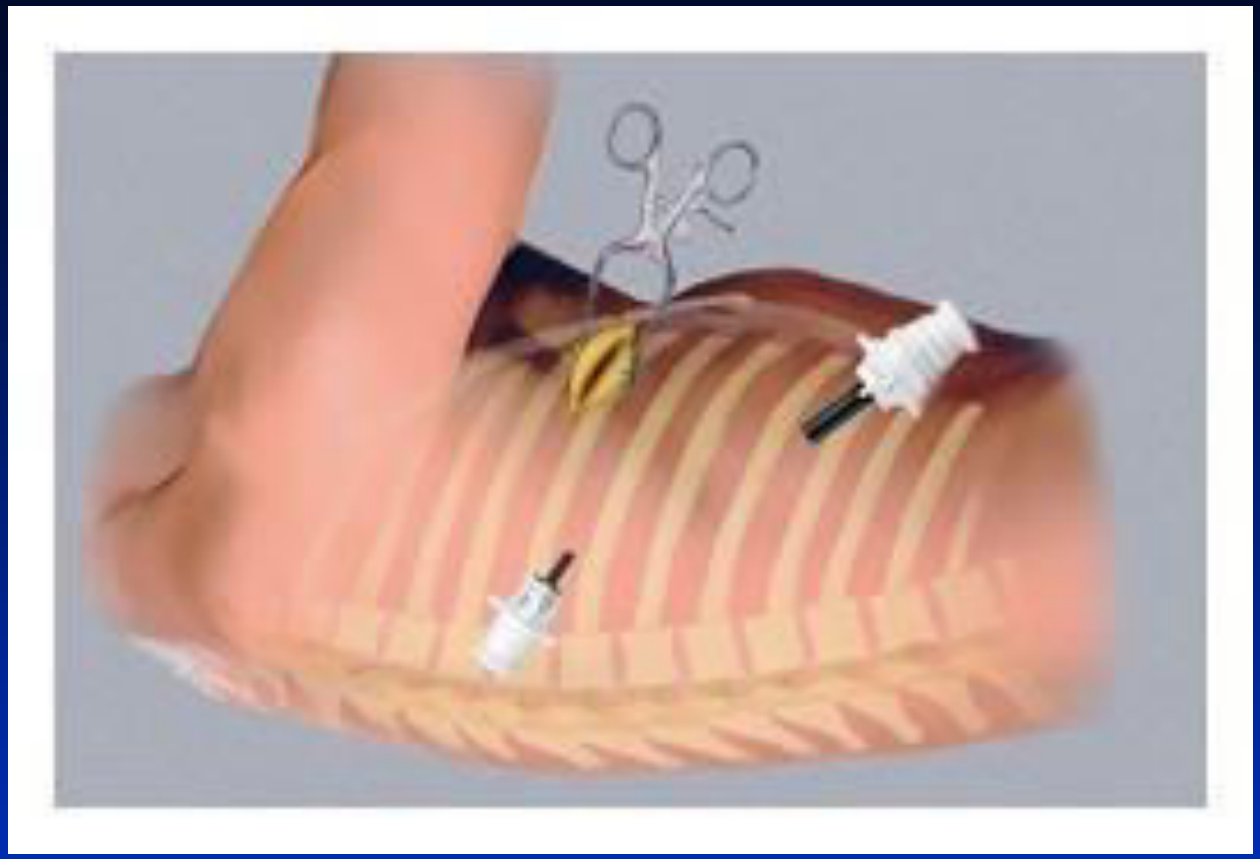
VATS Lobectomy

Video Assisted Thorascopic Surgery

VATS Lobectomy

- Standardize the definition of a VATS lobectomy to encompass a true anatomic lobectomy with individual ligation of lobar vessels and bronchus as well as hilar lymph node dissection or sampling using the video screen for guidance, two or three ports, and no retractor use or rib spreading.

CALBG 39802, 2007



Example of VATS Incisions

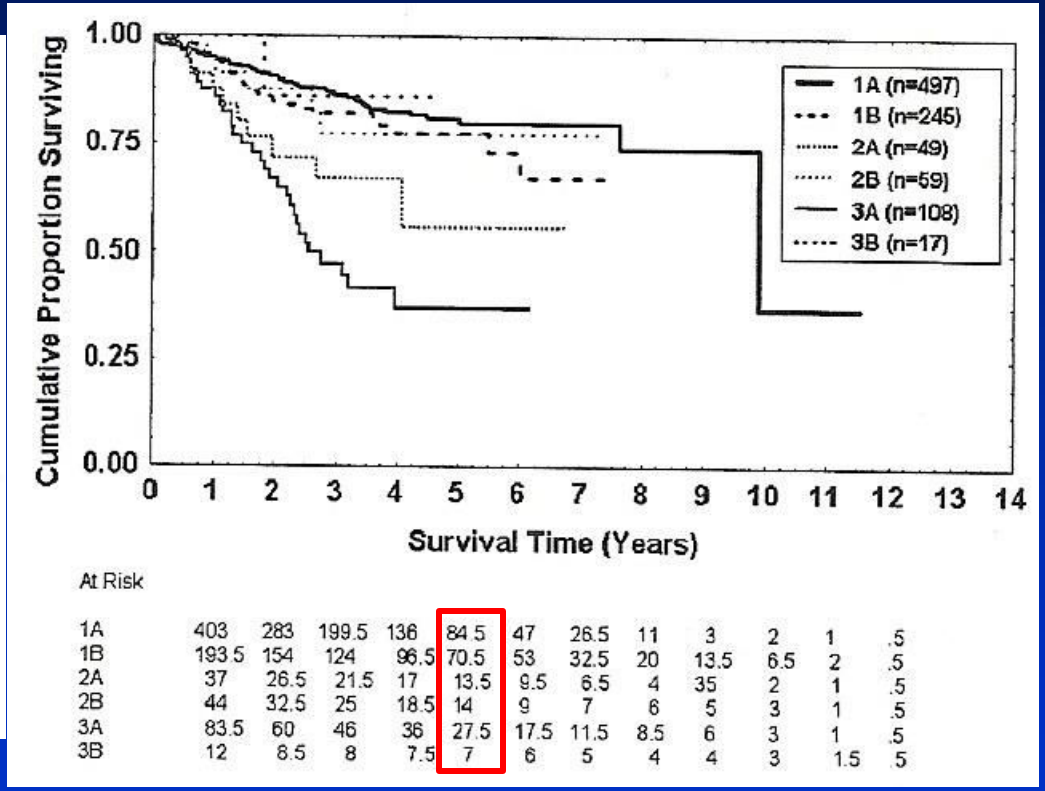
Video-Assisted Thoracic Surgery Lobectomy: Experience With 1,100 Cases

Robert J. McKenna, Jr, MD, Ward Houck, MD, and Clark Beeman Fuller, MD

Cedars Sinai Medical Center, Los Angeles, California

Table 1. Anatomic Pulmonary Resections Done With Video-Assisted Thoracic Surgery

Type of Resection	Number
Right upper lobectomy	403
Right middle lobectomy	92
Right lower lobectomy	158
Pneumonectomy	14
Segmentectomy	19
Sleeve lobectomy	3
Bilobectomy	18
Bilateral lobectomy	1
Left upper lobectomy	279
Left lower lobectomy	113



Results

- Mortality Rate = 0.8%
- Complication Rate = 15.3%
- Arrhythmias = 2.9%
- Prolonged Air Leak = 5.1%

- Conversion Rate = 2.5%
- Mean Age of Patients = 71.2 years
- Mean LOS = 4.78 days
- 20% discharged POD 1 or 2

ACOSOG Z0030 Trial :

- Open thoracotomy in patients older than 70 years, morbidity of 40-50%
- Atrial Arrhythmias = 15%
- Prolonged Air Leak = 8%
- Mortality Rate = 2.3% (Older than 70 years)

Thomas et al:

- Open thoracotomy in patients older than 70 years, mortality rate 12.8%

Oncologic Benefit of VATS?

Petersen et al:

- **VATS lobectomy has greater likelihood of planned delivery of adjuvant therapy after surgery**

- **61% VATS lobectomy received 75% or more planned adjuvant therapy without delay or dose reduction**

versus

- **40% open lobectomy received 75% or more planned adjuvant therapy**

Quality of Life:
Demmy et al, *Ann Thor Surg* 2008

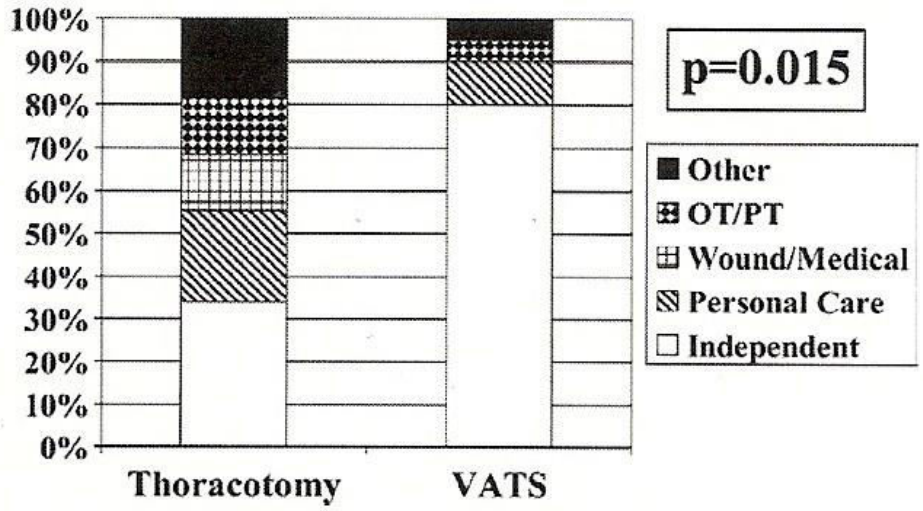


Fig 1. Discharge independence after thoracoscopic lobectomy. The bar graphs demonstrate a much lower need for home health services in the video-assisted thoracic surgery (VATS) group. The types of services needed for each procedure type are displayed as well. (OT = occupational therapy; other = other miscellaneous care needs; PT = physical therapy.) Adapted from Demmy TL, et al. Discharge independence with minimally invasive lobectomy. Am J Surg 2004;188:698–702.

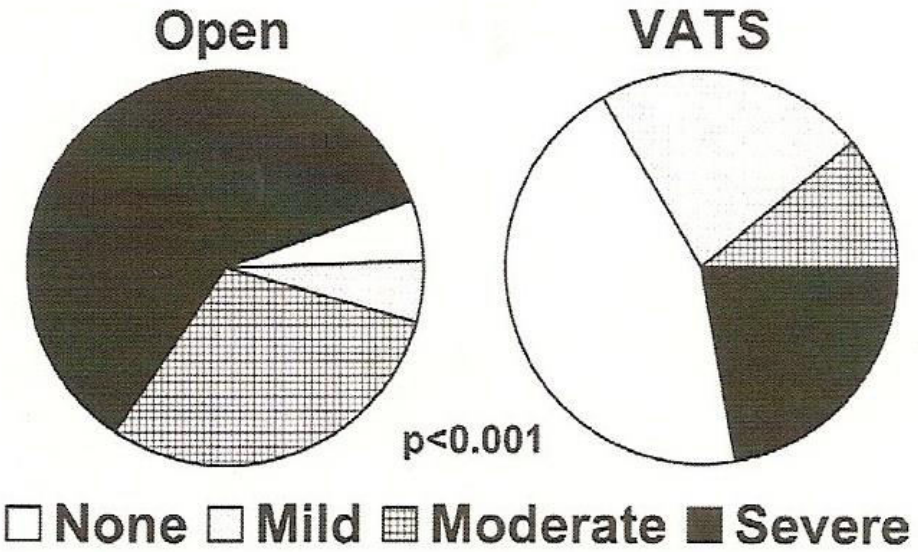


Fig 2. Pain control at 3 weeks after video assisted thoracic surgery (VATS) lobectomy. The pie charts show that VATS patients have significantly ($p < 0.01$) less pain as measured by the most potent analgesic still required: severe—schedule 2 narcotic; moderate—schedule 3 or lower; mild–nonsteroidal anti-inflammatory drugs or acetaminophen. These data represent an updated series of high-risk reported previously [49, 61].

Benefit of VATS Lobectomy in the Elderly

Koizumi et al:

- 32 octogenarian or nonagenarian patients
- 5 year survival rate of **56% with VATS lobectomy** with early stage cancer

Versus

- 5 year survival rate of **0% with open lobectomy** with early stage cancer

Use of Video-Assisted Thoracic Surgery for Lobectomy in the Elderly Results in Fewer Complications

Stephen M. Cattaneo, MD, Bernard J. Park, MD, Andrew S. Wilton, MS, Venkatraman E. Seshan, PhD, Manjit S. Bains, MD, Robert J. Downey, MD, Raja M. Flores, MD, Nabil Rizk, MD, and Valerie W. Rusch, MD

Departments of Surgery and Epidemiology and Biostatistics, Memorial Sloan-Kettering Cancer Center, New York, New York

Table 2. Perioperative Data

Characteristics	THOR (n = 82)	VATS (n = 82)	*p* Value[a]
Histology			
Adenocarcinoma	24 (29)	24 (29)	0.14
Adeno w/BAC	27 (33)	32 (39)	
Squamous	24 (29)	13 (16)	
Other	7 (10)	13 (16)	
Tumor diameter (range), cm	2.0 (0.3–8.0)	1.8 (0.1–7.5)	0.11
Pathologic stage			
IA	49 (60)	56 (68)	0.13
IB	15 (18)	19 (23)	
II	8 (10)	3 (4)	
III–IV	10 (12)	4 (5)	
Length of stay (range), days	6 (2–27)	5 (2–20)	<0.001
Complications, n (%)	37 (45)	23 (28)	0.04
Death, n (%)	3 (3.6)	0 (0)	0.10

Average age = 76 years

Table 4. Complication Profile

Type, n (%)	THOR (n = 82)	VATS (n = 82)	*p* Value[a]
None	45 (55)	59 (72)	0.04
Pulmonary	27 (33)	12 (15)	0.01
Cardiac (atrial fibrillation)	19 (23)	14 (17)	0.44
Genitourinary	5 (6)	2 (2)	
Gastrointestinal	4 (5)	0 (0)	
Infectious	4 (5)	1 (1)	
Neurologic	1 (1)	3 (4)	
Other	2 (2)	0 (0)	

VATS Lobectomy Summary

- Enhanced visualization
- Decreased trauma to the tissue
- Decreased postoperative pain
- Decreased postoperative respiratory and other complications
- Decreased Hospital Stay
- Shortened Recovery time, allowing return to work and daily activities sooner
- Ability to offer surgery to higher risk patients who would not be candidates otherwise