Investigation of Lung disease

No.12

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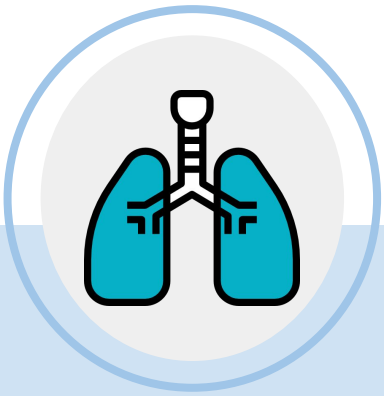

Objectives :

- ★ Describe the types of pulmonary diagnostic tests and procedures.
- ★ Explain each type of pulmonary diagnostic test and procedures.
- ★ Explain the role of each pulmonary diagnostic tests & procedures in diagnosing lung diseases.
- ★ Explain when and how to apply each diagnostic tests & procedures.

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Pulmonary diagnostic procedures

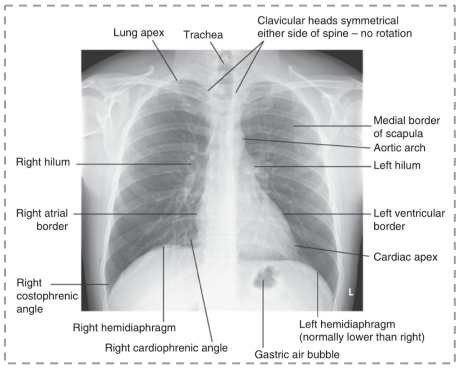
Diagnostic Methods

- Imaging
- Thoracentesis
- Pleural biopsy
- Pulmonary function test
- Bronchoscopy
- Scintigraphic imaging

1. Imaging

Chest X-ray

- **Chest X-ray:** performed on the majority of patients suspected of having chest disease. It is usually one of the first tests done to investigate someone who has a persistent cough, chest pain, shortness of breath, fever or who has had an injury to their chest wall or suspicion of cancer.
- Normal air filled lungs let the x-rays pass through so appear black.
- Some diseases, such as tuberculosis or lung cancer, may be obvious on the chest x-ray. Conversely, asthma or chronic bronchitis may be associated with a normal chest X-ray



Normal Chest- Xray

Common Chest X-ray abnormalities

Abnormality	Causes
Pulmonary & Pleural shadowing	• **Consolidation:** infection, infarction, inflammation and, bronchoalveolar cell carcinoma (rare) • **Lobar collapse:** mucus plugging, tumour, compression by lymph nodes • **Solitary nodule** • **Multiple nodules:** miliary tuberculosis (TB), dust inhalation, metastatic malignancy, healed varicella pneumonia, rheumatoid disease • **Ring shadows, tramlines and tubular shadows:** bronchiectasis • **Cavitating lesions:** tumour, abscess, infarct, pneumonia (Staphylococcus/Klebsiella), granulomatosis with polyangiitis (formerly known as Wegener's granulomatosis) • **Reticular, nodular and reticulonodular shadows:** diffuse parenchymal lung disease, infection • **Pleural abnormalities:** fluid, plaques, tumour
Increased translucency	• Bullae • Pneumothorax • Oligaemia
Hilar abnormalities	• Unilateral hilar enlargement: TB, lung cancer, lymphoma • Bilateral hilar enlargement: sarcoid, lymphoma, TB, silicosis
Other abnormalities	• Hiatus hernia • Surgical emphysema

To learn more about chest X-ray abnormalities click here

CT scan

◀ Computed tomography

- Provides detailed images of the pulmonary parenchyma, mediastinum, pleura and bony structures.
- It is essential in staging bronchial carcinoma by demonstrating tumor size, nodal involvement, metastasis and invasion of mediastinum, pleura or chest wall.

★ **3 modalities of CT scan:**

- **HRCT (Doesn't require contrast)** : Used if you are interested in **lung parenchyma** or **interstitium** e.g. Bronchiectasis(diagnosis >90% sensitivity and specificity) , pulmonary fibrosis, emphysema
- **CT with contrast**: Used if you are interested in the mediastinal lymph nodes, pleura
- **CT Angio**: pulmonary vasculature e.g. PE It is most commonly used to look for blood clots in the lungs (pulmonary emboli).

◀ HRCT (high resolution CT scan)

- Designed for detailed evaluation of interstitial structures of the lung .
- Assessment of diffuse inflammatory and infective parenchymal processes.
- Uses narrow slice thickness (1-2 mm) compared with 5-10 mm for routine scan
- These scans are used to detect and monitor Interstitial Lung Disease, Bronchiectasis, and Connective Tissue Diseases involving the lungs amongst many other conditions

Principal indications

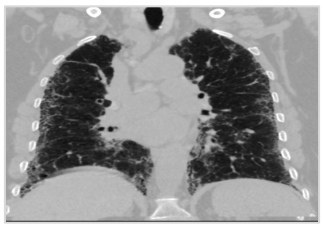
- Suspected interstitial lung disease
- Characterization of interstitial lung disease e.g. sarcoidosis[1], hypersensitivity pneumonitis[2], occupational lung disease and any other form of interstitial pulmonary fibrosis[3]
- Diagnosis of lymphangitis carcinomatosa.
- Suspected opportunistic lung infection in immunocompromised patients.
- Characterization of solitary pulmonary nodules
- Diagnosis of **bronchiectasis**; it has a sensitivity and specificity of greater than 90%.
- Distinction of emphysema from diffuse parenchymal lung disease or pulmonary vascular disease as a cause of a low gas transfer factor with otherwise normal lung function

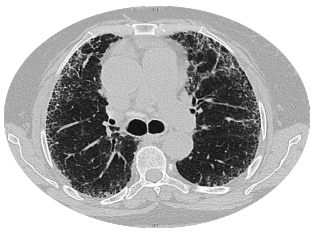
Sarcoidosis : Characterized by immune-mediated, widespread noncaseating granulomas, elevated serum ACE levels, and elevated CD4/CD8 ratio in bronchoalveolar lavage fluid. It's more common in African-American females. Often asymptomatic except for enlarged lymph nodes. CXR shows bilateral adenopathy and coarse reticular opacities ; CT of the chest better demonstrates the extensive hilar and mediastinal adenopathy.
Associated with **Bell palsy**, **U**veitis, **G**ranulomas (noncaseating epithelioid, containing microscopic Schaumann and asteroid bodies), **L**upus pernio (skin lesions on face resembling lupus), **I**nterstitial fibrosis (restrictive lung disease), **E**rythema nodosum, **R**heumatoid arthritis-like arthropathy, hypercalcemia (due to increased 1-alpha -hydroxylase –mediated vitamin D activation in macrophages). Biopsy is the gold standard for diagnosis.

Hypersensitivity pneumonitis: Mixed type III/IV hypersensitivity reaction to environmental antigen. Causes dyspnea, cough, chest tightness, fever, headache. Often seen in farmers and those exposed to birds. Reversible in early stages if stimulus is avoided.

Interstitial pulmonary fibrosis:
Repeated cycles of lung injury and wound healing with increased collagen deposition, "honeycomb" lung appearance, traction bronchiectasis and digital clubbing. The conditions takes an insidious course that initially presents with exertional dyspnea that progresses to dyspnea at rest, persistent nonproductive cough, and fatigue. Progression to respiratory failure usually occurs within 3–7 years.

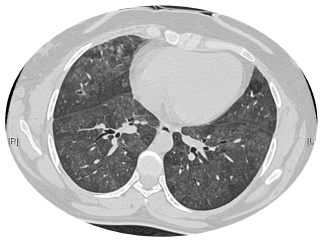
HRCT



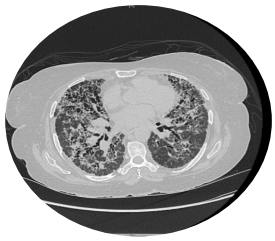


Reticulation bilaterally with small cystic structure (Honeycombing or fibrotic strands)

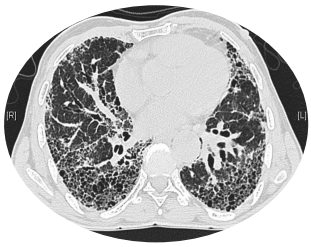
With these finding we can diagnose this patient with pulmonary fibrosis (But you can't say that the patient has idiopathic pulmonary **fibrosis** (IPF), you have to exclude other causes of pulmonary fibrosis first e.g. Connective tissue disorders, drug-induced, environmental factor, familial, congenital)



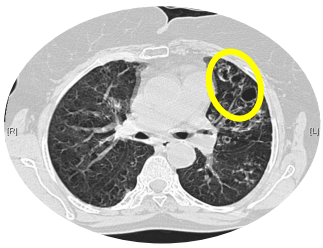
Hypersensitivity Pneumonitis : mosaic pattern (=air trapping), ground-glass opacity, (normal & abnormal areas)
an example is a **patient working in a farm and exposed to pigeon**
This is a presentation of someone who has a bird/parrot at home and is constantly exposed to antigens produced by the bird, resulting in hypersensitivity pneumonitis. (ddx should be obtained from history).



Sarcoidosis: it has similar picture to pulmonary fibrosis but it has predilection toward the bronchioles and you can see the fibrotic strands are going central.



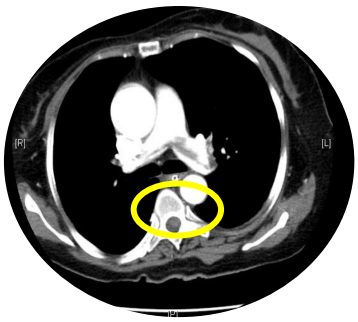
severe pulmonary fibrosis (advanced stage)
★**Crackles** are heard



Here it shows cystic type (Grape-like) bronchiectasis

CT Imaging

CT angiography



- Image data are acquired continuously as the tube and detector rotate within the gantry and the patient moves continuously through the gantry.
- If the filling defect is present we diagnose the patient with Pulmonary Embolism. The patient undergoes CT angiography with contrast which is white in images. We detect filling defects when there is stoppage of contrast movement, which appears as black colored spaces in images.

Grey opaque opacity sitting on the bifurcation of the pulmonary artery (Saddle PE)

Contraindications	Advantages
• Renal failure	• It's quick so it can be done in critically ill patients and children.
• Allergy to contrast [1]	• Less volume of intravenous contrast.
• **Pregnancy** [1]	• Permits greater processing of the raw data.[2]

MRI

MRI has been used in **staging lung cancer** and assessing **tumour invasion** in the mediastinum and chest wall and at the lung apex
Vascular structures can be clearly differentiated as flowing blood produces a signal void on MRI.

Transthoracic Ultrasound

Used for:

01 Confirming & assessing a pleural effusion (provides details about the nature of the effusion, such as whether it is a simple pleural effusion (single collection heavily loculated with adhesions or organized (more gelatinous).

02 Assists in determining the best site for pleural aspiration and intercostal chest drain placement

03 Ultrasound guided biopsy is used for lung masses that abut the pleura or pleural masses, if appropriate.

04 It is also used in bronchoscopy (endobronchial ultrasound, EBUS) to stage and sample mediastinal lymph nodes.

1-CT angiography is not done when the pt is allergic to contrast or is contraindicated to it (pregnancy). Instead we do V/Q scan to those patients.
2- You can visualize the pulmonary vasculature, lung parenchyma and other mediastinal structures

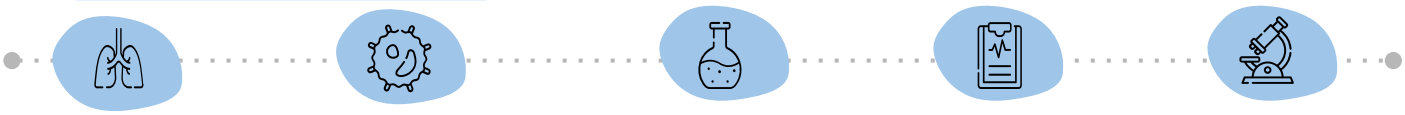
Thoracentesis

2. Thoracentesis

refer to pleural effusion lecture for more details

- Fluid is drained from the pleural cavity with a needle (aspiration).
- Before performing the procedure check the patient's **CBC** and **coagulation profile**, to exclude any bleeding problem (for e.g. thrombocytopenia) and **confirm pleural effusion by ultrasound** (or decubitus film if US isn't available).[2]

What to look for ?



Appearance[4]

Gram stain and cultures[5]
(Can be done within 3min in ER)

pH

Chemistry
(glucose,LDH amylase, protein)

Cytology

➜ **If any of the following features**[1] **are present, what's the best next step? Do CHEST TUBE (large bore)**

1. Gross appearance of **pus** (Indicating empyema) **or blood**
2. Gram stain **positive** (Indicating complicated parapneumonic effusion or empyema)
3. pH below **7.20** (Indicating complicated parapneumonic effusion or empyema)

Light's criteria:

measurements are taken from **pleural fluid & serum**

- 98% sensitive and 83% specific for exudative effusion using Light's criteria.
- Pleural effusion is exudative if one or more of the following

1. Ratio of pleural fluid protein level to serum protein level > 0.5
2. Ratio of pleural fluid LDH level to serum LDH level > 0.6 If pleural fluid LDH after measurement is 800 and the serum's is around 950 so its more than two thirds of the pleural fluid = exudative effusion.
3. Pleural fluid LDH level > 2/3 the upper limit of normal for serum LDH level

- **Absence of all 3 criteria = Transudative** indicating origin from **heart, liver, or kidney**

Indications for thoracentesis:

- What is the purpose of thoracentesis? To determine whether the pleural fluid is transudative or exudative in nature. There are three possible sources of transudative pleural effusion (heart, liver, or renal system), and no additional pleural investigations are required. If it is exudative, it has a wide range of dxx, and we need to look into it further.
- Pleural effusion of unknown etiology, with >10mm depth on lateral decubitus CXR or Ultrasound.
- Therapeutically for symptomatic relief (Mainly dyspnea)
- Concern for empyema.
- Air fluid level in pleural space.

Complications of thoracentesis[3]:

There are no absolute contraindications, and complications are rare, but the possibility should be taken into account

- Pneumothorax
- Bleeding
- Infection
- Hypotension
- Hypoxemia
- Air embolism
- Splenic laceration

1- Why are these features so important? Because if we don't drain IMMEDIATELY in these cases patients will develop fibrosis (If neglected the patient will suffer from a life-time **fibrothorax**, the patient will be restricted and he might require oxygen for the rest of his life)
2- So the proper order should be: CXR → Check CBC, coagulation profile, LFT, RFT → US (or decubitus film) → thoracocentesis
3-NEVER do thoracentesis for a patient with collapsed lungs → you will cause pneumothorax on top of collapse. Instead, do bronchoscopy.
4- If there is blood or pus in the pleural cavity, there will be a lot of fibrinous material inside, and the only way to treat this condition is to insert a chest tube.
5- positive culture indicates a complicated parapneumonic effusion

Pulmonary diagnostic procedures

◀ Chest tube:

Indications for chest tube insertion :

1. Empyema
2. Complicated parapneumonic effusion
3. Symptomatic pleural effusion
4. Hemothorax
5. Pneumothorax

3. Pleural biopsy

- A procedure in which a **sample of the pleura (parietal)** is removed with a special biopsy needle or during surgery to determine if Granulomatous disease, malignancy or another condition is present.

When is pleural biopsy indicated?

1- **Granulomatous disease e.g. TB**

2- **Malignancy**

4. Pulmonary function test

The term "pulmonary function test" is vague as there are various types of pulmonary function tests

- Used to aid diagnosis, quantify functional impairment, and monitor treatment or progression of disease.
- Categorization of different types of lung diseases: knowing whether it's restrictive or obstructive.

In summary, PFT helps in :
1- Categorizing types of lung diseases (restrictive versus obstructive)
2- Assessing disease severity (in overall prognosis and preoperative evaluation).
3- Evaluating post-treatment lung function

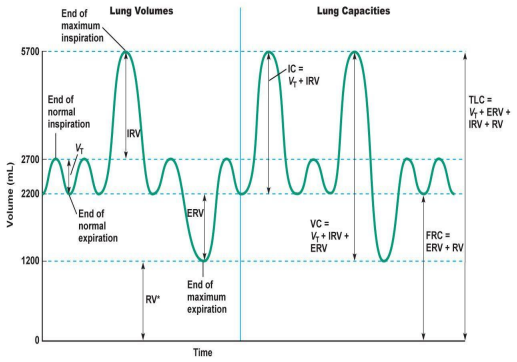
Types of PFT:

Spirometry	Lung volumes	PEFR	Diffusion capacity Alveolar membrane	Respiratory muscle strength
Performed for airway problems (obstructive)	Performed for an interstitial problem (restrictive)		Preformed if you there's a problem in diffusion (interstitium)	Preformed if there is an abnormality in the diaphragm or the respiratory muscle

Spirometry

What is Spirometry?

- The patient takes a maximum inspiration followed by s forced expiration (for as long as possible) into the spirometer.
- The spirometer measures the 1-second forced expiratory volume FEV1) and the total volume of the exhaled gad (forced vital capacity, FVC). Both FEV1 and FVC are related to height, age, sex, and ethnicity, and help to differentiate between an obstructive and a restrictive pattern of a respiratory compromise.



EXTRA	Lung Capacities	
Residual Volume	Volume of air **remaining** in the lungs after the most forceful expiration.	1200ml or 1.2L
Expiratory Reserve Volume:	The extra volume of air that can be **expired** by forceful expiration after the end of a normal tidal expiration	1100ml or 1.1L (1000ml M ,700ml F)
Inspiratory Reserve Volume:	The extra volume of air that can be **inspired** by a maximal inspiratory effort after normal inspiration	300ml or 3L (3.3L M ,1.9L F)
Tidal Volume:	Volume of air inspired or expired during **normal** (quiet) breathing	500ml or 0.5L (M + F)

EXTRA	Lung Capacities	
Total Lung Capacity:	Is the maximum volume to which the lungs can be expanded with the greatest possible effort.	5800ml or 5.8L ➔ VC+RV
Vital Capacity:	The volume of air that can be maximally expired after maximum inspiration.	4600ml or 4.6L ➔ TV+IRV+ERV
Functional Residual Capacity:	The amount of air that remains in the lungs at the end of normal expiration	2300ml or 2.3L ➔ EVR+RV
Inspiratory Capacity:	Volume of air inspired by a maximal inspiratory effort after normal expiration	3500ml or 3.5L ➔ TV+IRV

Pulmonary function tests

1 Spirometry -when you want to deal with airway diseases.

What it used for:	Measuring what?
★ Diagnose **obstructive** lung disease • **suggest** restrictive lung disease but can't diagnose. • It's used when you suspect problem in the airways e.g. COPD and asthma	• FVC (L) (forced vital capacity): predicted[1] **> 90%** • FEV1 (L) (forced expiratory volume in 1st second): predicted[1] **> 90%** • FEV1/FVC (ratio:) >70 -from 70 to 75 is normal, more than 75 is abnormal

★ **Obstructive:** Increased resistance to airflow caused by narrowing of airways

- Decreased both FVC and FEV1, but FEV1 is decreased **more** than FVC → The FEV1/FVC (ratio) less than 70 → decreased
- Increased resistance to expiratory airflow.

Restrictive: Impaired ability of the lungs to expand (as a result of reduced lung compliance)

- Decreased both FVC and FEV1, but FEV1 is decreased **less** than FVC → The FEV1/FVC (ratio) normal or increased.
- **Can't be diagnosed without obtaining lung volume, spirometry only gives a clue towards it**

2 Lung volume -when you want to deal with interstitial lung disease and so on.

What it used for:[2]	Measuring what?
• Diagnose **restrictive** lung disease. • Can diagnose air trapping. • Can **suggest obstructive** lung disease.	• **Total lung capacity (TLC): >90%** predicted • **Residual Volume (RV): >90%** predicted

PFT	Normal Range	Restrictive	Obstructive
FVC	≥ 70% predicted	< 70% Reduced (↓↓2L)	<70% reduced or normal
FEV1	≥ 70% predicted	< 70% Reduced **less** than FVC or normal	< 70% Reduced **more** than FVC (↓3L)
FEV1/FVC	approximately 75%	>75% increased or normal	<75% reduced
RV		Reduced	Increased / normal

3 Peak expiratory flow rate (PEFR)

Used to:	Diagnose asthma, and to monitor exacerbations of asthma and response to treatment.

1-based on the age, gender, height for each individual we have a predicted number for each individual
2- If there's a problem with the lung parenchyma (Interstitium), then you measure lung volumes by the **body plethysmograph**.

Pulmonary function tests

4 Diffusion capacity (DC)

What it used for:	Measuring what?
• Measures the **ability of gases to diffuse** from the alveoli into the pulmonary capillary blood. • Patients inhale a test mixture of 0.3% carbon monoxide(CO), which is taken up avidly by haemoglobin in pulmonary capillaries. • Carbon monoxide is not normally present in the lungs or blood but it's more soluble in blood than lung tissue • **TLco** or DLco also depends on the **V/Q** relationship as well as on the area and **thickness of the alveolar membrane**	**Transfer factor (TLco):** • Decreased DLco: Reflects loss or damage to the gas exchanging surface of the lung, Normal: >80% the defect is either in the alveoli , capillary membrane or both of them. • **Conditions with low DLco:** ○ **Emphysema:** this distinguishes emphysema from chronic bronchitis or chronic asthma in which DLco is normal or increased ○ Interstitial lung diseases ○ Pulmonary vascular disease. • Increased TLCO in: alveolar hemorrhage that is caused by (wegener disease, goodpasture syndrome and SLE).

5 Respiratory muscle strength

Respiratory muscle tests measure how much pressure your breathing muscles can generate when you breathe in or out.

What it used for:	Measuring what?
• Measured by pressure transducer at the mouth when subject make a maximal inspiratory effort from full expiration or maximal expiration effort from full inspiration. • **PImax**: Maximal inspiratory pressure • **PEmax**: Maximal expiratory pressure • **Causes of respiratory muscle weakness:** Motor neuron disease, Guillain-Barré Syndrome. [1]	**PImax, PEmax:** • **PI**→ reflect inspiratory muscles as diaphragm. • **PE** → expiratory muscles as abdominal muscles

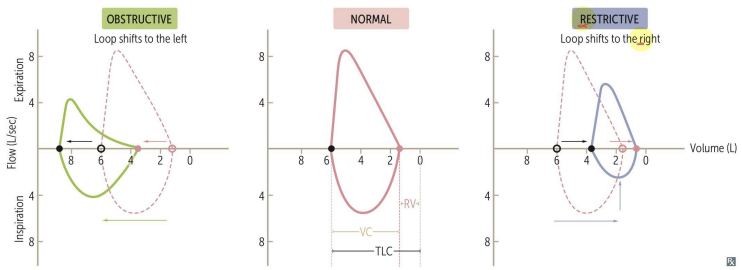
Clinical features of respiratory muscle weakness do not manifest until diaphragmatic strength is reduced to a quarter of its normal strength (unilateral diaphragmatic paralysis decreases ventilatory capacity by only 20%).
Patients with respiratory muscle weakness show spirometric findings of restrictive lung disease.

1-Metabolic disease , C.T disease (myositis), Drugs (steroids for long period of time), can also be caused by autoimmune disorders (SLE)

Pulmonary function tests

◀ Obstructive Vs Restrictive lung diseases

Parameter	Obstructive lung disease	Restrictive lung disease
RV	↑	↓
FRC	↑	↓
TLC	↑	↓
FEV1	↓↓	↓
FVC	↓	↓
FEV1/FVC	↓ (FEV1 decreased more than FVC)	Normal or ↑ (FEV1 decreased proportionately to FVC)



◀ DLco

DLco	Restrictive	Obstructive	Normal FEV1/FVC
↓ DLco	• **Late interstitial lung disease e.g. Sarcoidosis** • Post-pneumonectomy • Pulmonary edema (e.g., as a result of severe congestive heart failure)	• **Emphysema**	• **Pulmonary vascular diseases** (pulmonary hypertension, pulmonary embolism, hepatopulmonary syndrome) • Early interstitial lung disease • Pre-existing carboxyhemoglobinemia (e.g., due to smoking) • **Anemia**
Normal DLco	• **Respiratory muscle weakness** • **Pleural disorders** • **Thoracic cage deformities** • Obesity	• Alpha-1-antitrypsin deficiency • Bronchiectasis ○ Cystic fibrosis • **Chronic bronchitis** • **Bronchial asthma**	• Healthy findings
↑ DLco	• Obesity	• Bronchial asthma	• Polycythemia • Mild heart failure and left-to-right cardiac shunts

Pulmonary function tests

How do we approach pulmonary function test?

- First, we differentiate whether it is obstructive or restrictive → by spirometry.
- Second, we give bronchodilator ; to know if it's reversible or irreversible (COPD).
- Lastly →DLCO to know what type of COPD is it (emphysema → decreased, bronchitis → normal).
- Measure the inspiratory "diaphragm"/expiratory muscles, if all the tests are normal and SOB is present. Example, connective tissue dis/autoimmune dis (SLE, scleroderma, dermatomyositis, polymyositis) affecting muscles.
- If the patient is known to have connective tissue disease + progressive SOB→ MIP and MEP will show very low muscles strength, particularly EP "expiratory".
- The patient is stable, so steroids intake is usually the cause of his myopathy! "Which is the reason behind his dyspnea"

So we always have to think about drugs since they reduce muscle force.

Dr's explanation:

↓FVC + ↓FEV1 :
- Suggestive of obstructive

↑ FEV1/FVC:
- Suggestive of restrictive

How to confirm restrictive?
- By lung volume

↓ TLC :
- Diagnosis with restrictive lung disease confirmed

↓PI + ↓PE :
- Abnormality in the diaphragm and abdominal muscles indicating infiltration

↓ TLCO:
- Decreased perfusion capacity indicating infiltration

What is the diagnosis?

the patient has obstructive and restrictive lung disease with respiratory muscle weakness and decreased DLco

Which diseases can give such as these findings?

1) **Sarcoidosis** (both obstructive & restrictive) has a similar picture as asthma
2) SLE
3) Scleroderma
4) Due to corticosteroid therapy on top of lung disease (causing myopathy muscle weakness)

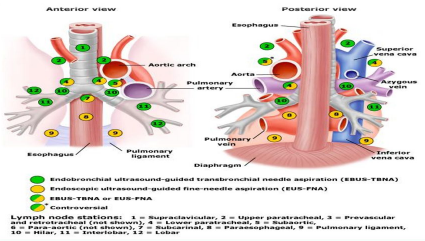
	Baseline		
Date and Time	03/02/2010	08:41	
SPIROMETRY	Pred	Pre	%Pred/P
FVC (L)	5.04	3.13	↓ 62.1
FEV 1 (L)	4.25	2.53	↓ 59.5
FEV 1 FVC		↑ 80.91	
MMEF 75/25 (L/s)	4.93	2.46	49.9
PEF (L/s)	9.73	7.88	81
FIF (50 (L/s)		4.09	
FEF 50 (L/s)	5.45	4.23	77.6
BODY PLETHYSMOGRAPH			
VC (L)	5.27	3.13	59.4
TLC (L)	6.9	4.51	↓ 65.4
ITGV (L)	3.25	3.58	110.2
ERV (L)	1.59	2.2	138.4 (air trapping)
RV (L)	1.66	1.38	83.1
RV % TLC	24.49	30.58	124.9
PI MAX (kPa)	10.96	7.11	↓ 64.9
PE MAX (kPa)	14.51	11.55	↓ 79.6
DIFFUSING CAPACITY			
TLCO SB (mmol/min/kPa)	11.63	5.27	↓ 45.3
Hb (g/100ml)		16.2	
TLCOc SB (mmol/min/kPa)	11.63	5.06	43.5
KCO (mmol/min/kPa)	1.68	1.54	91.7
TLC-He (L)	6.75	3.42	50.7

this patient has all abnormalities in the pulmonary function tests

Bronchoscopy

5. Bronchoscopy

- Is an endoscopic procedure allows direct visualization of the endo-bronchial tree down to the subsegmental level which is used for **diagnostic and therapeutic purposes**. [1]
- It is a fibrotic tube with a diameter similar to a stethoscope and a camera inside. It also has a suction channel and a channel where instruments such as forceps can be applied so we can grasp any object we see.



With advancements in technology, we now have an ultrasound within the bronchoscopy channel, which we call endobronchial ultrasound. The advantage is that when we go inside the airway, we can see the structures surrounding the airway (from the outside), whether they are lymph nodes, arteries, veins, or tumors, and we can easily sample from these areas. This facilitates the diagnostic process.

Diagnostic indications

- **Suspected lung cancer**
- Staging of lung cancer.
- Abnormal CXR. (collapsed lobes or segments)
- Hemoptysis.
- Localized wheeze or Stridor.
- Positive sputum cytology.
- Unexplained pleural effusion.
- Lung abscess.
- Obtain culture material.
- Airway trauma.
- Tracheoesophageal fistula.
- Diffuse lung disease
- Refractory cough
- Unexplained cough.
- Mediastinal lymph nodes.

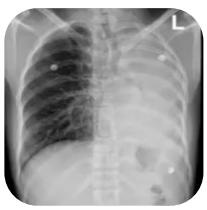
Therapeutic indications

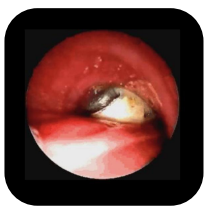
- Remove foreign bodies.
  - in an elderly patient, look for broken dentures
  - In children, think of toys.
  - In the mid range around 25-30, think of a slow growing tumor.
- Remove abnormal endobronchial tissue.
- Difficult endotracheal tube intubation.
- Endobronchial stent placement if there's tracheal stenosis.

Collapse

- Implying obstruction of the lobar bronchus) is accompanied by loss of volume and displacement of the mediastinum towards the affected side.

This is a scenario from an elderly patient who had a similar finding of chest x ray and when we scoped him, we discovered a foreign body inside his airway that blocked his bronchus. When we grasped it, we discovered that the patient had a broken denture inside, so as soon as we removed it, his lungs expanded and returned to normal. In children you will find plastic, toys, foreign bodies, peanuts etc..





What is the source of collapse?

Something in the airway (inside the lumen)	**Something in the wall of the airway**	**Something in the outer wall of the airway**
foreign body	A. inflammation	**Mass**: causing a significant loss of volume or compression by enlarged lymph nodes
mucus plugging	B. granuloma	
Malignancy	C. tumor	

1-If you want to see outside the luminal cavity (e.g. lymph nodes), you can use endobronchial ultrasound. If the patient is a smoker and the X-Ray or CT shows a mass then you always have to think of malignancy first. Do a bronchoscopy and biopsy to confirm suspicion.

6. Scintigraphic imaging

- Widely used for detecting pulmonary emboli although it is now performed less often owing to widespread use of D-dimer measurements and CT pulmonary angiography
- **Lung Scans V/Q (Ventilation/Perfusion)[1]:**

Ventilation	Perfusion
Radioactive tracer gas inhaled to lungs → picture here shows areas of lung that are not receiving enough air or retain too much air.	Radioactive substance injected into the vein→ to lungs → shows areas in lung which are not receiving enough blood.

Normal perfusion:

➔ When injected via peripheral venous site, the first capillaries encountered are the **pulmonary capillaries**. if **perfusion is present** at the capillary level of the lungs, nuclear medicine perfusion image would demonstrates "activity in the periphery of the lungs"

perfusion defect:

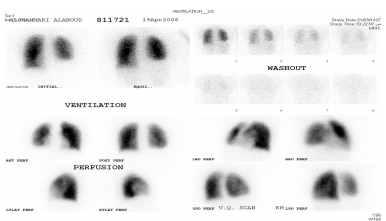
➔ If there is an **obstructing vascular lesion** in the pulmonary arterial circulation → **blocked perfusion** to the distal capillary level → nuclear medicine perfusion image would demonstrate "no activity in the periphery of the lungs" (will appear as gray areas)

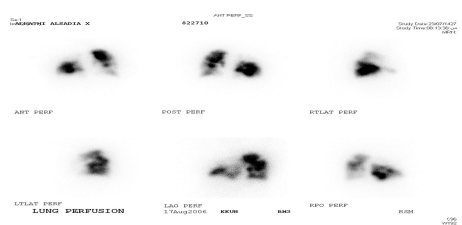
To assess perfusion:

➔ **Technetium (Tc) 99m radionuclide** is tagged to macroaggregated albumin to make small radioactive particles.

- is injected intravenously → they impact in pulmonary capillaries, where they remain for a few hours. → When Tc decays→ it emits a gamma ray detected by the nuclear medicine gamma camera → a nuclear medicine image is formed by detection of many gamma rays.
- The resultant pattern indicates the distribution of pulmonary blood flow; **cold areas** occur where there is defective blood flow (e.g. in pulmonary emboli).

Normal



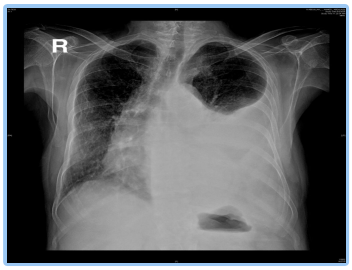


There's multiple segmental perfusion defects, highly suggestive of PE

1-It is used when patient is allergic to contrast although it only gives a probability.
2-V/Q scan isn't used to diagnose pulmonary embolism (it supports the diagnosis). The modality of choice to diagnose pulmonary embolism is CT angiography.

Case study 1:

-there are **four** stations to take it step by step in every clinical scenario at any field ***always remember it.*** assure
A) patient **haemodynamics, *(ABC)* (stable or unstable?),** ex. *if he is not oxygenated enough oxygenate the patient*
B) what is happening with the patient? what is his **clinical scenario and symptoms**
C) **do routine tests.** ex.*CBC and coagulation profile*
D) **performing diagnostic procedures** to confirm the diagnosis, ex. *Ultrasound or thoracentesis*



A 30 y/o gentleman presented to the ER complaining of SOB and fever for 1 week . Based on this clinical scenario, we can conclude that this is an acute problem with an infectious etiology.
No previous medical history of similar illness. On clinical examination the patient is diaphoretic, [RR=28, T=38.9, BP= 90/60, O2=84%] (unstable)
[On percussion there's stony dullness, absent breath sound and bronchial breath sounds are heard on the affected side. On the front examination, the trachea is shifted to the opposite side.] These findings indicate that there is 99.99 percent pleural effusion (hints: tracheal deviation to opposite side, **stony dullness**, and heard bronchial breath sounds).

X-Ray: it complements the finding

- Right Lung: Normal
- Left lung: White opacity affecting lower ⅔ and black like ball in the upper zone (representing the remnant of normal lung)
- Mediastinal shift to the opposite side, layering indicate pleural fluid is free floating and relatively acute. (no fibrin or septae in pleural cavity that prevent floating)

Q1: What's the most likely diagnosis?

- Diaphoretic + Fever + Consolidation of left middle and lower lung lobes → **Pneumonia**
- Stony dullness + absent breath sounds + Trachea is pushed to the opposite side → **Pleural effusion**

So, the patient has **Parapneumonic effusion**
First things that come to mind: duration is acute, etiology is infectious, pt is unstable

Q2: How would you manage such patient?

- ➜ **1st:** ABC (to stabilize the patient because he's is unstable (low O2 and BP))
- ➜ **2nd (For the O2):** 10 liter face-masked Oxygen; it's ok to give him 100% O2 because he's young and healthy (If old or has COPD you might kill him)
- ➜ **3rd (For the hypotension):** Establish IV access and give normal saline as a bolus 1 litre to resuscitate

★**After that the patient became stable. What should you next?** memorize these steps (up until 2nd) as they are important and done to EACH pt

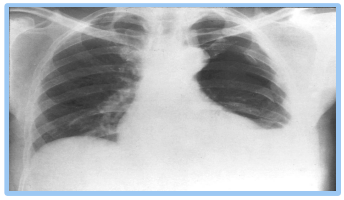
- ➜ **1st:** Do CBC (Why? To check WBC, Hb, and platelet count cut off is 75,000 (If it was less than conduct additional investigations to determine whether you can perform thoracentesis or not). If platelet count was 10,000 (Low) will you do thoracentesis? **NO**, it will cause bleeding and make things worse.
- ➜ **2nd:** LFT, RFT and Coagulation studies & consent (inform about procedure)
- ➜ **3rd:** Do **Ultrasound** (Confirmatory test and modality of choice, to MAKE SURE THAT THE PATIENT HAS PLEURAL EFFUSION BEFORE GOING FOR THORACENTESIS)

What if you don't have an ultrasound? Do **decubitus film** (If the patient has a pleural effusion in the right side hen ask for a right decubitus film, to see the fluid layering: if it's more than 1 cm depth from the outside layer then you can go for thoracentesis but If there were no layering it means that the fluid has been there for a long time and it loculated (formed fibrinous strands) and in this case it's really dangerous to do thoracentesis (this may cause pneumothorax). If there is a right pleural effusion, have the patient lie on his right side so that we can see the fluid layering. Then, measure the depth from the skin to the fluid layer; if it is more than 2 cm, it is relatively safe to insert the needle.

Ok, so let's say that patient is suitable for thoracentesis Semi-invasive procedure:
Once you insert the needle, the first thing you see is the appearance **& color** (based on the appearance you intervene immediately, don't wait for culture and other stuff e.g. if the you see pus (this indicates empyema), now this is not just the simple parapneumonic effusion it's complicated and you need to intervene immediately with a **LARGE BORE CHEST TUBE**. If the you don't see pus then do gram stain (you can do it within 3min in the emergency department) if gram stain is positive this also indicates a complicated parapneumonic effusion and requires immediate CHEST TUBE. (After all this you can send the sample for culture, pH, chemistry (Glucose, amylase, LDH, protein and check if it's transudate or exudate) and cytology. **Do not sit and wait for an investigation if you see pus or blood! Intervene right away.**

◀ Case study 2:

45y/o gentleman presented to the ER with a main complaint of SOB over the past 6 months, fever and weight loss (~10kg) over the past 3 months, patient reported that he was in prison two years ago (before his illness). On clinical examination his vital signs were stable, Trachea is central. Lung examination reveals stony dullness and absent breath sounds in the affected side. Clinical examinations suggest pleural effusion, but the scenario differs from case two.



Q1: Is this presentation acute or chronic?

- Chronic (while in previous case it's acute)

Q2: What's the most likely diagnosis?

- Could be TB or a granulomatous disease (since he was in prison) or malignancy (indicated by weight loss).
- He has stony dullness which indicated pleural effusion (but less severe than the previous case)

Q3: How is this case different from the previous case?

- The difference here is that you suspect TB and malignancy. So, thoracentesis by itself isn't enough!! **You HAVE to do pleural biopsy** (the main diagnostic test in this case).

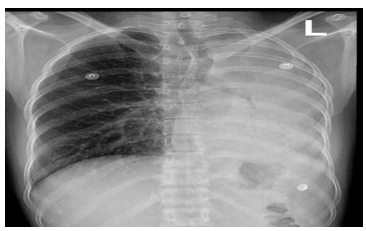
Because the chest x-ray shows abnormalities in the pleura, we must perform a thoracentesis and biopsy.

Q4: How would you manage such patient?

➜ **1st:** ABC always begin with it (even though he's stable)
➜ **2nd:** Establish IV access
➜ **3rd:** CBC , RFT, LFT, Coagulation studies, blood culture
➜ **4th:** Confirm pleural effusion by ultrasound or decubitus film
➜ **5th:** Go for thoracentesis followed by pleural biopsy.

◀ Case study 3:

A 30 y/o gentleman with no prior history of medical illness, presented with sudden onset of SOB. He reported that he was with his friend at a cafe. On clinical examination, RR=24, O2=84%, BP=80/40, T=34 (unstable). Lung examination reveals tracheal shift to the affected side, dullness to percussion with absent breath sounds.



❖ X-ray findings: White opacification (whole lung is blocked)
❖ Air is black whereas in pneumothorax it would be white and tracheal deviation to opposite side.

Q1: What's the most likely diagnosis?

- Obstruction where? in the bronchus leading to **lung collapse.** Something block his airway caused lung to collapse. No air inside lungs.

Q2: Can we do thoracocentesis in this case?

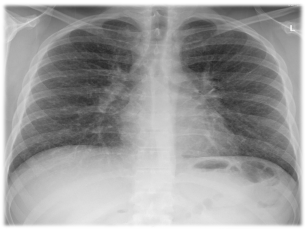
- **NO it is an absolute contraindication and might kill the pt**, the patient will develop pneumothorax bc the blockage is INSIDE the lumen of the left main stem bronchus.

Q3: How would you manage such patient?

➜ **1st:** ABC
➜ **2nd:** Establish IV access and give oxygen
➜ **3rd:** CBC , RFT, LFT, Coagulation studies
➜ **4th: Bronchoscopy** (No need for confirmation to do bronchoscopy, it's a waste of time)

◄ Case study 4:

- 50 yr old male with SOB and cough >3yrs.
- **Exam**: clubbing and bilateral **inspiratory crackles**
- **CXR**: reticulation bilateral
- **ABG**: hypoxic respiratory failure
- **PFT**: restrictive defect with significant impairment in DLco.



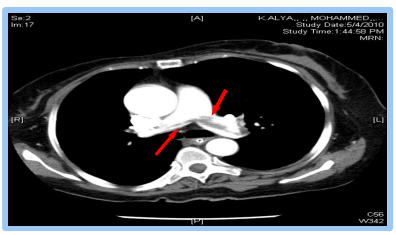
Q1: Is this acute or chronic? Chronic it is not asthma nor emphysema because there is no obstruction
Q2: What diseases give you crackles? Abnormality in the bronchiole (e.g. Bronchiectasis) or abnormality in the interstitium (e.g. Pulmonary fibrosis)
Q3: What diseases cause reticulation bilaterally? interstitial lung disease (e.g. Pulmonary fibrosis)
Q4: What diseases cause hypoxic respiratory failure? Any chronic lung disease
Q5: What does the PFT here indicate? pulmonary fibrosis
Q6: How to confirm Pulmonary fibrosis? The modality that we want to preform is CT (we want to know the abnormality in the lung and the chest xray didn't give us much information)
High resolution CT-scan (HRCT)

◄ Case study 5:

- A 45 years old female with Right sided chest pain for 1 day (acute).

on Investigation:

- ABG : pH 7.32, PaCO2 28[1], PaO2 50[1], O2sat 88%[1]
- ECG : sinus tachycardia.CXR : normal
- Spiral CT aka CT-Angio
- V/Q Scan



Q1: What's your interpretation of the ABG?
- She's hypocapnic and has hypoxic respiratory failure

Q2: What's the most likely diagnosis?
- Pulmonary embolism (PE)

Q3: What's the best diagnostic method for PE?
- CT-angiography aka spiral CT: Includes injecting contrast into the cubital vein red arrows are pointing at multiple filling defects both at the bifurcation of pulmonary trunk "hypodense opacification with silver/gray-like material" ("saddle" pulmonary embolism).

Q4: If the patient was allergic to contrast or Pregnant; what's the modality of choice?
- V/Q scan

Common Chest X-ray abnormalities

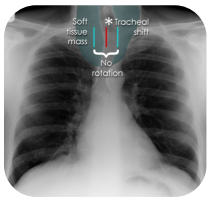
Causes

Tracheal displacement

Before deciding if the trachea is central it is important to establish that the patient is not rotated.

If the trachea is genuinely displaced to one side, try to establish if it has been pushed or pulled by a disease process. Anything that increases pressure or volume in one hemithorax will push the trachea and mediastinum away from that side. Any disease which causes volume loss in one hemithorax will pull the trachea over towards that side

- No patient rotation - the spinous processes (red line) are centra between the medial clavicles (blue lines)
- Trachea (asterisk) shifted to the left of the midline
- Soft tissue mass mainly to the right of the trachea
- **Diagnosis:**
  - Mediastinal thyroid enlargement



Hilar abnormalities

The hila consist of vessels, bronchi and lymph nodes. On a chest X-ray, abnormalities of these structures are represented by a change in position, size and/or density.

- **Hilar enlargement**

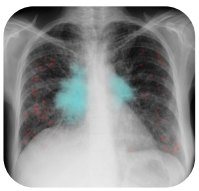
Hilar enlargement may be unilateral or bilateral, symmetrical or asymmetrical. In combination with clinical information, each of these patterns is often helpful in reaching a diagnosis. Bilateral, symmetrical hilar enlargement should raise the suspicion of sarcoidosis, particularly if there is evidence of paratracheal enlargement, or lung parenchymal shadowing.
If a hilum has moved, you should try to determine if it has been pushed or pulled, just like you would for the trachea. Ask yourself if there is a lung abnormality that has reduced volume of one hemithorax (pulled), or if there has been increase in volume or pressure of the other hemithorax (pushed).

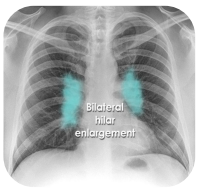
(A) Bilateral hilar enlargement
- Both hila are larger and denser than normal

(B) Asymmetric hilar enlargement
- Both hila are larger and denser than normal
- The right hilum is bigger than the left
- Multiple small lung nodules
- Missing right breast shadow (mastectomy)

Clinical information
- Known breast cancer, Increase SOB

Diagnosis
- Metastatic disease
- Breast cancer





Consolidation

Normally we assess the lungs by comparing the upper, middle and lower lung zones on the left and right. Asymmetry of lung density is represented as either abnormal whiteness (increased density), or abnormal blackness (decreased density). Once you have spotted asymmetry, the next step is to decide which side is abnormal. If there is an area that is different from the surrounding ipsilateral lung, then this is likely to be the abnormal area. If the alveoli and small airways fill with dense material, the lung is said to be consolidated. It is important to be aware that consolidation does not always mean there is infection, and the small airways may fill with material other than pus (as in pneumonia), such as fluid (pulmonary oedema), blood (pulmonary haemorrhage), or cells (cancer). They all look similar and clinical information will often help you decide the diagnosis.

- **Air bronchogram**

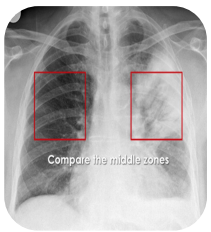
If an area of lung is consolidated it becomes dense and white. If the larger airways are spared, they are of relatively low density (blacker). This phenomenon is known as air bronchogram and it is a characteristic sign of consolidation.

Comparing sides does not always give the answer. The lungs may be abnormal on both sides and so awareness of the normal appearances of lung parenchyma becomes more important

Consolidation with air bronchogram
- The left middle zone is white
- Dark lines through the area of white are a good example of air bronchogram

Clinical information
- The patient had a high temperature and a productive cough

Diagnosis
- Pneumonia - consolidation with pus



Pleural disease

The pleura only become visible when there is an abnormality present. Pleural abnormalities can be subtle and it is important to check carefully around the edge of each lung where pleural abnormalities are usually more easily seen. Some diseases of the pleura cause pleural thickening, and others lead to fluid or air gathering in the pleural spaces.

- **Pneumothorax**

A pneumothorax forms when there is air trapped in the pleural space. This may occur spontaneously, or as a result of underlying lung disease. The most common cause is trauma, with laceration of the visceral pleura by a fractured rib.If the lung edge measures more than 2 cm from the inner chest wall at the level of the hilum, it is said to be 'large.' If there is tracheal or mediastinal shift away from the pneumothorax, the pneumothorax is said to be under 'tension.' This is a medical emergency!

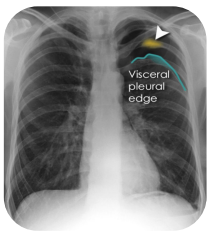
- **Pleural effusion**

A pleural effusion is a collection of fluid in the pleural space. Fluid gathers in the lowest part of the chest, according to the patient's position.If the patient is upright when the X-ray is taken, then fluid will surround the lung base forming a 'meniscus' – a concave line obscuring the costophrenic angle and part or all of the hemidiaphragm.If a patient is supine, then a pleural effusion layers along the posterior aspect of the chest cavity and becomes difficult to see on a chest X-ray.

Pleural effusion
- The left lower zone is uniformly white
- At the top of this white area there is a concave surface - meniscus sign
- The left heart border, costophrenic angle and hemidiaphragm are obscured
- Slight blunting of the right costophrenic angle indicates a small pleural effusion on that side

Clinical information
- Life long smoker
- Weight loss and increasing shortness of breath

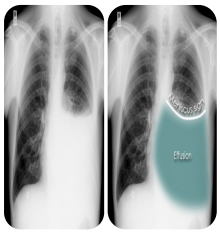
Diagnosis
- Large left pleural effusion
- Underlying bronchogenic carcinoma



Pneumothorax
- Visible pleural edge (blue line)
- Lung markings not visible beyond this edge

Clinical information
- Fall from height - trauma to chest

Diagnosis
- Left pneumothorax due to a rib fracture (arrowhead)
- The trachea and mediastinal structures are not displaced so there is no 'tension'



Costophrenic angle blunting

Costophrenic angle blunting

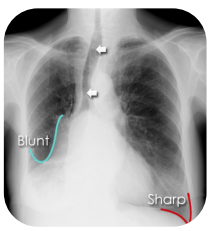
Blunting of the costophrenic angles is usually caused by a pleural effusion, as already discussed. Other causes of costophrenic angle blunting include lung disease in the region of the costophrenic angle, and lung hyperexpansion.

Note: Pleural effusions do not cause volume loss

Right costophrenic angle blunting
- The left costophrenic angle is sharply defined (normal)
- The right costophrenic angle is blunt (abnormal)
- There is volume loss in the right hemithorax with corresponding shift of the mediastinum and trachea to the right (arrows)

Clinical information
- Chronic smoker
- Chronic shortness of breath with recent worsening

Diagnosis
- Lung cancer occluding the central airways with collapse of the right middle and lower lobes – confirmed by CT and bronchoscopy



Summary

Thoracentesis
(removing fluid from the space between pleura and the wall of the chest.)

What to look for in thoracentesis ?
- Appearance (color)
- Gram stain, and cultures:
- pH
- Chemistry: (glucose, amylase, LDH5 , protein)
- Cytology

light's criteria:
- pleural protein/serum protein ratio (Transudate is <0.5), (Exudates is >0.5)
- Effusion LDH/serum LDH ratio (Transudate is <0.6), (Exudate is >0.6)
- Effusion LDH level greater than two-thirds the upper limit of the laboratory's reference range of serum LDH

Note:
- NEVER do thoracentesis for a patient with collapsed lungs → you will cause pneumothorax on top of collapse. Instead, do bronchoscopy.

- If the fluid's appearance is Pus OR Gram stain is positive OR pH is below 7.2 → Chest tube immediately

Bronchoscopy
(Visualization of the central airways down to subsegmental level)

Diagnostic indications:
- Suspected lung cancer + Staging of lung cancer.
- Abnormal CXR. (collapsed lobes or segments)
- Hemoptysis.
- Refractory or Unexplained cough.
- Localized wheeze or Stridor.
- Positive sputum cytology.
- Mediastinal lymph nodes.
- Unexplained pleural effusion.
- Lung abscess.
- Obtain culture material
- Airway trauma.
- Tracheoesophageal fistula
- Diffuse lung disease

Therapeutic indications:
- Remove foreign bodies.
- Remove abnormal endobronchial tissue.
- Difficult endotracheal tube intubation.
- Endobronchial stent placement

Pleural Biopsy

When is a pleural biopsy indicated?
- Granulomatous disease. Ex(TB)
- Malignancy

Note: if dealing with TB or Malignancy order Thoracentesis + Pleural biopsy

Summary

Pulmonary Function Test (PFT)

	What it used for	Measuring What?
Spirometry	- Can diagnose obstructive lung disease - Can suggest restrictive lung disease but can't diagnose.	- FEV1 (L) - FVC (L)
Lung Volume	- Can diagnose **restrictive** lung disease. - Can diagnose air trapping. - suggest obstructive	**- Total lung capacity (TLC)** **- Residual Volume (RV):** - Vital capacity (VC) - If TLC, VC, RV < 90% → restrictive.
Diffusion Capacity (DLCO)	- Measures the ability of gases to diffuse from the alveoli into the pulmonary capillary blood.	**Transfer factor (DLco):** - Decreased DLco reflects loss or damage to the gas exchanging surface of the lung. - Emphysema - Interstitial lung diseases - Pulmonary vascular disease.
Respiratory muscle strength	- Diagnosing diseases that affect the muscle in the respiratory system; - Motor neuron disease, Guillain-Barré Syndrome.	**PImax, PEmax:** - **PI**→ reflect inspiratory muscles as the diaphragm. - **PE** → expiratory muscles as abdominal muscles.

CT Imaging

(HRCT, CT with contrast, CT Angiography), for PTs suspected to have interstitial disease

HRCT (high resolution CT scan):	CT Angiography
- Designed for detailed evaluation of interstitial structures of the lung -Principal indications: ● Suspected interstitial lung disease ● Characterization of interstitial lung disease ● Characterization of solitary pulmonary nodules ● Diagnosis of bronchiectasis	**Advantages:** - Critically ill patients - Children - Less volume of intravenous contrast - Permits greater processing of the raw data **Contraindications:** - Renal failure - Allergy to contrast - Pregnancy If the filling defect is present we diagnose the patient with Pulmonary Embolism.

Lecture Quiz

Q1: In which of the following patients CT Angiography must be avoided?
A. a critically ill patient
B. a pediatric patient
C. a renal failure patient
D. a patient of suspected pulmonary embolism

Q2: A 61-year-old male former smoker (40 pack-years) complains of dyspnea and cough. Pulmonary function testing shows normal spirometry and lung volumes; there is an isolated reduction in diffusing capacity (Dlco). The most useful next test is
A. Echocardiography
B. Right-sided heart catheterization
C. High-resolution computed tomography of the chest
D. Maximal respiratory pressures
E. Bronchoalveolar lavage for hemosiderin-laden macrophages

Q3: Which of the following procedures can be used to remove foreign bodies?
A. HRCT
B. Bronchoscopy
C. Thoracentesis
D. Chest tube

Q4: You are discussing a patient with your registrar who has become acutely short of breath on the ward. After performing an arterial blood gas, you have high clinical suspicion that the patient has a pulmonary embolism. Which of the following is the investigation of choice for detecting pulmonary embolism?
A. High-resolution CT chest (HRCT)
B. Chest x-ray
C. Ventilation/perfusion scan (V/Q scan)
D. CT pulmonary angiogram (CT-Pa)

Q5: You are asked to request imaging for a patient with a suspected pneumothorax who you have just examined in accident and emergency. Which of the following would be the most appropriate first step imaging modality?
A. CT-chest
B. Ultrasound chest
C. Chest x-ray
D. V/Q scan
E. CT - Pa

Q6: A 45-year-old woman with rheumatoid arthritis is seen for dyspnea on exertion that has occurred over the past 3 to 4 months. She has not noticed cough or fever and has had no associated orthopnea, paroxysmal dyspnea, edema, or chest pain. She has hypertension. Regular medications include lisinopril and methotrexate. She has smoked a package of cigarettes daily since age 20. Results of pulmonary function tests (PFTs) are shown in the table.
What is the correct interpretation of her PFTs?
A. Obstructive lung disease, not responsive to bronchodilators
B. Obstructive lung disease, responsive to bronchodilators
C. Restrictive lung disease
D. Mixed obstructive and restrictive lung disease
E. Small airways disease

	Results	Predicted	% Predicted
Before Bronchodilators			
FEV_1	1.60 L	2.85 L	56%
FVC	1.94 L	3.53 L	55%
FEV_1/FVC	82%	84%	99%
After Bronchodilators			
FEV_1	1.62 L	2.85 L	57%
FVC	1.96 L	3.53 L	55%
FEV_1/FVC	84%	84%	100%

Answers: Q1:C | Q2:C | Q3:B | Q4:D | Q5:C | Q6:C

Answers Explanation File!

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