Investigation of lung diseases

Objectives:

- Types of pulmonary diagnostic procedures.
- Role of various specialized pulmonary procedures in diagnosing lung diseases.
- When to apply specific tests.

We highly advise you to study the pleural effusion lecture first.

[Color index : Important | Notes | Extra | **scenario**]

Resources:

- 435 slides

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Types of pulmonary diagnostic procedures

Pulmonary Diagnostic Procedures

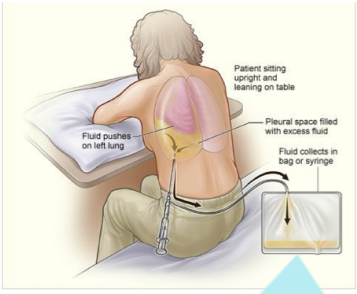
A detailed history, thorough examination and basic haematological and biochemical tests usually indicate the likely diagnosis and differential. A number of other investigations are normally required to **confirm the diagnosis and/or monitor disease activity.**

Imaging:	- **Chest X-ray:** This is performed on the majority of patients suspected of having chest disease. **" will be more clear in the radiology lecture + we advise to see this file here"**
	- **Computed tomography:** a) HRCT b) CT angio
Pleural aspiration:	- **Thoracentesis:** removing fluid from the space between **pleura** and the **wall of the chest**
Intercostal drainage:	- **Chest tube.**
Pleural biopsy:	Sampling of the pleura.
Endoscopic examination:	**Bronchoscopy:** Visualization of the central airways down to subsegmental level.
Pulmonary function tests:	Clinically used for assessing the airflow limitation.
Scintigraphic imaging	**Lung Scans: V/Q (Ventilation/Perfusion).**

Thoracentesis:

- is a procedure to remove fluid from the **(pleura space)** for **diagnostic** or **therapeutic** purposes.

  Ex: Pleural effusion and Empyema[1] .
- Fluid is removed (drained) from the pleural cavity with a needle (**aspiration**).



The needle is always inserted above the ribs → Because all the vessels are below the ribs.

Chest tube:

different than thoracentesis, It is a **large bore tube** (27-28 french diameter).

- **thoracentesis** is mainly for **diagnostic purposes**, and sometimes for **symptomatic relief.**
- **chest tube** is most important when confronted with pus, infection or blood (fluid that needs **immediate evacuation**).

Indication for chest tube insertion:

1. **Empyema** "pus in the pleural cavity"
2. Complicated parapneumonic effusion: (**positive gram stain**) Complicated ≈the organisms are going from the lung parenchyma into the pleural cavity,
3. Symptomatic pleural effusion and cannot drain properly using thoracentesis
4. Hemothorax "blood in the
5. Pneumothorax,

[1] Pus in pleural cavity

★ Step one:

Before doing the procedure you have to do:	
ABC rule	Make sure of the **(Airway, Breathing, Circulation).** The Patient must be stable.
Laboratory tests (Baseline investigations)	**1. Complete blood count:** (look at **WBC**, **hemoglobin**, and **platelets**) ★ if the platelets count is less that 50,000 mcL, **you will not insert your needle**
	2. Coagulation profile: ★ PT, INR, APTT + Make sure that this patient does **not have bleeding diathesis** . Ask is the **patient is taking any coagulation modifiers.** (you will not do thoracentesis until you **correct any coagulation problem**)
	3. Kidney function: ★ Check for uremia → it can affect bleeding time .
	4. Liver function.
Confirm Pleural Effusion	**1. Ultrasound** (we **heavily** rely on ultrasound) ★ To see fluid level and determine how far you want to go with your needle.
	2. Decubitus film here (Ask the pt to lay on affected side, with gravity and fluid movement > will see a layer of pleural fluid. If more than 2 cm → then it's relatively safe to insert needle) **((if less than 2 cm then it's not safe, b/c you might cause complications))** ★ Can determine whether fluid is free flowing or loculated, fluid have to be >1cm

★ Step two:

- **What to look for in thoracentesis?**

1. **Appearance (color):** **a.** Blood→ **Hemothorax** , **b.** Pus→ **Empyema** (indicating infection)
2. **Gram stain, and cultures:** If positive→ **complicated parapneumonic effusion** (infected pleura)
3. **pH:** If acidotic → **empyema**, renal failure
4. **Chemistry:** (glucose, amylase, LDH[2], protein)
5. **Cytology.**

- What are the **complications** of thoracentesis?

1. Pneumothorax (untrained hand can introduce air into the pleural cavity),
2. Bleeding (when the physician doesn't know his **anatomy** and instead of going above the rib, went underneath the rib where the vessels are > laceration > bleeding),
3. Infection (not following **proper hygienic precaution** > can introduce infection),
4. Hypotension **(drains too much** fluid, more than 1.5 Liters),
5. Hypoxemia (can be **secondary to hypotension**),
6. Air embolism (introduce air into the circulation),
7. Splenic laceration (insertion is too low).

NEVER do thoracentesis for patient with collapsed lungs → you well cause pneumothorax on top of collapse. Instead, do bronchoscopy..

[2] Lactate dehydrogenase

★ Step three

- **Separation of Transudates from Exudates:** (explained more clearly in the table below)
  - *Pleural* fluid **protein** divided by the *serum* protein greater than 0.5
  - *Pleural* fluid **LDH** divided by the *serum* LDH greater than 0.6
  - *Pleural* fluid LDH **greater than two-thirds** of the upper limit of normal for the *serum* LDH

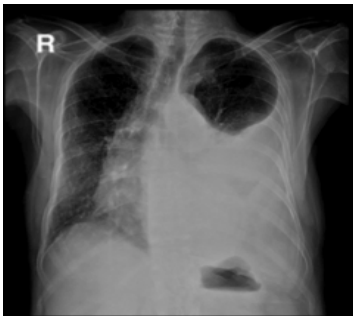
Type of Fluids[3]			
Light's Criteria		Transudate	Exudate
	Effusion protein/serum protein ratio	<0.5	>0.5
	Effusion LDH/serum LDH ratio	<0.6	>0.6
	Effusion LDH level greater than two-thirds the upper limit of the laboratory's reference range of serum LDH		

IMP!: If the fluid's appearance is **Pus** OR **Gram stain is positive** OR **pH is below 7.2** → **Chest tube immediately**

rapid intervention is required or the patient might become bed ridden

★ You have to drain it immediately or else it will heal by fibrosis **(fibrothorax)** (not pulmonary fibrosis, b/c we are talking about fibrosis in the pleural cavity not in the lung parenchyma).

- **only needs 1 to be positive to be classified.**



Scenario (1):

A **30 y/o gentleman** presented to the **ER** complaining of **SOB** and **fever for 1 week .** On examination, the pt is **tachypneic, O2 saturation is 89%, reduced chest expansion on the affected side, stony dullness** to percussion, and area of **bronchial breath sounds** on the specific area. On the front examination, the **trachea is shifted** to the opposite side. Based on this clinical scenario, **what am I dealing with?**

○ **From the history:**	- **SOB + fever** > **indicate infection**, and - **tachypnea + O2 saturation of 89%** > **make this patient unstable**
○ **On examination & investigation**	- **Stony dullness** > **pleural effusion,** - **bronchial breath sound** > supportive to your suspicion of **pleural effusion,** - **tracheal shifting to the right side** > could either mean that something is **pushing the trachea** from the left side OR something is **pulling the trachea** to the right side - **CXR** > it's more likely that something is **pushing** > **pleural effusion**.
○ **After confirming the diagnosis:**	1. **stabilize the patient.** 2. **ALWAYS** mention that you want to do your **ABCs.** (Airway, Breathing, and Circulation) + (O2 saturation, Establish IV access…) + CBC, coagulation profile, liver and kidneys function test. 3. Order the **investigation** that confirms what you are dealing with > **Thoracentesis**[4]

[3] See pleural effusion lecture.

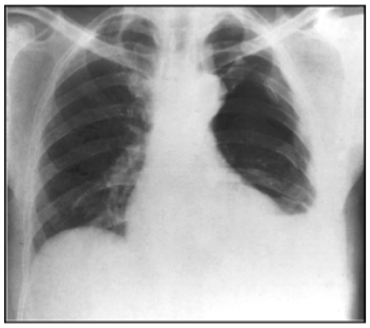
[4] (Needle into the **pleural cavity** > **thoracentesis**, Needle in the **abdomen** > **paracentesis**, Needle **b/w the vertebra** > **lumbar puncture)**

○ 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.[5]

◆ Indication of pleural biopsy

1. **Granulomatous disease (e.g. TB)**
2. **Malignancy**
3. Exudative effusion without pus or blood, gram stain and pH is 7.20.
4. Recurrent pleural effusions of unknown etiology.
5. Pleural mass or thickening.



Scenario (2):

A 45 y/o gentleman, reported history of **fever** and **weight loss** over the past six months. He was in prison for 5 months. On examination, he was **cachectic,** BP and all vitals signs were stable. **O2 saturation was 96%**. Lung examination revealed **chest expansion is affected** on the same side and **stony dullness** to percussion on that area.

○ **From the history:**	- **Fever + Weight loss > infection "TB"** or **malignancy.** - **O2 saturation of 96%> patient is stable.**
○ **On examination & investigation**	- **Stony dullness > pleural effusion,** - **CXR > no mediastinal shift, blunted costophrenic angle on the left side > pleural effusion. ..! - why is it different from the 1st scenario?** It's chronic.
○ **After confirming the diagnosis:**	1. You don't need to stabilize the patient because **he is already stable,** 2. **ALWAYS** mention that you want to do your **ABCs.** (Airway, Breathing, and Circulation) + (O2 saturation, Establish IV access…) + CBC, coagulation profile, liver and kidneys function test.[6] - even if patient is stable 3. Order the **investigations** that confirm what you are dealing with > **Thoracentesis + pleural biopsy**[7] " if dealing with **TB or malignancy"** 4. **Ultrasound or decubitus film.**[8]

- When is Using thoracentesis not enough?

When the diagnosis can't be made unless we take a biopsy like if we **suspect granulomatous disease (TB) or malignancy??**

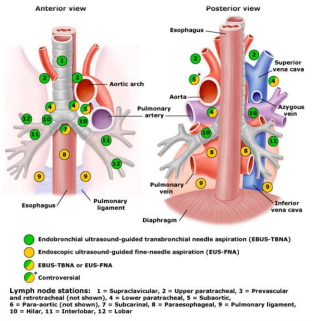
In this case and by Using thoracentesis, do you think the effusion will be transudative or exudative?

It will be **exudate** b/c if it was transudate then you know that either the lab did something wrong or the diagnosis is incorrect.

- Remember you cannot do the pleural biopsy unless you **confirm that it is exudative** b/c if it was transudative then it is very unlikely that the cause is TB or malignancy. [9]

[5] can yield positive results in up to 80% of cases of tuberculosis and 60% in cases of malignancy
[6] Why? b/c i'm going to do TWO procedures now. Thoracentesis AND pleural biopsy.
[7] (not lung biopsy, pleural biopsy).
[8] to document and confirm that this pt has pleural effusion
[9] Remember the causes of the transudative and exudative pleural effusion.

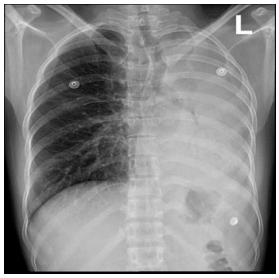
○ Bronchoscopy



is an instrument (flexible fiber-optic material that has a light source and a camera on the end) usually performed under local anaesthesia with sedation and inserted from the mouth or nose for an endoscopic technique of visualizing the inside of the airways (lumen) for diagnostic[10] and therapeutic purposes.

- If you want to see outside the luminal cavity (e.g. **lymph nodes**[11]) > you can use endobronchial ultrasound

Diagnostic indications	Therapeutic indication
1) Suspected lung cancer + Staging of lung cancer. 2) Abnormal CXR. (collapsed lobes or segments) 3) Hemoptysis. 4) Refractory or Unexplained cough. 5) Localized wheeze or Stridor. 6) Positive sputum cytology 7) Mediastinal lymph nodes 8) Unexplained pleural effusion 9) Lung abscess 10) Obtain culture material 11) Airway trauma 12) Tracheoesophageal fistula 13) Diffuse lung disease	1) Remove foreign bodies. - in an elderly patient > think of broken dentures - And in children > think of peanuts/toys - In the mid range around 25-30 > think of a slow growing tumor 2) Remove abnormal endobronchial tissue. 3) Difficult endotracheal tube intubation. 4) Endobronchial stent placement.



Scenario (3):

A 30 y/o gentleman presented with **SOB** over the past 3 hours and he denied any history of fever. On examination, he's **hypoxic**, **O2 saturation is 80%**, **BP is 90/60**. Lung examination reveals **reduced chest expansion**, **tracheal shift** to the affected side, **dullness** to percussion, and **absent breath sound.**

○ **From the history:**	- **Sudden SOB,** - **O2 saturation is 80%** here , **BP is 90/60 (hypoxic + hypotensive) > patient is unstable (in shock)**
○ **On examination & investigation**	- **Dullness** > against pneumothorax (would be hyperresonant). - **Absent breath sound**[12] **> lung collapse** here - **CXR > pulled trachea >** against tension pneumothorax (b/c tension pneumothorax will push)
○ **After confirming the diagnosis:**	1. You need to **stabilize** the patient because. (treat hypotension and O2 saturation) 2. **ALWAYS** mention that you want to do your **ABCs.** (Airway, Breathing, and Circulation) + (O2 saturation, Establish IV access…) + CBC, coagulation profile, liver and kidneys function test. 3. Order the **investigation** that confirms what you are dealing with > **Bronchoscopy**[13]

[10] Abnormal tissue in the bronchial lumen or wall can be biopsied, and bronchial brushings, washings or aspirates can be taken for cytological or bacteriological examination

[11] Transbronchial needle aspiration (TBNA) may be used to sample mediastinal lymph nodes and to stage lung cancer.

[12] could be pneumothorax .. but see other signs.

[13] We think it's inside so we do bronchoscopy.

- **Collapse:** (implying obstruction of the lobar bronchus) is accompanied by loss of volume and displacement of the mediastinum towards the affected side.
  - What is the source of this collapse?

Something in the airway (inside the lumen)	Something in the wall of the airway	Something in the outer wall of the airway
e.g. foreign body, mucus plugging or malignancy	e.g. inflammation, granuloma, tumor	mass that is causing a significant loss of volume or compression by enlarged lymph nodes

In this case "scenario 3" We don't know what is the exact pathology . . But the **CXR** hints that there is an **abrupt cut off sign** on the left mainstem bronchus (you can see it abruptly disappear after the bifurcation by a little in the image) > a hint that there is an **endobronchial mass**

- **Pulmonary function test (PFT)[14]:** here

  Includes: Spirometry, Lung volumes, Diffusion capacity, Respiratory muscle strength (here)

  - **Mainly for:**

1- **Categorization of different types of lung diseases**: knowing whether it's restrictive or obstructive. *

2- **Assessment of diseases severity:** e.g. pre – operation or stage of obstruction.

3- **Post-treatment evaluations of lung function:** easement of drug efficacy.

1. Spirometry: here

What it used for:	Measuring what?
• Measures the amount (**volume**) and/or speed (**flow**) of air that can be inhaled and exhaled. • Assess abnormality in airways: ★Can diagnose obstructive lung disease ★Can suggest restrictive lung disease but can't diagnose. ★Indication: patients with asthma or COPD	1- **FEV1**[15]: should be >90% of the predicted value 2- **FVC**[16] (forced vital capacity): predicted >90% 3- **FEV1/FVC (ratio)** ≥ 75[17] *we use the actual num. in calculation the ratio not the % ★ If **ratio** is **less than 75** → **obstructive** ★ If **ratio normal or more than 75** → suggest **restrictive** **(but must confirm with → lung volume test)**

* difference between restrictive and obstructive lung disease: here

Obstructive:[18]	- **Decreased** both **FVC and FEV1**, **but FEV1 is decreased more than FVC** → **The FEV1/FVC (ratio) decreased** - increased **resistance to expiratory airflow**.
Restrictive:	- **Decreased** both **FVC and FEV1**, **but FEV1 is decreased less than FVC** → **The FEV1/FVC (ratio) normal or increased.**[19]

[14] these tests vary considerably, not only with sex, age and height, but also between individuals of the same age, sex and height, so there's predicted values in FVC, ex 3L & test 1.5L > so this is 50% of his predicted value (predicted "normal"/actual)

[15] The forced expired volume in 1 second "the volume exhaled in the first second"

[16] the total volume exhaled

[17] excellent measure of airflow limitation.

[18] To distinguish large airway narrowing (e.g. tracheal stenosis or compression) from small airway narrowing, flow/volume loops are recorded using spirometry

[19] Due to enhanced elastic recoil.

2. Lung volume:

What it is used for:	Measuring what?
• Measures Lung capacity ★Can diagnose restrictive lung disease ★Can diagnose air trapping[20] ★Can suggest obstructive lung disease.	1- **Total lung capacity (TLC)**[21]: the total amount of air in the lungs after taking the deepest breath possible; >90% predicted 2- **Residual Volume (RV) :** lung volume representing the **amount of air left in the lungs** after a forced exhalation; > 90% predicted. 3- Vital capacity (VC) : the maximum amount of air that can be expelled from the lungs after the deepest possible breath ; >90% predicted ★ **If TLC, VC, RV < 90% → restrictive.**

- If FEV1/FVC ratio is more than 70 then → i need to do **lung volume** (put the pt. in the body ***plethysmography*** which's sealed body, we know what it's exactly the gas measurement inside that box and we ask the pt. to inhale as well exhale and we can measure his lung volume).

3. Diffusion capacity (DLCO): (To distinguish emphysema from chronic bronchitis or asthma) here

What it is used for:	Measuring what?
• Measures the ability of gases to diffuse from the alveoli into the pulmonary capillary (**Gas exchange**). • To measure the capacity of the lungs to exchange gas, patients inhale a test mixture of **0.3%** *carbon monoxide* (CO), which is taken up avidly by haemoglobin in pulmonary capillaries. ***not** normally present in lungs or blood but it's more soluble in blood than lung tissues. • Inhalation of small amount of **CO** Reflect loss or damage to the gas exchanging surface of the lung[22]. **Normal: >80%** ★ In lung disease the diffusing capacity (DLCo) also depends on the **V/Q** relationship as well as on the area and **thickness of the alveolar membrane.**	**Transfer factor (DLco)[23]:** ★ Decreased DLco Reflects loss or damage to the gas exchanging surface of the lung, the defect is either in the - alveoli e.g."emphysema", - capillary, - membrane b/t them. • e.g. **Emphysema** (distinguish emphysema from chronic bronchitis or chronic asthma), **interstitial lung diseases** & **pulmonary vascular disease.** ★ **Normal** value in diseases that affect upper part of respiratory system e.g. **chronic bronchitis**. ★ DLCO is **normal or increased** in Asthmatics. ★ **Increased** DLCO in: alveolar hemorrhage that is caused by (wegener disease, goodpasture syndrome and SLE).

4. Respiratory muscle strength:

What it is used for:	Measuring what?
• Measured by **pressure** transducer at the mouth when subject make a maximal inspiratory effort from full/maximal expiration effort from full inspiration. ★Diagnosing diseases that affect the muscle in the respiratory system.	**PImax, PEmax :** • MIP→ reflect **inspiratory muscles** as diaphragm. • MEP → **expiratory muscles** as abdominal muscles. ★ Motor neuron disease, Guillain-Barré Syndrome, metabolic disease , C.T disease (myositis), **Drugs (steroids for long period).**

[20] In chronic airflow limitation (particularly in COPD and asthma) the total lung capacity (TLC) is usually increased as will as the RV "for air trapping obstructive"

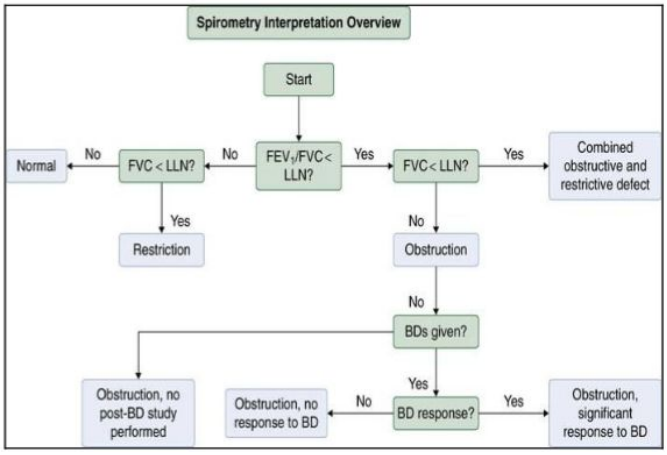
[21] measured by asking the patient to rebreathe a known amount of non-absorbed gas (usually helium) and recording how much the test gas is diluted by lung gas. Or by plethysmograph for more accurate result in some cases like cystic lung.

[22] damage in the alveoli/alveoli-capillary membrane.

[23] used in the early detection and assessment of progress of diseases affecting the lung parenchyma (e.g. idiopathic pulmonary fibrosis, sarcoidosis, asbestosis). - chronic pulmonary embolism> in pulmonary circulation

◆ How do we approach Pulmonary function tests? (Obstructive pattern)

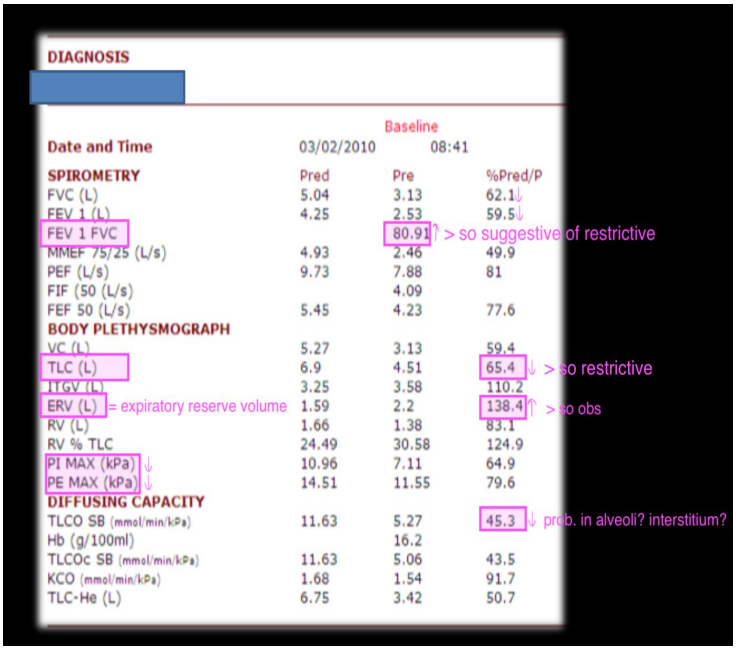
- First, we differentiate whether it is obstructive or restrictive → by **spirometry**.
- Second, we give **bronchodilator** short-acting β 2 adrenoceptor agonists (e.g. salbutamol); to know if it's reversible (asthma: large improvement in FEV1 (over 400 mL) and variability in peak flow over time are features of) 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 pt. is known to have **connective tissue disease** + **progressive SOB**→ **MIP and MEP** will show **very low muscles strength,** particularly EP "expiratory". The Pt. 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.



19.4 How to interpret respiratory function abnormalities

	Asthma	Chronic bronchitis	Emphysema	Pulmonary fibrosis
FEV_1	↓↓	↓↓	↓↓	↓
VC	↓	↓	↓	↓↓
FEV_1/VC	↓	↓	↓	→/↑
TL_{CO}	→	→	↓↓	↓↓
K_{CO}	→/↑	→	↓	→/↓
TLC	→/↑	↑	↑↑	↓
RV	→/↑	↑	↑↑	↓

(RV = residual volume; see text for other abbreviations)



Nonsmoker pt. Has this lab results.

Findings include:

1) **restrictive** 2) **obstructive** 3) **reduced DLCO**

4) **reduced muscles strength.**

He probably has a systemic disease "SARCOIDOSIS"

Sarcoidosis: (a connective tissue disease)

It is an autoimmune disease that affects all **body organs**:

- can damage the **interstitium** >causing **fibrosis** , and cause airway disease that mimics bronchial asthma or COPD. " **restrictive** + **obstructive**"
- its **Granuloma** can affect/attack the **muscle** → affecting diaphragm and expiratory muscles. "**reduced muscles strength."**
- And by interstitium damage or by pulmonary hypertension secondary to sarcoidosis →" **reduce DC** "

- **imaging :**
  - ★ **Computed tomography (CT)[24]:** important

    Provides detailed images of the pulmonary parenchyma, mediastinum, pleura and bony structures.

Chest CT consists of three types:

1) HRCT > for "lung parenchyma"
2) Normal CT with **contrast** > for "lymph node & pathologies in mediastinum"
3) CT Angiography > specifically for "pulmonary embolism"

1. HRCT (high resolution CT scan): without contrast

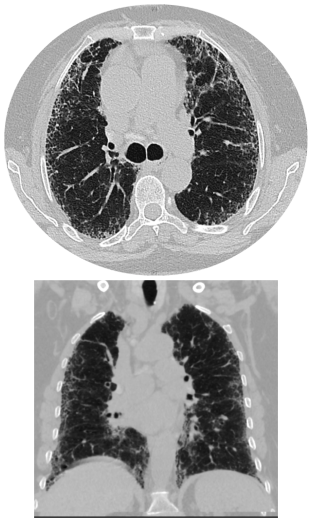
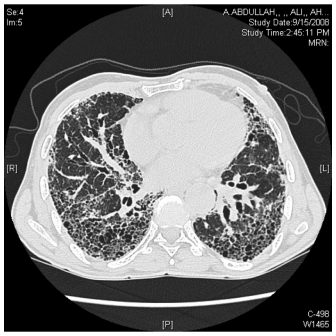
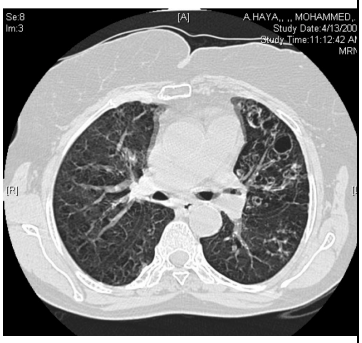
Designed for detailed evaluation of interstitial structures of the lung ,

- assessment of diffuse inflammatory and infective parenchymal processes.
- Uses narrow slice thickness (1-2 mm) compared with 5-10 mm for routine scan.

Slices the lung into very small measurement (1.5 mm) .

◆ Principal indications:

1. Suspected interstitial lung disease[25]
2. Characterization of interstitial lung disease[26]
3. Characterization of solitary pulmonary nodules
4. Diagnosis of bronchiectasis; it has a sensitivity and specificity of greater than 90%.
5. Diagnosis of lymphangitis carcinomatosa.

			
- **In Cross-section:** abnormal lung parenchyma gives hint that the patient has interstitial lung disease, particularly pulmonary fibrosis. - **In coronal view:** distribution of fibrosis	Pulmonary fibrosis also but more extensive (there's destruction of lung parenchyma & thickening of septa)	Hypersensitivity Pneumonitis: mosaic pattern (=air trapping), ground-glass opacity, (normal & abnormal areas) hypersensitivity pneumonitis	dilated cystic bronchi, so we are dealing with bronchiectasis.

[24] CT is essential in staging bronchial carcinoma by demonstrating tumour size, nodal involvement, metastases and invasion of mediastinum, pleura or chest wall.Information on tumour stage may be gained by examining the mediastinum, liver and adrenal glands.

[25] sarcoidosis, cryptogenic and extrinsic allergic alveolitis, occupational lung disease, and any other form of interstitial pulmonary fibrosis.

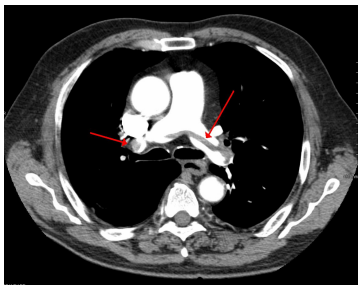
[26] Distinguishing emphysema from diffuse parenchymal lung disease or pulmonary vascular disease as a cause of a low gas transfer factor with otherwise normal lung function.

2. CT Angiography: with contrast

- 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.

Advantages:	Contraindications:
1. Critically ill patients 2. Children 3. Less volume of intravenous contrast 4. Permits greater processing of the raw data	1. Renal failure 2. Allergy to contrast 3. Pregnancy

NOTE:*Gold standard for the confirmation of Pulmonary Embolism diagnosis.
*We have to do V/Q scan instead of CT angiography if the patient is contraindicated to CT angiography



Scenario (4):

A 45 years old female with **Right sided chest pain** for **1 day.**
- on Investigation:
1- ABG : pH 7.32, PaCO2 28, PaO2 50, **O_2sat 88%**
2- ECG : sinus tachycardia.
3- CXR : normal
Answer: Diagnosis is most likely **pulmonary embolism** → confirm by ***CT angiography****.

**CT angiography*: red arrows: multiple filling defects both at the bifurcation of pulmonary trunk "hypodense" ("saddle" pulmonary embolism).

- **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):** here

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.**

To assess perfusion: **Technetium (Tc) 99m radionuclide** is tagged to macroaggregated human 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).

◆ How do we approach V/Q scans?

• A normal scan essentially excludes a clot → the chance of PE is ZERO

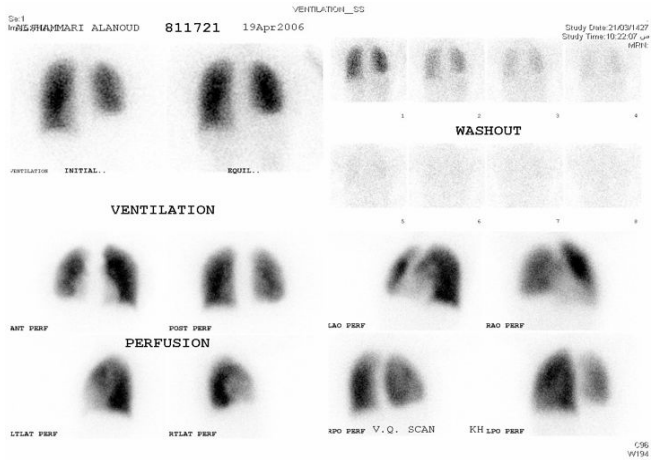
• V/Q is chosen first only in pregnancy.

Lung scan: normal perfusion Q:

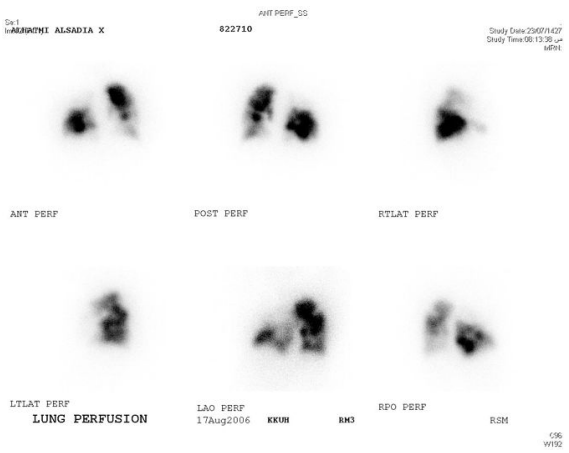
- When injected via peripheral venous site, the first capillaries encountered are the **pulmonary capillaries**. if **perfusion is present** at the capillary level of the lungs, nuclear medicine perfusion image would demonstrates "activity in the periphery of the lungs"

Lung scan: perfusion defect Q:

- 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"



Normal



PE (note the decreased perfusion)

Summary tables

- Physical signs on examination:

Table 14.2 Physical signs of respiratory disease

Pathological process	Chest wall movement (reduced)	Mediastinal displacement	Percussion note	Breath sounds	Vocal resonance	Added sounds
Consolidation (i.e. lobar pneumonia)	Affected side	None	Dull	Bronchial	Increased	Fine crackles
Collapse						
Major bronchus	Affected side	Towards lesion	Dull	Diminished or absent	Reduced or absent	None
Peripheral bronchus	Affected side	Towards lesion	Dull	Bronchial	Increased	Fine crackles
Fibrosis						
Localized	Affected side	Towards lesion	Dull	Bronchial	Increased	Coarse crackles
Generalized (e.g. idiopathic lung fibrosis)	Both sides	None	Normal	Vesicular	Increased	Fine crackles
Pleural effusion (>500 mL)	Affected side	Away from lesion (in massive effusion)	Stony dull	Vesicular reduced or absent	Reduced or absent	None
Large pneumothorax	Affected side	Away from lesion	Normal or hyperresonant	Reduced or absent	Reduced or absent	None
Asthma	Both sides	None	Normal	Vesicular Prolonged expiration	Normal	Expiratory polyphonic wheeze
Chronic obstructive pulmonary disease	Both sides	None	Normal	Vesicular Prolonged expiration	Normal	Expiratory polyphonic wheeze and coarse crackles

- Causes of a Collapsed lung:

Table 14.3 Causes of collapse of the lung

Enlarged tracheobronchial lymph nodes due to malignant disease, tuberculosis

Inhaled foreign bodies (e.g. peanuts) in children, usually in the right main bronchus

Bronchial casts or plugs (e.g. allergic bronchopulmonary aspergillosis)

Retained secretions – postoperatively and in debilitated patients

- Sudden change in O2 saturation:

8.4 Causes of sudden changes in oxygen saturation

Patient factors

- Bronchospasm
- Lung collapse due to thick secretions blocking the proximal bronchial tree
- Pneumothorax
- Impaired peripheral perfusion

Equipment factors

- Displacement of the endotracheal tube (extubation, endobronchial intubation)
- Blockage of the endotracheal tube
- Disconnection from the ventilator
- Oxygen supply failure
- Detached probe

- Obstructive and restrictive lung diseases:

TABLE 2-2 Obstructive Versus Restrictive Lung Disease

Measurement	Obstructive	Restrictive
FEV_1	Low	Normal or slightly low
FEV_1/FVC	Low	Normal or high
Peak expiratory flow rate	Low	Normal
Residual volume	High	Low, normal, or high
Total lung capacity	High	Low
Vital capacity	Low	Low

- Pulmonary function test:

TABLE 2-7 Important Pulmonary Studies

Test	Explanation of Test	Use	Comments
Spirometry	• From maximum inspiration, the patient exhales as rapidly and forcibly as possible to maximum expiration. • Spirometer plots the change in lung volume against time (see lung volumes below).	• Helps to distinguish obstructive from restrictive lung disease • Useful in assessing degree of functional impairment as well as monitoring effectiveness of treatment (e.g., during asthma exacerbation) • May detect respiratory impairment in asymptomatic patients (e.g., smokers)	• Volumes are measured as percentages of predicted values based on age, height, and sex. • Incorrect measurement or technique may lead to false positives.
DL_{CO}	• The patient breathes in a small, specific amount of CO, and the amount transferred from alveolar air to pulmonary capillary blood is measured. • CO is a diffusion limited gas, so other variables are eliminated. • Essentially measures the surface area of the alveolar-capillary membrane	• Can often distinguish between asthma, emphysema, and COPD • Useful in monitoring various conditions, such as sarcoidosis and emphysema	1. Causes for low DL_{CO} include: • Emphysema • Sarcoidosis • Interstitial fibrosis • Pulmonary vascular disease • Also lower with anemia due to reduced binding of CO to hemoglobin 2. Causes for high DL_{CO}: • Asthma (increased pulmonary capillary blood volume) • Obesity • Intracardiac left-to-right shunt • Exercise • Pulmonary hemorrhage (alveolar RBCs bind with CO)
Ventilation–perfusion ($\dot{V}/\dot{Q}$) scan	• Compares the degree of ventilation to perfusion of the lungs; an exact match would correspond to a $\dot{V}/\dot{Q}$ ratio of 1 • A high $\dot{V}/\dot{Q}$ ratio occurs when there is inadequate perfusion of an adequately ventilated lung. Thus, dead space is increased. • The normal ratio of ventilation to perfusion is 0.8, so there is normally some degree of $\dot{V}/\dot{Q}$ mismatch, with some degree of shunting	Diagnosis of PE	It is very rare to have a "normal" or "negative" $\dot{V}/\dot{Q}$ scan. When $\dot{V}/\dot{Q}$ scans are ordered for evaluation of suspected PE, the result is usually "low," "indeterminate," or "high probability"