How to read a normal chest x ray: a step by step approach

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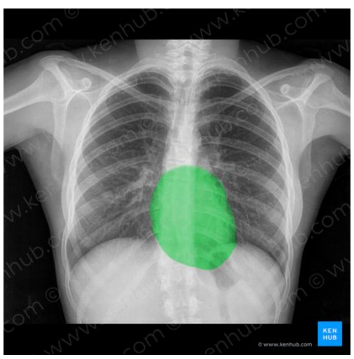
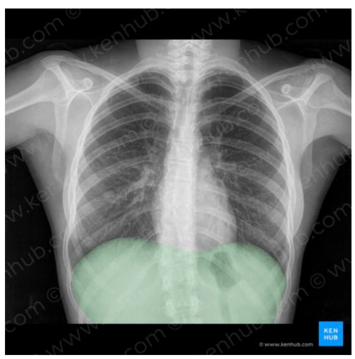




Cardiac silhouette 1/5

Synonyms: *none*

X-ray of the chest (also known as a **chest radiograph**) is a commonly used imaging study, and is the most frequently performed imaging study in the United States. It is almost always the first imaging study ordered to evaluate for pathologies of the thorax, although further diagnostic imaging, laboratory tests, and additional physical examinations may be necessary to help confirm the diagnosis.

X-rays are emitted by a machine, travel through the patient, and are picked up by a receptor on the other side of the patient. Some of these rays are absorbed more than others depending on the tissues through which they travel. This differential absorption allows for the creation of an image on radiographic film. In this image, air is black, bones are white, and the rest of the tissues fall on a spectrum in between.

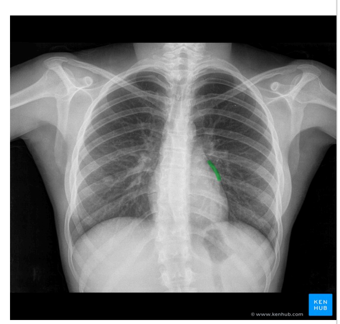
Key facts about how to read chest X-rays	Table quiz
Determining the view	*Posteroanterior* (standard): patient stands or sits upright approximately 6 feet in front of the beam source and faces the receptor. *Lateral*: patient stands or sits upright with his or her arms raised and turns 90 degrees so that the left side faces the receptor *Anteroposterior*: patient lies down on top of the receptor, such that the X-ray beam travels through the patient from front to back
Determining the quality	***R****otation:* compare the positions of the left and right medial clavicular joints to the spinous processes in the more central aspect of the image ***I****nspiration:* counting the posterior ribs visible in the lung fields ***P****enetration*: the vertebrae behind the heart are barely visible, and the diaphragm can be traced up until reaching the edge of the spine. MNEMONIC - **RIP**
Systematic analysis	**A**ir, airway, apices **B**ones **C**ardiac shadow, cardiovascular system **D**iaphragm **E**dges, effusions, extrathoracic soft tissues **F**oreign bodies **G**astric bubble, great vessels **H**ilum Impression MNEMONIC - Alphabet (**ABCDEFGHI**)

Step 1: Determine the view

When presented with a chest X-ray, the first thing one should do is try to determine the view, that is, the positions of the patient and machine and thus the trajectory of the rays relative to the patient. Chest X-ray can be:

- Posteroanterior (PA)
- Lateral
- Anteroposterior (AP)

These terms refer to the patient's position and therefore tell you the direction that the X-ray beam travels through the body to the receptor. **PA films** are the standard: the patient stands or sits upright approximately 6 feet in front of the beam source and faces the receptor on the other side, with the X-ray taken while the patient is maximally inspiring (i.e. the lungs are filled with as much air as the patient is capable of inhaling). To take left **lateral films**, the patient stands or sits upright with his or her arms raised and turns 90 degrees so that the left side faces the receptor; this allows the X-ray beams to travel from the emitter through the patient from right to left to the receptor on the other side.



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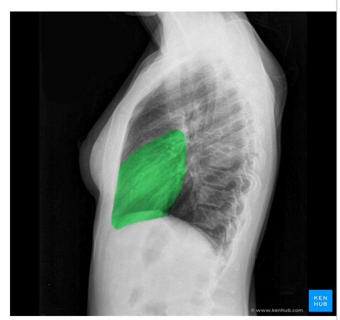
Posteroanterior X-ray (border of left atrium in green)

If a patient is not able to stand or sit upright, an image can be taken with the patient lying down on top of the receptor, such that the X-ray beam travels through the patient from front to back (i.e. as an **AP study**). These can be taken in the X-ray department, but they are more commonly taken at the patient's bedside as **portable studies**. AP studies do not tend to be as diagnostically revealing as PA studies for a number of reasons. For example, bed-bound patients may struggle with achieving maximal inspiration, limiting the potential for full lung expansion and therefore the view of the lungs on the film. Another notable feature of AP studies is the enlarged appearance the heart and mediastinum take on AP views.



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Lateral chest X-ray

Let's take a second to try to understand why it is that the *heart appears bigger than normal on AP studies.* Imagine you are holding a flashlight, pointing it so that the circle of light appears against a white wall a foot away from you. Now imagine holding a pen in front of that light, so that the pen casts a shadow onto the wall. If you hold the pen directly in front of the flashlight, is the shadow big or small? In this case, the shadow formed by the pen is large, and much larger than the pen's true size. Contrarily, what happens if you hold the pen as far as you can away from the flashlight, so that it sits directly in front of the wall? In this case, the shadow is much smaller, and is a much more accurate representation of the pen's true size.

Do you see now the relevance of this example? The same thing that happens to the pen's shadow when you hold it closer to the flashlight and farther from the wall happens to the picture of the heart created by the rays in an AP view. Anatomically, the heart is located in the anterior thoracic cavity; so when a person faces forward toward an X-ray machine, the heart is closer to the X-ray machine and farther from the film behind it. If a person faces away from the X-ray machine, however, the heart is farther from the X-ray machine and closer to the film on the other side. If the light from the flashlight is a metaphor for the beams emitted by the X-ray machine and the pen is a metaphor for the heart, it makes sense that the shadow cast by the heart on the film will be larger if the X-ray beams travel through the patient's body from front to back (AP), overestimating the true size of the heart and mediastinum.

Maybe you're feeling a little overwhelmed by all this; besides, *how can you tell if the view is PA or AP just by looking at it*? What if the patient just has cardiomegaly, how could you tell the difference at first glance between this and just a big shadow? Good news: in the real world of the hospitals, the **X-ray is usually labeled** in some way, either on the image itself or in the report, especially if it was taken via the portable AP technique.

Step 2: Determining image quality

In assessing a chest X-ray, there's a lot to consider, and a lot to remember to look for. This is where mnemonics become extremely useful. To evaluate the quality of an image, you can use the mnemonic **R.I.P.**, which stands for **rotation**, **inspiration**, and **penetration**.

Rotation

To assess whether the patient is rotated, first direct your attention towards the medial aspects of the clavicles and compare the positions of the left and right **medial clavicular joints** to the **spinous processes** in the more central aspect of the image. If the patient was positioned straight-on and not significantly rotated, the distances between the medial margins of the left and right clavicles and the central spinous process should appear to be approximately equal.

If a patient is rotated more to the right, the distance between the medial margin of the right clavicle and the spinous process will be greater than the distance between the medial margin of the left clavicle and the spinous process. If a patient is rotated more to the left, the distance between the left clavicle and the spinous process will be greater.

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Clavicle and clavicular joint X-rays (Anterior view)

Inspiration

In a good diagnostic study, the image will have been taken when the patient is maximally inspiring (i.e. the lungs are at their fullest). This can be evaluated by counting the **posterior ribs** visible in the lung fields. If the patient exhibited good inspiratory effort (i.e. he or she was willing and able to take a nice deep breath and hold it for the image), you should be able to count approximately 10 ribs before you get to the diaphragm marking the lower border of the thoracic cavity.

Penetration

Penetration describes the extent to which X-rays pass through the body, allowing for the creation of an image with clearly discernible features. In an X-ray with good penetration, the **vertebrae** behind the heart are barely visible, and the **diaphragm** can be traced up until reaching the edge of the spine.

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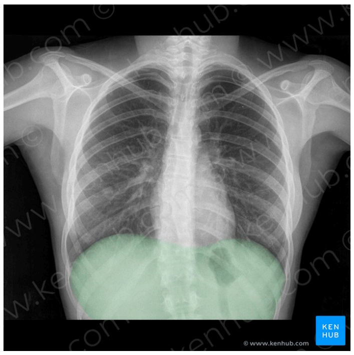


Diaphragm
Diaphragma

1/3

Synonyms: Respiratory diaphragm, Thoracoabdominal diaphragm, show more...

Step 3: Following a systematic approach

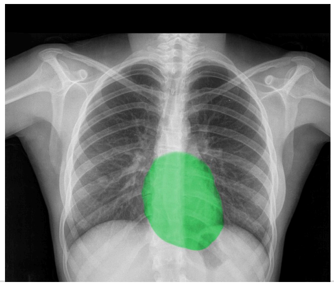
Once the quality of the radiograph has been evaluated, you can begin to assess the image. It is important to make sure you look at every part for pathology; otherwise you can potentially miss a lot, which can be highly detrimental to the patient. Because of this, taking a systematic approach to assessing any medical image is advised. One of the easiest ways to do this is, again, with a mnemonic. While more than one mnemonic exists, a common and relatively simple one for assessing a chest X-ray is the **ABCs.**

Want to test your knowledge before diving into the **ABCs** down below? Let's go!

What is highlighted in green? 1/15

Mediastinum

Gastric bubble



Costophrenic angle

Cardiac silhouette

Air, airway, apices

When you picture a chest X-ray, what is the first thing you think of? If you thought “lungs,” that’s a pretty solid response, because needing to evaluate the lungs is one of the biggest reasons to order a chest X-ray. **Air on an X-ray looks dark**, so when the lungs are clear and healthy, that’s exactly how they should look: not quite black, because there is still tissue there, but still quite dark.

If the lungs look like they have regions of density within them, that’s something to take note of. You’ll want to ask yourself, are the **densities localized** (i.e. only in certain parts of the lungs, like in one lobe, or just in the bases) or **diffuse** (throughout the entire lung field)? Do they obscure the diaphragm? You’ll want to compare what you see in the image with the patient’s **history** and **physical findings**. If the patient presented with a cough, fever, and shortness of breath and a lobe of one of the lungs appears dense (more gray or white in color), the patient may have pneumonia. If there appears to be a density with well-defined borders in one of the lungs of a patient experiencing a cough and weight loss, the mass lesion may represent a malignancy. If the lungs of a patient demonstrate diffuse markings that appear to follow the vasculature and are visible all the way to the periphery of the lungs, the patient may have vascular congestion, which can be due to heart failure. Look at the **fissures** as well, as these can also demonstrate thickening or excess fluid.

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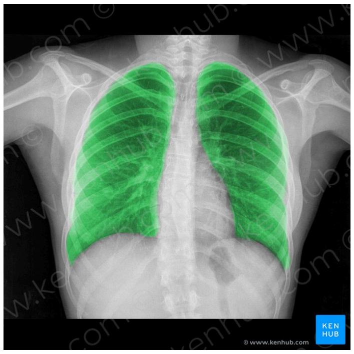

Lung
Pulmo

1/2

Synonyms: *none*

Even if there are no obvious densities, however, that does not necessarily mean the lungs are devoid of pathology: for example, a patient with emphysema may have lungs that look clear, but if you take a closer look you may notice they look even darker than usual, and this is because of air-trapping in this disease. This will be discussed in more detail later, in clinical correlates.

You'll also want to look for areas of **lucency**: does there appear to be a darker bubble in the apex (topmost portion) of the lung, possibly representing a ruptured bleb (kind of like a bubble in the lung tissue) and subsequent pneumothorax (free air in the thoracic cavity)? If a pneumothorax is large enough, it can even cause the lung to collapse: in this case, you can frequently trace the borders of the shrunken lung closer to the middle of the chest, while the region surrounding will look darker as it contains only air without lung tissue.

Examining the **trachea** is also important: you'll want to check to make sure the trachea is midline, and if it isn't, you'll want to see if you notice foreign bodies in the bronchi, midline shift of other mediastinal structures, or any signs of atelectasis (collapse of the lung). Also take a look at the **hilar region** (where the trachea bifurcates, forming the left and right main bronchi). if a patient has bilateral hilar lymphadenopathy (i.e. enlarged lymph nodes on both the left and right), you should be able to see this on a chest X-ray. This finding could signify the presence of a condition called sarcoidosis (see clinical correlates for more information).

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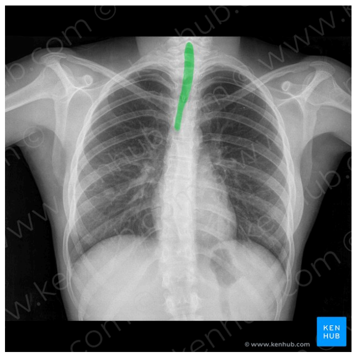

Trachea

1/2

Synonyms: *none*

Bones

When assessing the bones, **symmetry** is probably the easiest thing to start with: asymmetry between the bones on the right and the left sides of the patient could be the simplest sign to pick up that something isn't right. While looking at the bones, also keep an eye out for lesions: do you see any areas that look patchy? A region that looks **light** and **patchy** could represent an old break with healed, reformed sclerotic bone. A particularly dark or light spot on one or more of the bones could be a lytic or blastic lesion, respectively. (Knowing a bit about the patient's medical history will help put some of this into context.)

Also, make sure to look out for masses, growths, or other irregularities in the bone. Always follow the **edges of the bone**: the bright edges represent the bone cortex, which you should be able to follow all the way around the surface. If the cortex appears interrupted, it could signify the presence of a break, or even a cancer (like osteosarcoma).

Cardiac shadow, cardiovascular system

One of the first things to do when evaluating the **heart** is to look at where it is. This may seem silly, as you have probably been taught by now that the heart lies predominantly in the left hemithorax, but it is important to know that some patients will not house their heart here! There are, in fact, people whose heart lies in the right hemithorax, a condition known as "**dextrocardia**." This condition may or may not be isolated, meaning that the person could just have the heart on the right side and everything else in the usual location, or their other internal organs could be a mirror image of the norm as well (i.e. the liver appears on the left instead of the right, the stomach and spleen on the right instead of the left, etc.), a condition called "**situs inversus**". This is not an anomaly you'll want to miss! While some patients have isolated situs inversus, it can also occur due to a genetic condition called **Kartagener syndrome** (also known as primary ciliary dyskinesia), which also presents with repeat sinus and lung infections and infertility.

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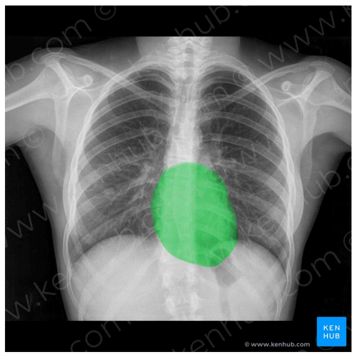

Cardiac silhouette 1/2

Synonyms: *none*

The next feature of the heart that you should evaluate is its **size**. In a standard PA film, the width of the heart, or rather the width of the "**cardiac shadow**" (the shadow the heart makes on the film) should appear to be less than 50% the diameter of the chest. If it appears to take up more space than this, the patient may have **cardiomegaly** due to underlying pathology (or, as previously mentioned, the film could be AP - always check).

While you're checking out the heart and great vessels, take a minute to look at the **mediastinum**. If it's widened, for example, you could be looking at a mass, an aortic aneurysm (dilation), or an aortic dissection.

Diaphragm

The **shape** of the diaphragm can also provide a great deal of information regarding a patient's current state of health. Normally, the diaphragm is curved and the right hemidiaphragm is higher than the left because it sits on top of the liver. If the diaphragm looks flattened, it could be that the patient has chronic asthma or chronic obstructive pulmonary disease (COPD). It is also extremely important to look for **free air** under the diaphragm, as this signifies a gastric or intestinal perforation and constitutes a surgical emergency.

Edges, effusions, extrathoracic soft tissues

In evaluating a chest X-ray, it is also vital to check the costophrenic angles at the peripheral edges of the diaphragm, as **blunting** of the costophrenic angles (such that they are no longer appear sharp and their borders no longer appear distinct, but rather "grayed-out") could signify the presence of a pleural effusion (a fluid collection between the pleura and lung tissue). Pleural effusions may not always be obvious, so it is always important to look attentively. A small posterior effusion may be seen more easily via a lateral film rather than a PA film.

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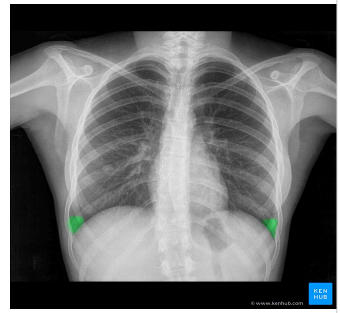

Costophrenic angle: Anterior view

Foreign bodies

We briefly mentioned this previously, but the “F” in this mnemonic is here to remind you to check for foreign bodies just in case you forgot! Many times, patients will have **tubes** or **iatrogenic devices**. This can include lines, nasogastric or orogastric tubes, cardiac monitor leads, and others. Always make sure to look for such items: make note of what is present, where they are, and if they are correctly placed.

Gastric bubble, great vessels

Oserve the **gastric bubble** (the bubble of air in the stomach): make sure it is present and in the standard location on the left side of the body. If not, take note, and investigate. If you did not attend to the **great vessels** while examining the cardiac silhouette and vasculature, use the “G” in this mnemonic to remind you to do so now.

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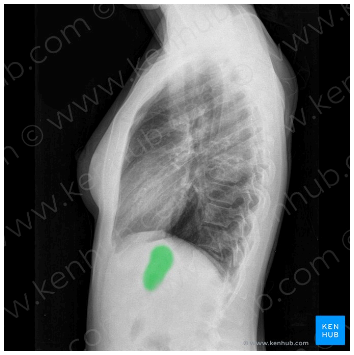


Gastric bubble 1/2

Synonyms: *none*

Hilum

When evaluating the hila (the lung bases containing vessels, bronchi, and lymphatics), it is important to look for **lymphadenopathy**, **calcifications**, and, as mentioned in our previous discussion of assessing the lung fields, **masses**.

Impression

Finally, the last thing you will want to do is provide a final synopsis of your findings. This may not include every single finding, but it should highlight the most significant ones, especially those that correlate with the patient's **current history** of presenting illness and **physical exam findings**.

Ready to give it a try reading X-rays? Tackle the following study units and see how much you know.

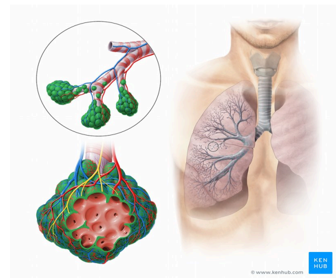
Clinical notes

Aortic dissection

Multiple layers of tissue make up the wall of a blood vessel. The innermost layer is called the **intima**; the middle layer is called the **media**; and the outermost layer is called the **adventitia**. The **aorta** is a large artery [illegible] blood moving at high pressures; because of this, a tear in the intima of the aorta can occur. When this happens, blood can enter the media and push the intima away from the other layers, creating an additional space referred to as a "false lumen." Depending on the severity of the injury, the false lumen can become quite large. The outer adventitial layer of the aorta is not as strong or elastic as the other layers, so enlargement of the false lumen can lead the aorta to can become significantly dilated. As mentioned previously, this can lead to the appearance of a widened mediastinum on a chest X-ray.

Emphysema

Emphysema is a disease that results from the loss of elasticity in the lung tissue, specifically in the walls of the **alveoli** (the tiny air pockets that comprise lung tissue and allow for gas exchange to occur between the air within them and the capillaries that border them). Breakdown of these elastic fibers can occur due to a genetic condition, or it can be due to environmental influences. In patients with the inherited condition, there is deficiency of an enzyme called **alpha-1 antitrypsin**. This enzyme is usually produced in the liver and transported to the lungs; but patients with the deficiency make an enzyme that is not functional and therefore is not transported.



Alveolus (anterior view)

Patients without the inherited condition usually acquire emphysema from **smoking**, as the chemicals in cigarette smoke lead to loss of alpha-1 antitrypsin in the lungs. When present and functional, alpha-1 antitrypsin inhibits another enzyme in the lungs called **elastase**, which breaks down the elastic fibers. When alpha-1 antitrypsin is not present, elastase can go unchecked and continuously break down elastin. Breakdown of elastin results in hyper-compliance of the lung tissue: the alveoli fill with air easily, but they lose their ability to contract back to their original shape. This leads to the alveoli becoming ballooned out, trapping air in the lungs. As you might expect, this air trapping leads to **hyperinflation** of the lungs, typically giving the patient a "**barrel-chest**" appearance.

On chest X-ray, this widened chest may be observed, as well as flattening of the diaphragm due to the hyperinflated lungs pushing down on it. Because the alveoli are super-filled with air, the patient's lungs will typically appear darker than normal on chest X-ray (because, like we said, air appears darker than tissue). Stress on the thin walls of the alveoli, due to their loss of elastic tissue and the amount of air they contain, can also lead them to rupture, leading to the formation of even larger air-filled spaces and further darkening the overall appearance of the lungs. Pneumothorax is a potential complication of emphysema from the rupture of multiple alveoli.

Sarcoidosis

Sarcoidosis is a systemic granulomatous disease that affects not only the lungs, but many organs throughout the body. The finding of **bilateral hilar lymphadenopathy** on a chest X-ray, especially in a young adult with shortness of breath, hypercalcemia, and systemic symptoms (such as fatigue and weight loss) is highly indicative of this disease process. **Pulmonary reticular opacities** can also be seen on an X-ray.

Coin lesion

The term coin lesion refers to a small, round opacity appearing in the periphery of the lung field on a chest X-ray or CT scan. While these can represent **benign hamartomas** (normal tissue in an abnormal location), they should be monitored for growth over time as they can also represent the beginning stages of cancer, particularly **lung adenocarcinoma**.

Pancoast tumor

A pancoast tumor is an **apical lung tumor**. On a chest X-ray, these tumors will lead the upper part of the lung to look more opaque than the rest. These tumors are particularly clinically important because of the surrounding structures on which they can impinge if they grow large enough: apical lung tumors can compress the regional blood vessels (leading to vascular congestion), the sympathetic ganglia (leading to Horner's syndrome, presenting with the triad of miosis, ptosis, and anhidrosis - that is, constriction of the pupil, drooping of the eyelid, and loss of the ability to sweat respectively), or even the brachial plexus in shoulder (leading to neurological symptoms in the arm).

Acute respiratory distress syndrome

Acute respiratory distress syndrome (ARDS, also frequently referred to as **hyaline membrane disease** and **diffuse alveolar damage**) is a diffuse inflammatory reaction that takes place in the lungs due to a variety of insults (including, but not limited to, sepsis, infectious or aspiration pneumonia, pancreatitis, drug toxicity, and smoke inhalation). After suffering the inciting incident, patients become increasingly short of breath and demonstrate hypoxemia, respiratory alkalosis, and other laboratory derangements that progressively worsen, typically over the following 6 to 72 hours. This occurs due to edema, inflammation, and subsequent formation of a thick hyaline membrane along the walls of the alveoli in the lungs. This membrane formation thickens the diffusion barrier between the air in the alveoli and the capillaries in the alveolar walls, preventing effective movement of oxygen into the bloodstream. A chest X-ray in a patient with ARDS will typically demonstrate **diffuse opacification** of the alveoli.

Tuberculosis

Tuberculosis is a disease that results from infection with the bacteria *Mycobacterium tuberculosis*. This disease has multiple stages, and can either be limited to the lung (**pulmonary tuberculosis**) or disseminated throughout the body (**miliary tuberculosis**, although this tends to occur primarily in patients who are significantly immunocompromised).

In patients with suspected pulmonary tuberculosis, chest X-ray is enormously useful, and for this reason is one of the initial tools used in the diagnostic process. Some classic signs of tuberculosis that can be seen on a chest X-ray are:

- focal infiltrations of the apical or posterior segments of the upper lobes, or of the superior segments of the lower lobes
- cavitary lesions
- fibrosis due to tissue destruction
- enlargement of the lymph nodes in the hilum and mediastinum

Clinical case

A patient is wheeled into the trauma bay after a motor vehicle accident. The patient was not wearing his seatbelt when he crashed into the car in front of him, causing him to fly through the windshield. Miraculously, the patient does not appear to have any penetrating injuries; although he does have obvious bruising on his chest. As your team examines him, it is clear he is having trouble breathing. As he inhales, you notice that while most of his chest is expanding, there is a part of the patient's chest that appears to be moving separately from the rest, instead moving inward on inspiration.

Flail chest occurs when a rib or multiple ribs sustain more than one fracture, creating an unattached, "free-floating" segment called a flail segment. This fractured, separated segment cannot assist with expansion of the chest, and instead paradoxically moves inward during inspiration due to the negative pressure created in the thorax when a person's chest expands to allow for the inhalation of oxygen. Flail chest is particularly dangerous because these free segments with their sharp edges have the potential to bruise or even perforate the lung beneath them.

On a chest X-ray, **fractures** may be noted in the affected ribs; but patchy regions of the lung where contusions have been sustained may also be present and should be noted. If the broken rib has resulted in a punctured lung and/or intrathoracic bleeding, a **pneumothorax** (air in the thorax) or **hemothorax** (blood in the thorax, opacifying part of the lung field) may be visible on the X-ray as well.

Sources

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