Cardiac and vascular pathologies can be rapidly diagnosed with radiographic techniques. X-ray, CT and MRI are common methods used for diagnosis. X-rays provide a 2D image that is used in angiography and to detect other cardiac pathologies. CT scans use X-rays to generate a 3D image and are used to diagnose acute vascular events. MRI uses electromagnetic and radio waves to generate high-resolution 3D images and to determine the after effects of vascular damage.

Overview

**X-ray examination** relies upon X-rays, which are part of the electromagnetic spectrum. An X-ray producing source sends the X-rays through the patient and onto a receiver. The representative image is based upon how the **different density of tissues** absorbs the X-rays.

*Bones* will absorb more and thus have an opaque white color, while *lungs* are considered soft tissue and full of air, appearing black because they do not absorb as much of the X-rays. Tissues with the same density, who are bordering each other, will appear as one continuous opacity and not distinct from each other.
For the USMLE, you should know how to interpret a plain film chest x-ray. Having a system is important as it will help you to spot pathology quickly and effectively. There are many systems out there which will encompass every aspect of an X-ray, but on the USMLE it is best to use a quick method as you only have just over one minute per question.

The quickest one is the **ABC method**. A is for **airway**, where you look at the **trachea** and mediastinum. B is for **breathing**, to assess lung fields and pleura. C is **circulation**, examining the **heart** and aorta. It will be important to familiarize yourself with the common pathologies seen in each region.

**Interpreting Technical Aspects of chest x-Ray**

There are some standard outlines to get a proper chest radiograph. Rotation and inspiration are important technical factors in getting a perfect chest radiograph, as failure to get a proper standard of getting chest radiographs may result in misinterpretation and misdiagnosis.

**Rotation**: a satisfactory chest radiograph is free from rotation. It is confirmed by the fact that the medial ends of the clavicles are at equal distance from the spinous processes of the vertebral bodies. In case of rotation one side of the chest radiograph is darker than the other one. This can be falsely interpreted as pathological conditions. Darker side on rotation can be misdiagnosed as pneumothorax or pulmonary embolism and lighter side is misinterpreted as pleural effusion or airspace consolidation.

**Inspiratory effort**: It is also important that the patient has made a good inspiratory effort. This is confirmed by the visibility often ribs posteriorly in mid-clavicular line in the frontal chest x-ray. Poor inspiratory effort results in prominent pulmonary vessels resulting false diagnosis of cardiac failure.

**Cardiac Pathologies**

There are many cardiac pathologies that can be diagnosed with a simple chest X-ray.

*Image: “Acute pulmonary edema. Note enlarged heart size, apical vascular redistribution (circle), and small bilateral pleural effusions (arrow),” by James Heilman, MD. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0)*

**Heart failure** is often broken up into two categories for the USMLE: left- and right-sided. **Left-sided heart failure** occurs when the left ventricle cannot pump enough blood to
the body, causing blood to back up in the lungs. Symptoms include pulmonary edema, orthopnea, paroxysmal nocturnal dyspnea, and patients can cough up pink frothy sputum.

Right-sided heart failure occurs when the right ventricle cannot pump enough blood to the lungs, leading to blood collecting in the liver and periphery. Symptoms include jugular venous distension, peripheral edema, hepatomegaly.

Diagnosis can be made with a plain film imaging, which can show central pulmonary venous congestion and cardiomegaly. Cardiomegaly is determined on a PA plain film that measures the ratio between the cardiac width and thoracic width and should be less than 0.5-0.6.

In the pediatric population, tetralogy of Fallot is a common test question and has four pathologies: pulmonary stenosis, right ventricular hypertrophy, overriding aorta, ventricular septal defect. Chest X-ray will often show the heart appearing as a boot shape.

Mediastinal widening is a finding on chest X-ray that will have a distinct pathology and can include aortic aneurysm, aortic rupture, and esophageal rupture. An infection with anthrax (bacillus anthraces), a gram-positive rod, can present this way.

Vascular Pathologies

There are very few vascular pathologies that the USMLE likes to test on that can be seen using X-rays. One to be familiar with is Monckeberg, a disease where the media of arteries becomes calcified to the point where they can be seen on an X-ray. It is very rare and generally a benign pathology.

Angiography is a technique where multiple X-rays are taken, and a dye known as contrast is injected in order to visualize the arteries. They are often done in the cath lab but can also be done in the general operating rooms.

Fibromuscular dysplasia is a small to medium vessel angiopathy that affects younger women. It can lead to cerebral vascular events and renal stenosis. It is often seen on X-ray as the string of beads sign in the renal arteries.
Coronary angiography is the standard for assessing coronary artery disease as it allows for the evaluation of coronary blood flow. Contrast is used to visualize the coronary arteries and to determine the amount of stenosis. It will be important to know the anatomy and their locations on angiography.

Peripheral vascular disease is a common disease that results from atherosclerosis causing a narrowing of the vascular lumen leading to limb ischemia. PVD can lead to pain, limb impairment and eventual loss of the affected limb. Angiography can be used to visualize the stenosis, and at the same time PVD can be treated with balloon angioplasty.

One concern with contrast is the detrimental effect on kidney function. Patients with impaired kidney function should generally avoid contrast if they can. In recent years, carbon dioxide has been used instead of contrast in patients with impaired kidney function. A skilled vascular surgeon can use this gas to show the stenosis in a peripheral artery nearly as well as with contrast.

Computer tomography (CT) is a machine-based technique that shoots multiple x-rays at the patient while the x-ray source rapidly rotates around the patient to generate a 3D image. The image that is produced is divided into slices with a set width that can be adjusted depending upon what is being imaged.

Unlike a chest X-ray, you will be only given one slice of an CT on the USMLE and must be able to determine section and location through anatomical landmarks. It is important to review the major anatomy that can be seen on a CT. When reviewing pathology looking for a bleed, blood appears white due to the absorption of X-rays by the iron.

Coronary artery imaging with CT angiography is used to evaluate for coronary artery disease. It is a test that is accepted by many but not readily used without specific indications.

Abdominal aortic aneurysms are outpouchings through the media. They can be seen as pulsatile masses in the abdomen to the left of the umbilicus. This is due to a loss of the
vasa vasorum in that part of the abdominal aorta.

They are found most commonly in over-50-year-old male smokers and highly associated with atherosclerosis. Other causes include hypertension and Marfan syndrome. They are considered pathological, and treatment is deemed necessary when the lumen reaches a diameter above 5.5cm. CTs and serial ultrasounds are used to monitor progression.

Thoracic aneurysms occur secondary to hypertension, Marfan syndrome and are seen in tertiary syphilis.

Aortic dissection occurs when there is a longitudinal tear within the lumen of the aorta. The way the tear occurs results in a false lumen where blood collects. This can result in rupture and lead to either death from hypoperfusion or cardiac tamponade followed by obstructive shock.

Symptoms often include a tearing sensation that radiates to the back and a change in blood pressure between arms. This is most likely to be seen in hypertensive older patients and in younger patients with Marfan syndrome. X-ray can also be used as an initial test which would show mediastinal widening.

Pulmonary embolism (PE) is a medical emergency and needs to be treated quickly as it can be fatal. PEs originate from venous thrombosis found in the extremities. Patients will present with acute onset shortness of breath, hypoxia and chest pain. Management includes anticoagulation with heparin and thrombolysis with urokinase and streptokinase. A CT pulmonary angiography for suspected PE is the most sensitive and specific test for it.

Cerebral vascular events can be rapidly seen with CT of the head. Any patient that loses consciousness should have a head CT to rule out any threatening pathology.

Epidural hematomas appear as biconvex collections of blood outside of the dura due to rupture of the middle meningeal artery. The cavity fills rapidly and can lead to brain herniation with a CN III palsy (down- and out-gaze).
Subdural hematomas are concave collections of blood below the dura layer due to bridging vein rupture. It is usually seen in older populations due to cerebral atrophy. Subarachnoid hemorrhages occur due to rupture of aneurysms in the brain. The most common is the berry, or saccular, that is often found in the anterior communicating artery of the circle of Willis but can be found at other branching points of arteries.

They can also be caused by arteriovenous malformations. Patients will present with what is often described as “the worst headache of my life.” Berry aneurysms can also be seen with a CT head that utilizes contrast and can be treated from there with clipping or coiling.

Magnetic Resonance Imaging (MRI) uses a very large electromagnet to detect natural isotopes in your body and cause them to release radiofrequency energy that is converted into a 3D image. This technique produces high resolution images that can show many distinct pathologies.

The exam often takes a long period of time and relies upon the patient remaining still. It is often used after vascular events have occurred to visualize soft tissue damage. On the USMLE, much like a CT scan, MRI images will consist of one slice of which you will be required to determine section and level, based upon anatomical landmarks. It would be good to go through and review the relevant anatomy easily visualized by MRI.

Out of all vascular defects, an MRI will be most likely used for examining an arteriovenous malformation. This is a common vascular lesion characterized by arteries joining veins without capillaries separating them. Capillaries normally dampen the higher pressure from arteries, but in the case of AVMs, the veins experience higher blood pressures. AVMs usually affect young adults and carry a risk of rupture in a small percentage of those who suffer. Hypertension can increase the risk of rupture.

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