Definition

X rays are electromagnetic radiation that differentially penetrates structures within the body and creates images of these structures on photographic film or a fluorescent screen. These images are called diagnostic x rays.

Purpose

Diagnostic x rays are useful in detecting abnormalities within the body. They are a painless, non-invasive way to help diagnose problems such as broken bones, tumors, dental decay, and the presence of foreign bodies.

Description

X rays are a form of radiation similar to light rays, except that they are more energetic than light rays and are invisible to the human eye. They are created when an electric current is passed through a vacuum tube. X rays were accidentally discovered in 1895 by German physicist Wilhem Roentgen (1845-1923), who was later awarded the first Nobel Prize in physics for his discovery. Roentgen was also a photographer and almost immediately realized that the shadows created when x rays passed through the body could be permanently recorded on photographic plates. His first x-ray picture was of his wife's hand. Within a few years, x rays became a valued diagnostic tool of physicians world-wide.

How x rays work

X rays pass easily through air and soft tissue of the body. When they encounter more dense material, such as a tumor, bone, or a metal fragment, they are stopped. Diagnostic x rays are performed by positioning the part of the body to be examined between a focused beam of x rays and a plate containing film. This process is painless. The greater the density of the material that the x rays pass through, the more rays are absorbed. Thus bone absorbs more x rays than muscle or fat, and tumors may absorb more x rays than surrounding tissue. The x rays that pass through the body strike the photographic plate and interact with silver molecules on the surface of the film.

Once the film plates have been processed, dense material such as bone shows up as white, while softer tissue shows up as shades of gray, and airspaces look black. A radiologist, who is a physician trained to interpret diagnostic x rays, examines the pictures and reports to the doctor who ordered the tests. Plain film x rays normally take only a few minutes to

perform and can be done in a hospital, radiological center, clinic, doctor's or dentist's office, or at bedside with a portable x-ray machine.

Special types of x-ray procedures

Mammograms are fixed plate x rays that are designed to locate tumors within the breasts. Dental x rays are designed to locate decay within the tooth. Sometimes a liquid called contrast material (for example, barium) is used to help outline internal organs such as the intestines. The contrast material absorbs x rays, helping to make soft tissue more easily visible on the x-ray films. Contrast material is commonly used in making x rays of the digestive system. The contrast liquid can be swallowed or injected, depending on the part of the body being x rayed. This may cause some minor discomfort.

Fluoroscopy is a special x-ray technique that produces real-time images on a television monitor. With fluoroscopy, contrast material is injected into a blood vessel. The physician can then watch the real-time movement of the contrast material to determine if there are blockages in circulation. Fluoroscopy is also used to help guide catheters into place in the heart during cardiac catheterization or to guide an endoscope during endoscopic surgery.

Computed tomography or CT scan works on the same principles as fixed plate x rays, only with a CT scan, an x ray tube rotates around the individual, taking hundreds of images that are then compiled by a computer to produce a two-dimensional cross section of the body. Although many images are taken to produce a CT scan, the total dose of radiation the individual is exposed to is low. Other common imaging techniques such as **magnetic resonance imaging** (MRI) and ultrasound do not use x rays.

How x rays are performed

Fixed plate x rays are extremely common diagnostic tests. A trained x-ray technologist takes the x ray. The individual is first asked to remove clothing and jewelry and to wear a hospital gown. The x ray technologist positions the patient appropriately, so that the part of the body to be x rayed will be between the x-ray beam and the film plate. Usually the individual either lies on an adjustable table or stands. Parts of the body that are especially sensitive to damage by x rays (for example, the reproductive organs, the thyroid) are shielded with a lead apron. Lead is very dense and effectively protects the body by stopping all x rays.

It is essential to remain motionless during the x ray, since movement causes the resulting picture to be blurry. Sometimes patients are asked to hold their breath briefly during the procedure. must protect the fetus from x-ray exposure.

If a contrast material is to be used, the individual will be given special instructions to prepare for the procedure and may be asked to remain afterwards until recovery is complete. (See Preparation and Aftercare below.)

Precautions

Although unnecessary exposure to radiation should be avoided, the low levels of radiation one is exposed to during an x ray does not cause harm with a few exceptions. Pregnant women should not have x rays unless in emergencies the benefits highly outweigh the risks. Body parts not being x rayed should be shielded with a lead apron, especially the testes, ovaries, and thyroid.

Preparation

No special preparation is needed for fixed plate x rays unless contrast material is used. When x rays are scheduled that involve the use of contrast material, the physician will give specific instructions for preparation. For example, in a lower GI series, the individual may have to fast and use special **laxatives** to cleanse the bowel before swallowing the contrast material. Parents can prepare children for x rays be explaining what will happen and that these tests are short and painless.

Risks

Low dose exposure to x rays creates minimal cell damage and minimal risk when x rays are performed in an accredited facility. There is an increased risk that a developing fetus will develop leukemia during childhood if exposed to x-ray radiation; pregnant or potentially pregnant women should avoid x rays. There is also a slight risk of an allergic reaction to the contrast material or dye used in certain x rays.

X-ray Artifacts

X-ray artifacts can present in a variety of ways including abnormal shadows noted on a radiograph or degraded image quality, and have been produced by artificial means from hardware failure, operator error and software (post-processing) artifacts.

There are common and distinct artifacts for film, computed (CR) and digital radiography (DR).

Common causes

1. improper handling of the films
2. errors while processing the films
3. patient movement while taking the image

Common artifacts (all forms of radiography)

1. motion artifact
    a. due to patient movement resulting in a distorted image
2. image compositing (or twin/double exposure)
    a. superimposition of two structures from different locations due to double exposure of same film/plate
3. grid cut-off
4. radiopaque objects on/external to the patient (e.g. jewelry (e.g. necklaces, piercings), clothing (e.g. buttons), hair (e.g. pony tail, hair braids etc.).
5. debris in the housing
    a. debris in the housing caused by the collimator tube can cause small trapezoidal regions, indicative of lead shavings

Film radiography artifacts

1. finger marks
    a. improper handling with hands
2. clear film
    a. malfunction of the machine or placing the film in the fixer before developer solution
3. static electricity
    a. black “lightning” marks resulting from films forcibly unwrapped or excessive flexing of the film
4. crescent-shaped black lines
    a. due to fingernail pressure on the film
5. crescent-shaped white lines
    a. due to cracked intensifying screen

6. black film
    a. complete exposure to light.
7. clear spots
    a. air bubbles sticking to film during processing
    b. fixer splashed on film prior to developing
    c. dirt on the intensifying screen

Computed/digital radiography artifacts

1. detector image lag or ghosting
    a. latent image from previous exposure present on current exposure
2. incorrect detector orientation i.e. upside-down cassette
    a. spoke like radiopaque lines
3. backscatter
    a. electronics are visible on the exposed image
    b. increased radiation exposure required for portable DR (digital radiography) examinations
4. stitching artifacts
    a. occur when two separate DR or CR (computed radiography) images are merged into a single image
5. over exposure
6. dead pixel artifact
7. signal dropout [4]
    a. large areas of signal loss, due to detector drop
8. speckled radiopaque spots
    a. due to detector drop
9. detector calibration limitation
    a. faint radioopaque striping (often vertical) in the background of an image, yet not evident on the anatomy
    b. this artifact should be carefully examined, if it does not interfere with the anatomy, it is not a detector failure/grid cut off, rather a limitation of the detector calibration.
    c. often seen as lower exposure
10. failure of detector offset correction
    a. similar to ghosting, however, the digital detector not being calibrated when promoted is the cause
11. electronic shutter failure
    a. the digital image often will have obscurely shaped, tight collimation that defies logic
    b. often a computer error often fixed with recollimation post exam (this should be explored before reexamination)
12. values of interest misread

a. image appears washed out, and underexposed
b. this is often due to a largely collimated area of smaller anatomy i.e. a patella protection
c. tighter digital collimation in conjunction with reprocessing will correctly assign the correct values of interest

13. mid gray clipping [4]
    a. loss of contrast in areas of different pixel density yet not change in density can be seen i.e. the metal on a knee replacement
    b. due to poor contrast enhancement
14. grid-line suppression failure
    a. faint grid lines present on an image, with no grid cut off