X ray production and interaction with matter engineering essay

The x-ray tube is the most important part of the x-ray machine because the tube is where the x-rays are actually produced. The production of x-rays requires a rapidly moving stream of electrons that are suddenly decelerated or stopped. (C., Andy, 2008). Basically this means that when fast-moving electrons slam into a metal object x-rays are produced. (Bushong, 2008, Ch. 6 p. 101). Inside of the x-ray tube are three main factors that play important roles in x-ray production: 1.) The cathode

2.) The anode

3.) The vacuum

The cathode and anode are basically the only components that help in the production of x-rays.

The cathode or also known as the fast-moving electrons is a negatively charged electrode that contains a focusing cup and a filament. The focusing cup is made of nickel or molybdenum and nearly surrounds the filament. It is open at one end to allow electrons to flow freely across the tube from the cathode to the anode. (Fauber, 2009, p. 15). It has a negative charge, which keeps the electrons emitted from the filament spreading apart. The focusing cups purpose is to focus the stream of fast-moving electrons. The filament is coil of wire (about 2mm diameter and 1 to 2cm long) that emits the electrons when it is heated. When the current through the filament is sufficiently high, the outer-shell electrons of the filament atoms are “ boiled off” and ejected. (Bushong, 2008, Ch. 7 p. 122). This is also referred to as thermionic emission.

The Anode

The positively charged electrode of the tube is called the anode. It consists of a stator, rotor, and a target. The stator is an electric motor that turns the rotor at very high speeds. These speeds range from 3, 000 to 10, 000 revolutions per minute (RPM). The rotor is rigidly connected to the target through the anode stem, causing the target to rotate rapidly during x-ray production. High Strength ball bearings in the rotor allow it to rotate smoothly at high speeds. (Fauber, 2009, p. 17). The last component of the anode is the target. The target is the " metal object" that is struck by the focused stream of electrons coming from the cathode. The target then stops the fast-moving electrons and thus creates the opportunity for the production of x-rays.

(Nave, 2006, http://hyperphysics. phyastr. gsu. edu/Hbase/quantum/xtube. html)

The Vacuum

Another contributing factor called a vacuum, which allows for more efficient x-ray production and longer tube life. However, if there is just a little gas is inside the tube, the electron flow from the cathode to the anode is reduced, fewer x-rays are produced, and more heat is generated. If there is too much gas, x-ray production falls and the tube can fail. (Bushong, 2008, Ch. 7 p. 122). This is why the radiographer needs to be aware of the amount of heat that is produced during x-ray production because excessive heat can damage the tube: and without the tube x-ray production cannot be created.

X-ray Interaction with Matter

If x-ray production falls, then x-rays cannot interact with matter. X-ray production and x-ray interaction with matter help to form an image. X-rays interact with matter in five different characteristics: 1.) Coherent Scattering

2.) Compton Effect

3.) Photoelectric Effect

4.) Pair Production 5.) Photodistegration

Only the Compton effect and the photoelectric effect are important in the process of creating an x-ray image.

Coherent Scattering

Coherent scattering is an interaction with low energy x-rays, below the diagnostic range. The incoming photon interacts with the atom causing it to become excited. Fauber (2009, Ch. 3 p. 49) has suggested that the x-ray doesn’t lose energy, but changes direction. Coherent scattering contributes very little to the x-ray image, and only a few percent undergo this type of scatter. Coherent scatter contributes slightly to the deterioration of the image, often referred to as image noise, the general graying of an image that reduces image contrast. Most coherent scattered x-rays are emitted in a forward direction. Coherent scattering is a small importance to creating an x-ray image. However, if these scattered photons are absorbed within the tissue, they do contribute to the radiation exposure to the patient.

Compton Effect

The Compton effect can occur in all x-ray energies and are very important interaction with matter. When scattered x-rays interact with an outer-shell electron, the electron is thrown or ejected from the atom and the atom becomes ionized. The electron that was ejected is called a secondary electron. With the secondary electron ejected the x-ray scatter continues in a different direction with less energy then it started out with. During a Compton interaction the scattered x-ray and secondary electron have divided the energy between them, but usually the scattered x-ray maintains most of it. Eventually both lose all their energy and the scattered x-ray is absorbed photo electrically, while the secondary electron loses all of its energy through ionization and then falls into a vacancy in the electron shell created by a previous ionizing event. The purpose of the Compton effect is to reduce as much contrast on the x-ray image.

Photoelectric Effect

The photoelectric effect takes place when the incident x-ray is not scattered, but is totally absorbed during the ionization of an inner-shell electron. The incident photon disappears, and the k-shell electron; called a photoelectron is ejected from the atom. The x-ray image results from the difference between those x-rays that are absorbed by photoelectric interaction and those x-rays that are absorbed during ionization through the body as image-forming x-rays.

Pair production

Pair production is explained by Bushong (2008, Ch. 10 pg. 168) as an incident x-ray that has sufficient energy; it may escape interaction with electrons and come close enough to the nucleus of the atom to be influenced by the strong nuclear force field. This causes the x-ray to disappear between the nuclear field and x-ray, and in its place forms two electrons: a positron (positively charged) and one that is negatively charged. Pair production interacts with matter, but does not occur during x-ray imaging.

Photodistegration

The last characteristic of x-ray interaction with matter is Photodistegration, although it does not occur is diagnostic radiology. This process by which very high-energy x-rays (approximately reaching above 10 MeV) can escape interaction with electrons and the nuclear electric field, and can be absorbed directly by the nucleus. When this occurs the nucleus is raised to an excited state and instantly emits a nucleon or other nuclear fragments, which are released. (Bushong, 2008, Ch. 10 pg169).

Conclusion

In conclusion x-ray production and x-ray interaction with matter help to create an x-ray image. Without both basic concepts a simple image would not be possible. Two of the three components that make up the inside of an x-ray tube is: the cathode and anode, which are both important factors in x-ray production. Similar to the five ways an x-ray can interact with matter, only two are important to the formation: the Compton effect and the photoelectric effect. X-ray production and x-ray are different in so many

ways, also they go hand in hand, but without one the other does not exist and without either diagnostic imaging cannot occur.