X-Ray and Their Application in the Medical

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ABSTRACT

The aim of this work was to develop, implement and use a computational framework to study and address the major outstanding issues in digital chest imaging in order to expedite its introduction into routine clinical use.The information about X-rays and how they are produced are discussed, as well as some applications of X-rays in medicine, as well as their risks and how to prevent them. This was done in the first chapter of this research.As for the second chapter, the chest area and its sections (heart, lungs, diaphragm, middle) were selected, and multiple samples (X-ray images) were selected for each organ, and some information that contributes to creating a work environment was identified. specified. also pointed out.In the third chapter, the previously reviewed samples are discussed and explained in detail As well as reviewing the problems facing the technician and how to overcome them.

Keywords: X-Ray , applications , medicine , chest area

Introduction

On 28 December 1895, Wilhelm C Röntgen presented his paper „ Über eine neue Art von Strahlen" („ On a New Kind of Rays") to the Würzburg Physical Medical Society [1]

These rays had been labelled with the letter „x" to represent their unknown nature, which is understandable at a time when there was no knowledge of this strange radiation, and the nature and characteristics of radiation in general were not understood. The knowledge we have gained about x-rays belies the name, as we now possess extensive information about all aspects of x-rays. X-rays are a form of radiation or electromagnetic wave, as are radio waves and visible light. Electromagnetic waves are variations in the amplitude of energy in time and are classified according to the speed with which they fluctuate over time. This defines the concept of the wavelength,

the time taken by a wave to complete a full sequence. [2]

As a wave oscillates faster its wavelength becomes smaller and its frequency increases. More specifically, all electromagnetic waves lie in the electromagnetic spectrum, which is arranged by the wavelength or its equivalent, the frequency. X-rays lie above ultraviolet radiation, visible light and radio waves in the spectrum, and below cosmic radiation; they are a form of high energy radiation, with a high frequency and short wavelength. We now know that the best way to produce x-rays is by accelerating electrons, which produce the desired radiation on impact with a target made of a suitable substance. This process is performed inside a vacuum tube in which two electrodes are installed. A high electric potential is applied to the electrodes to accelerate electrons from the cathode which then impact on the anode, producing x-rays. All this is possible if there is a

system outside the tube controlling the process. This is similar to the conditions inside the tube of an old-fashioned TV screen, the cathode ray tube (the generation of electrons, the application of a high voltage, and the screen as the target), in which small amounts of x-rays are produced

1-1 The main components of an x-ray unit are [3]

1. A source of electron (a filament)
2. An evacuated space in which to speed up the electrons
3. A high positive potential to accelerate the negative electron
4. A target (anode) which the electrons strike to produce xray

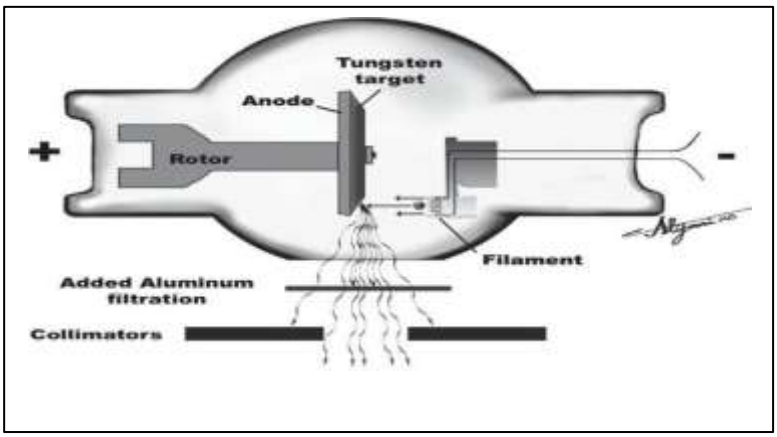


Figure (1-1) represents the components of the x-ray unit

1-2 X-ray Generation

A classical X-ray tube is depicted in Fig. 2 . An X-ray tube is basically an evacuated tube made of glass with a cathode and a solid metal anode in it.

Thermionic emission occurs by the heated filament at the cathode. Heat induced electrons e− are produced because the thermal energy applied to the filament material is larger than its binding energy. Then, the electrons are accelerated by the tube‟s acceleration voltage between the negative cathode and the positive anode. When those fast electrons hit the anode, they are decelerated and deflected by the electric field of the atoms of the anode material. Any acceleration of loaded particles results in electromagnetic waves. So does the slowing down., the negative

acceleration, of the electrons in the metal anode. It generates X-rays. [4]

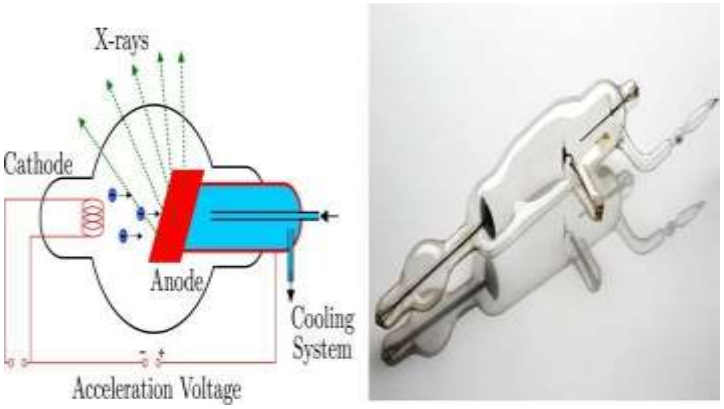


Figure 1-2 Vacuum X-ray tube: The image on the left shows a schematic how electrons are accelerated from the cathode to the anode to genereate X-ray photons. The image on the right shows a historic vacuum X-ray tube. Image provided by Science Museum, London, Wellcome Images under Creative Commons by-nc-nd 2.0 UK The anode is tilted by a certain angle to

direct the emerging. [5]

X-rays in the right direction. Typically each electron is slowed down or deflected several times so it causes the creation of several photons. However it can also happen that an electron loses all its velocity and thus its energy in one step. In this case, only one photon containing the complete energy of the electron is created. [6]

The production of X-rays is caused by two different processes as shown in Fig. 7.8. First, if the electron interacts with an inner-shell electron of the target, characteristic X-radiation can be produced. This kind of X- rays results from a sufficiently strong interaction that ionizes the target atom by a total removal of the inner-shell electron. The resulting "hole" in the inner-shell is filled with an outer-shell electron. The transition of an orbital electron from an outer-shell to an inner-shell is accompanied by the emission of an X-ray photon, with an energy equal to the difference in the binding energies of the orbital electrons involved. Therefore, the characteristic radiation produces a line spectrum, or discrete spectrum. Obviously, this kind of radiation is material dependent. Both the production of characteristic X-rays as well as thermal energy involve interactions

between the accelerated electrons and the electrons of the target material. [7]

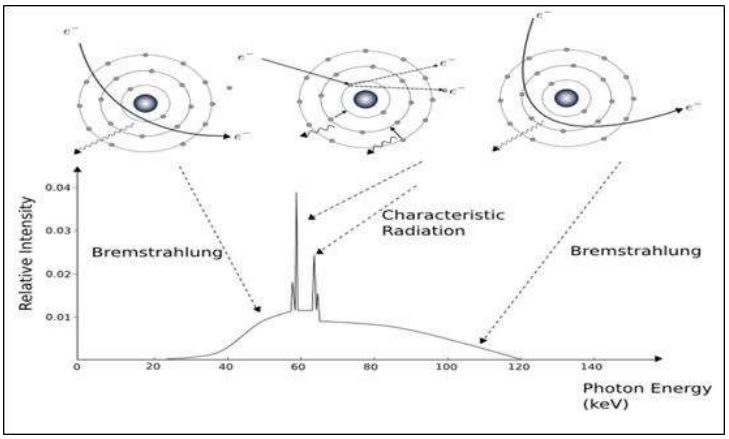


Figure 1-3 X-ray spectrum of a tungsten tube. The peaks correspond to the characteristic radiation; the continuous part of the spectrum represents the Bremsstrahlung.

Another type of interaction in which the electron can lose its kinetic energy delivers the second process of X-ray production, caused by the

interaction of the electron with the nucleus of a target atom. As the colliding electron passes by the nucleus of an anode atom, it is slowed down and deviated in its course, leaving with reduced kinetic energy in a different direction. This loss in kinetic energy reappears as an X-ray photon. This type of X-rays is called Bremsstrahlung, where "bremsen" is the German verb for slowing down. The amount of kinetic energy that is lost in this way can vary from zero to the total incident energy. While the characteristic radiation results in a discrete X-ray spectrum of characteristic peaks, the Bremsstrahlung provides a continuous spectrum. The number of X-rays emitted decreases rapidly at very low photon energies. The spectrum of a tungsten source is given in Fig. 3. In medical imaging, very low energies of an X-ray spectrum are typically removed prior to an interaction with the patient by using a thin metal plate which is placed between the patient and the X-ray source. The reason for this is that almost all of the low energy photons would be absorbed by the patient, thus, leading to an increased patient dose without a substantial improvement of image quality. The metallic plate is also called X-ray filter, which is not to

be confused with the mathematical filters used for image processing [8]

1-3 X-ray Imaging

1-3-1 Image Intensifiers

Unlike the old X-ray films, which use X-rays directly to change the chemical properties of the X-ray film material, the modern detection systems first convert the X-rays to light and eventually to electrons.

X-ray image intensifiers are vacuum tubes that are used to convert X-rays into visible light, an image. The schematic principle of this process is shown in Fig. 4. First, the incoming X-ray photons are converted to light

photons using a phosphorus material called the input phosphor. The produced light is further converted to electrons by exploiting the photoelectric effect inside a photocathode. These electrons are then accelerated and focused towards the output phosphor using an electron optic system. In the output phosphor, the electrons are converted back to visible light which can then be captured by film material or television

camera tubes. [9]

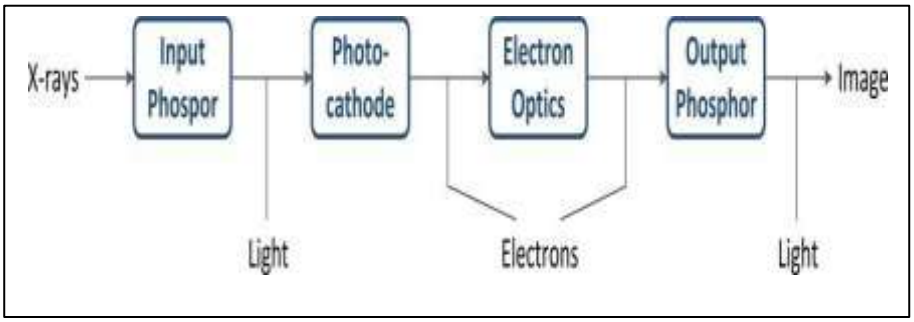


Figure 1.4 Schematic principle of an image intensifier detector. The X-rays are first converted to light, which is converted to electrons. An optic accelerates the electrons towards a fluorescent screen which converts the electrons to light, which eventually results in an image.

1-3-2 Flat Panel Detectors

In the recent years, flat panel detector (FPD) became the state-of-the-art in X-ray detector technology for radiography, angiography, and C-arm CT applications. They were first introduced in the mid 1990s and their main advantages are a direct digital readout of the X-

ray image and an increased spatial resolution. Flat panel detectors can be categorized into direct and indirectly conversion FPDs. . [10]

1-3-3 Indirect Conversion FPDs

Similar to the image intensifier system discussed in the previous section, the FPD still converts X-rays to light photons by using a layer of cesium iodide (CsI). Also the tubular structure of the CsI is identical to the input layer of an image intensifier system as shown in Fig. 7.14. The major difference are the subsequent detection steps. Image intensifiers make use of a further conversion of light photons to electrons which are then accelerated to increase and control illumination. This additional conversion step is not necessary for flat panel detectors. Instead a matrix of photodiodes is directly attached to the CsI layer and converts the emitted light photons to an electric charge which is then stored in capacitors for each pixel. Each pixel also contains a thin-film transistor (TFT) which acts as small "switch" used

for the readout of the stored charges. [11]

1-3-4 Direct Conversion FPDs

Instead of an explicit conversion to light photons, direct conversion FPDs have a homogeneous layer of X-ray sensitive photoconducters on the TFT matrix. The top layer is a high-voltage bias electrode that builds an electric field across the photoconductor. If X-rays are absorbed by the photoconductor, so called charge-carriers are released, electron-hole pairs. These pairs are then separated to negative and positive charges and transported to the pixel‟s electrodes by the global electric field. Positive charges travel to the bottom of the individual pixel electrodes where they are stored in capacitors [12]

1-4 some uses of X-rays:

- Any region of the body can be scanned: brain, neck, abdomen, pelvis and limbs.
- Staging primary tumours such as colon and lung for secondary spread, to determine operability or a baseline for chemotherapy.
- Radiotherapy planning.
- successful.
- Vascular anatomy such as coronary arteries

1-5 X-ray Applications

1-5-1 Radiography

Radiography describes the process of creating two dimensional projection images by exposing an anatomy of interest to X-rays and measuring the attenuation they undergo when passing through the object. It is a very common form of X-ray imaging and is used in clinics around the globe.

The main application area is the examination of fractures and changes of the skeletal system. Here, the high attenuation coefficient of bones compared to the surrounding tissue delivers a good contrast and allows for distinct detection and classification of fractures. Moreover, radiography can be used to detect changes of a bone‟s consistency or density, e. g., in case of osteoporosis or bone cancer. In Fig. 5, two X-ray images of an arm with fractures of Ulna and Radius bones are shown on the left. Furthermore, the Sample shows a color image taken from the arm after intervention and also two further X-ray images of the treated arm where the bones have been

internally fixated using metal plates [13]

Figure 1-5: Arm showing fractures in radiographic images, the corresponding color image after surgery and the radiographic images after fixation of the bones using metal rods

1-5-2 Fluoroscopy

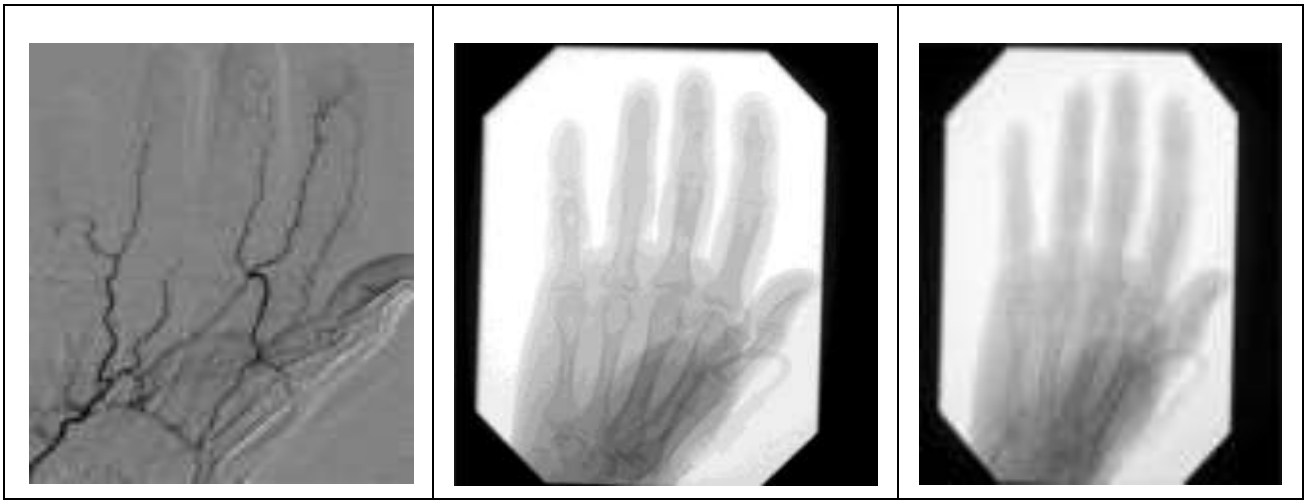
Conventional radiography typically refers to the acquisition of a single or small number of X-ray projection images for a specified view. In contrast, fluoroscopy describes a sequence of radiographic images acquired periodically at a certain frame rate. The X-ray source can either be triggered for each frame or simply provide a constant radiation exposure to the region of interest. Potential X-ray detectors can be image intensifiersor the newer FPDs. The frame rate is typically limited by the acquisition speed of the detection system. For image intensifiers, it is given by the inertia of the final fluorescent screen, whereas for FPDs it is determined by the speed of the electronic detector readout step. In practice, frame rates of

30 frames per second are possible. However, rates are often reduced for dose reasons **[14]**

1-5-3 Digital Subtraction Angiography

Angiography refers to the imaging of arteries (venography for veins) to analyze properties such as shape, size, lumen, or flow rate. Usually, the attenuation properties of vessels do not substantially differ from that of the surrounding tissue which makes X-ray-based imaging hard and yields poor contrast.To increase image quality and contrast often contrast agent is injected into the blood circulation. Contrast agent is a liquid that provides an increased attenuation coefficient compared to normal soft tissue. Typical contrast media are iodine and examinations. Thus, iodine is injected into the blood circulation whereas barium can be swallowed to investigate, the

stomach or colon. [15]



a b c

Figure 1-6 Process of creating a DSA. In (a) the hand was imaged and no contrast agent has been injected (mask image). In (b) the same hand has been imaged but including

injected contrast agent. The difference of (b) and (a) represents the angiogram as shown in Fig (c). Images provided by

Adam Galant, Siemens Healthineers AG.In DSA, a fluroscopic sequence of a fixed anatomy is acquired. At the same time contrast agent is injected in regular intervals into the vessel system. X-ray images that have acquired the scene without contrast agent are assumed to show the background tissue that is typically not of interest. If we now subtract the initially acquired background image from an X-ray image with contrast and assume that no patient motion has taken place, we can measure the attenuation caused only by the injected contrast agent. As the contrast agent is limited to the vessel system, it has been injected to, the outcome of such a subtraction will be a visualization of the vessels only. In Fig. 6, an example for a DSA acquisition is presented. First the contrast agent free image, i. e., the mask image, is acquired as shown in Fig. 6(a). Then contrast is injected into the vascular system and after some waiting a further image, the fill image, is acquired. The difference of both images is then the so the contrast agent

and thus the vessels are visualized (c f. Fig 6) [16]

1-6 Risks

As in many aspects of medicine, there are risks associated with the use of X-ray imaging, which uses ionizing radiation to generate images of the body. Ionizing radiation is a form of radiation that has enough energy to potentially cause damage to DNA. Risks from exposure to ionizing radiation include [17]

- a small increase in the possibility that a person exposed to X-rays will develop cancer later in life.
- tissue effects such as cataracts, skin reddening, and hair loss, which occur at relatively high levels of radiation exposure and are rare for - many types of imaging exams. For example, the typical use of a CT

scanner or conventional radiography equipment should not result in tissue effects, but the dose to the skin from some long, complex interventional fluoroscopy procedures might, in some circumstances, be high enough to result in such effects.

- Another risk of X-ray imaging is possible reactions associated with an intravenously injected contrast agent, or "dye", that is sometimes used to improve visualization.

- The risk of developing cancer from medical imaging radiation exposure is generally very small, and it depends on:

- radiation dose - The lifetime risk of cancer increases the larger the dose and the more X-ray exams a patient undergoes.

- patient‟s age - The lifetime risk of cancer is larger for a patient who receives X-rays at a younger age than for one who receives them at an older age.

- patient‟s sex - Women are at a somewhat higher lifetime risk than men for developing radiation-associated cancer after receiving the same exposures at the same ages.

- body region - Some organs are more radiosensitive than others

- The above statements are generalizations based on scientific analyses of large population data sets, such as survivors exposed to radiation from the atomic bomb. One of the reports of such analyses is Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII. While specific individuals or cases may not fit into such generalizations, they are still useful in developing an overall

approach to medical imaging radiation safety by identifying at-risk populations or higher-risk procedures.

- Because radiation risks are dependent on exposure to radiation, an awareness of the typical radiation exposures involved in different imaging exams is useful for communication between the physician and patient.

2-1 Introduction

Although everyone understands what one means when it is said to “get an x-ray”, or refers to the image on film as “an x-ray”, the proper term for an image on x-ray film is a radiograph. There are four densities on a radiograph. They are from black to white: gas, fat, water and mineral. Gas, of course, is self-explanatory and includes air in the lungs and upper airway, gas in the intestines, and gas such as nitrogen in so called vacuum spaces. It becomes black on a radiograph because there are few molecules to stop or attenuate the x-ray beam as it passes through the body to darken the film. It won‟t take the student or practitioner long to recognize normal gas patterns on a radiograph, and as we start to program the computer that we call a brain between his or her ears, the student will begin to use pattern recognition as a means to correct interpretation.

Fat, on the other hand, is just a shade or two lighter than gas, a dark gray, and becomes important in specific locations, as we‟ll see later. Water density tissue makes up the majority of body parts and includes muscle and organs. Since we‟ve all been made aware that the body is made up of 70+% water, it is no surprise to find it usually comprises most of the volume seen on a radiograph of, for instance, the abdomen in a healthy individual. Although water density tissue varies in its density even on plain film radiographs, it has a uniform appearance when compared to the other three densities of gas, fat and mineral. It is a lighter shade of gray than fat, but not as white as the mineral seen in bone or the really white appearance of metal, such as seen in an ingested foreign body like a coin. Now that you have the basics of the four densities down, let‟s review them on an actual radiograph. In Sample 1 we have appropriately labeled the four densities on a plain film of the abdomen.

A system that is useful for interpretation of chest radiographs includes evaluation of the lungs, heart, mediastinum, diaphragm and bony thorax. S. K. Imes, MD, a solid teacher and a product To that system I would add 1) the corners of the film and 2) a check of the labels. I also routinely check the medial ends of the clavicles when there are prior studies to compare. This is done not particularly to look for pathology, although occasionally abnormalities are seen, but because the clavicles are the "fingerprints" of the chest radiograph. I can't tell you how many times I've caught another person's chest film in the wrong envelope by comparing the clavicles. Keep in mind my additions to the checklist, but memorize in some order the basic system

which is:

1. LUNGS
2. HEART
3. MEDIASTINUM
4. DIAPHRAGM

2-2 Description of the research samples

(Sample 1).diseased lung. Presented below is a section of normal lung as seen under the microscope.

Sample(2) :For radiologic-pathologic correlation a PA (posterior-anterior) view of a normal chest is presented in below.

Sample (2.) Photomicrograph of a section of lung in a patient with acute interstitial pneumonia. Red arrow shows beginning alveolar filling as well, which is what happens as the inflammation progresses. The black arrows show the invasion of the interstices by inflammatory cells. The green arrows point to small arteries. Courtesy of MedCenter One, Bismarck, N.Dak., Dept. of Pathology

Sample(3) : Photomicrograph of a patient with chronic or usual interstitial pneumonia.Note the increased amount of fibrosis (red arrow). The black arrows point to deposits of anthracosis. One would not be able to tell the difference from the acute phase on a chest radiograph unti comparison films showed the process to have not changed significantly over a period of time. Courtesy of MedCenter One, Bismarck, N.Dak., Dept. of Pathology

Sample(4) is a patient with this phenomenon.

Sample(5) patient with alveolar filling infiltrate in the right middle lobe. (posterior- anterior) view

Sample (6.) The hart :Approximate positions of the various chambers as seen on PA(posterior-anterior) view

Sample 7. Transverse cardiac diameter shown above by the black line is in error because it includes the cardiac fat pad. anterior view

Sample(8) The cause of the partial loss of the right heart border in the PA view of the chest above is not due to silhouetting. Experienced radiologists recognize this as an almost “Aunt Minnie”. in the lateral view

Sample 9. The Samples illustrate some of the common normal and abnormal bulges we encounter in daily practice. . anterior view

Sample(10). Mass distorting the normal contour of the left side of the mediastinum (blue arrows) proved to be a nonHodgkin‟s lymphoma in a 26- year-old male. The vertical stripes over the right side of the chest are computer or scanner artifacts

Sample(11) . Blue outlined arrows point to a gas filled structure superimposing the left heart border in the PA projection and seen to be anterior in the lateral projection. This is a classical presentation of a foramen of Morgagni hernia as confirmed in barium GI series in Sample

Sample (12) . Barium in the upper GI tract confirms a loop of bowel has herniated through the foramen of Morgagni

Sample 13 . location of Bochdalek hernia Reprinted with permission anterior view.

Samples 14 White -contrast in distal stomach Pink - herniated stomach Orange- spleen Red – aorta Yellow- kidneys Blue - rt. lobe of liver Green - gall bladder Turquoise- pancreas Lightning bolts- diaphragmatic crus

Samples 15 (right and below right) view . point to diaphragmatic calcifications in this patient with documented asbestos exposure.

2-3. Causes of take X-Ray foe the samples:

It's about abnormal patterns in chest. only to give a few tips until (you are) able to consult with a diagnostic radiologist on any given case.

2-4. Work environment

When x-rays were performed, self-protection and the protection of the department's workers, colleagues and nursing staff, were taken into consideration.

The door of the x-ray room was locked and it was ensured that all those in it, except the patient, got out and stood behind the lead barrier while exposing the patient to radiation. And when urgently needed, they are dressed in a protective shield from the rays.

Also accompanying the patient was isolated outside the room at the time of the x- ray.

The TLD is a special device for measuring the amount of radiation to which a worker in the X-ray department is exposed.

Only what was needed and nothing more was photographed.

Any woman of gestational age was asked about the possibility of pregnancy and the treatment of this according to hospital policy.

Reduce the return of images to the patient by taking a high-quality image the first time.

Explain how the x-rays will be done in a very brief way for the patient, as he does not know what to expect or what will happen, then he must be reassured. This leads to patient cooperation and this in turn will improve the quality of the image, reducing the possibility of it being returned.

Determining the exposure factors and making them as few as possible to make an accurate diagnosis. Here, care must be taken not to reduce exposure factors too much, as this leads to poor quality images.

And the energy ranges from 124 electron volts to 124 kiloelectron volts.

2-5 Steps to take a picture of the patient:

A picture showing the steps for taking an x-ray of the patient, to the chest.

Figure 2-1: showing the steps for taking an x-ray of the patient, for the chest

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