بسم الله الرحمن الرحيم

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Effect of KVp in Digital Image Quality

تأثير جهد الأنبوب علي جودة الصورة الرقمية

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Of Master degree in Medical Physics

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الأيـــة

قال تعالي :

(اللَّهُ نَزَّلَ أَحْسَنَ الْحَدِيثِ كِتَابًا مُتَشَابِهًا مَثَانِيَ تَقْشَعِرُّ مِنْهُ جُلُودُ الَّذِينَ يَخْشَوْنَ رَبَّهُمْ ثُمَّ تَلِينُ جُلُودُهُمْوَقُلُوبُهُمْ إِلَىٰ ذِكْرِ اللَّهِ ذَٰلِكَ هُدَى اللَّهِ يَهْدِي بِهِ مَنْ يَشَاءُ وَمَنْ يُضْلِلِ اللَّهُ فَمَا لَهُ مِنْ هَادٍ)

صدق الله العظيم

الزمر 23

Dedication

To: My parent for their patience and Encouragement My brothers, sisters and teachers for their help and support My friends For their valuable supports I dedicate this work .

Acknowledgements

First and foremost, I would like to express my deepest gratitude to Dr. Husain Ahmed, without his help this work could not have been accomplished .

My thanks also go to Medical Modern Center.

Deep thanks to my family for their consistent mental support.

Abstract

This research aimed to evaluate the effect of KVp in digital image quality ,this study was conducted it the modern medical center , before the date collection peocess has calibrated x_ray devices .
The Tube voltage (KVp) reduction results in a parallel increase in film contrast that can improve image quality. 8 phantom images were scanned with the tube voltage varied between 43 and 120 KVp, and the mAs adjusted to maintain a constant exposure level between 1.25 and 160 mAs. At a constant x-ray tube voltage, the surface dose and energy imparted were directly proportional to the input exposure, the result indicating that decreasing the kilovoltage will improve image quality by improving the contrast, the image contrast substantially increased with low tube voltage. However, with identical dose, use of 60 kV and 40 mAs resulted in higher contrast compared with Contrast at 105 kV and 2.5 mAs.
The main finding of the study was there is no relation between kv_p increasing and contrast , D_{max} , D_{min} . This finding is due to possibility of monpulatit density and contrast in digital image , and it's not like film screen system where the density and contrast were control mainly by kvp .this image quality also was evaluated by visual perception by questionnaire 50 professional radiologist were asked to evaluate the image quality , the result showed that 34% of from the asked group evaluated the image in the range of better resolution , 28% of from the asked group evaluated the image in the range of acceptable resolution , 38% of from the asked group evaluated the image in the range of poor resolution , were 34% of from the asked group evaluated the image in the range of better resolution , were 62% from asked group evaluated the image in the range of better contrast ,24% of from the asked group evaluated the image in the range of acceptable contrast , 14% from the asked group evaluated the image in the range of poor contrast ,the final result were find that no fixed relationship between increasing KV_p and contrast .

الملخص

تهدف هذة الدراسة لتقييم تأثير جهد الأنبوب على جودة الصورة الرقمية ,ولقد أجريت هذه الدراسة في المركز الطبي الحديث , وقبل عملية جمع البيانات تمت معايرة أجهزة الأشعة السينية .

جهد الانبوب يقل مع زيادة تباين الفيلم وهذا يحسن من جودة الصورة .و تم تقييم جودة الصورة الإشعاعية عن طريق أخذ ثمانيه صور بالفانتوم بجهد أنبوب يتراوح بين43 و 120 وقيمة تيار تتراوح بين 1.25و160 وتم تثبيت انبوب الأشعة السينية.وكانت الجرعة السطحية والطاقة المنقولة يتناسبان طردياً مع التعرض الداخل والنتيجة تشير الى ان انخفاض الجهد يحسن من جودة الصورة والتباين، وتباين الصورة يزيد بصورة ملحوظة مع انخفاض الجهد. ومع ذلك في الجرعة المماثلة يستخدم جهد بمقدار (60 KV) وتيار بمقدار (40 mA) في التباين العالي مقارنة مع التباين عند (150 KV) و (2.5 mA).

النتائج النهائية لهذة الدراسة تشير الى لا توجد علاقة ثابته بين KV والتباين D_{max} و D_{min} وهذة النتائج بسبب إمكانية تحسين الكثافة والتباين في الصورة الرقمية وعدم وجود ذلك في نظام الافلام.

تم ايجاد الكثافة البصرية للصور لتقيم الجودة من حيث تباين ودقة ووضوح الصورة الإشعاعية بالإستبيان والتقييم البصري ,حيث تم إستبيان 50 خبير مختص في مجال الأشعة التشخيصية لتقييم جودة الصورة, وكانت نتيجة الإستبيان كالأتي % 34 من المجموعة قيمت الصور بدرجة وضوح عالية , % 28 من المجموعة قيمت الصور بدرجة وضوح مقبولة , و % 38من المجموعة قيمت الصور بدرجة وضوح منخفضة, و % 62 من المجموعة قيمت الصور بدرجة تباين عالية , و % 24

من المجموعة قيمت الصور بدرجة تباين مقبولة , و % 14من المجموعة قيمت الصور بدرجة تباين منخفضة , أثبتت النتائج النهائية عدم وجود علاقة (ثابتة) بين زيادة الجهد والتباين .

Contents

List of tables

List of figures

List of Abbreviations

KVp	Kilovoltage peak
mAs	Milli ampere second
Hz	Hertz
keV	Kilo electron volt
UV	Ultravilot
ADCs	Analog-to-Digital Converters

Chapter one

Introduction

1.1. Introduction:

Ionizing (or ionising) radiation is radiation that carries enough energy to liberate electrons from atoms or molecules, thereby ionizing them. Ionizing radiation comprises subatomic particles, ions or atoms moving at relativistic speeds, and electromagnetic waves on the short wavelength end of the electromagnetic spectrum. Gamma rays, X-rays, and the upper vacuum ultraviolet part of the ultraviolet spectrum are ionizing, whereas the lower ultraviolet, visible light (including laser light), infrared, microwaves, and radio waves are considered non-ionizing radiation. The boundary is not sharply defined, since different molecules and atoms ionize at different energies. Typical particles include alpha particles, beta particles and neutrons, as well as mesons that constitute cosmic rays. Ionizing radiation arises from a variety of sources, such as bombardment of the Earth by cosmic rays, the decay of radioactive materials, matter at extremely high temperatures (e.g. plasma discharge or the corona of the Sun), or acceleration of charged particles by electromagnetic fields (e.g. lightning or supernova explosions). Ionizing radiation can also be generated by the production of high energy particles in X-ray tubes and particle accelerators. Ionizing radiation is invisible and not directly detectable by human senses, so radiation detection instruments such as Geiger counters are required (Gayle,1997).

However, in some cases ionizing radiation may lead to secondary emission of visible light upon interaction with matter, such as in Cherenkov radiation and radio luminescence.It is applied in a wide variety of fields such as medicine, research, manufacturing, construction, and many other areas, but presents a health hazard if proper measures against undesired exposure aren't followed.

Exposure to ionizing radiation causes damage to living tissue, and can result in mutation, radiation sickness, cancer, and death. Peak kilovoltage (kVp) is the maximum voltage applied across an X-ray tube. It determines the kinetic energy of the electrons accelerated in the X-ray tube and the peak energy of the X-ray emission spectrum. The actual voltage across the tube may fluctuate. kVp controls the resulting photographic property known as "radiographic contrast" of an x-ray image (the amount of difference between the black/whites). Each body part contains a certain type of cellular composition which requires an x-ray beam with a certain kVp to penetrate it. The body part is said to have "subject contrast" (that is, different cellular make up: some dense, some not so dense tissues all within a specific body part). For example: bone to muscle to air ratios in the abdomen differs from that of the chest area. So the subject contrast is said to be higher in the chest than in the abdomen. In order to image the body so that the maximum information will result, higher subject contrast areas require a higher kVp so as to result in a low radiographic contrast image and vice versa. Although milliampere second (mAs) is the primary controlling factor of radiographic density, kVp also affects the radiographic density in a roundabout way. As the energy (kVp) of the stream of electrons in the x-ray tube increases, the more likely the x-ray photons created from those electrons will penetrate the cells of the body and reach the image receptor (film or plate), resulting in increased radiographic density (compared to lower energy beams that may be absorbed in the body on their way to the Image Receptor) (Gayle,1997).

However, "scatter radiation" also contributes to increased radiographic density; in that, the higher the kVp of the beam, the more scatter will be produced. Scatter is unwanted density (that is, density created without bringing any pertinent information to the image receptor). This is why kVp is not primarily

used to control density - as the density resulting from increasing kVp passes what is needed to penetrate a part, it will only add useless information to the image. Increasing mAs causes more photons (radiation) of the particular kVp energy, to be produced. This is helpful when larger parts are imaged, because they require more photons. The more photons you can get to pass through a particular tissue type (whose kVp is interacting at the cellular level) will result in a statistically increased amount of photons reaching the image receptor. The more photons that pass through a part, and reach the image receptor with pertinent information - the more useful the density is created on the resulting image. Conversely, lower mAs creates less photons, which will decrease density, but is helpful when you image smaller parts. Effect of Changing X-ray Tube Voltage (kV) In screen film radiography, the choice of x-ray tube voltage (kV) affected the image contrast; this is no longer the case for any digital radiographic system. (Gayle,1997)

1.2. Objectives:

1.2.1. General objectives:

The main objective of the study is to determine how kvp effected on digital image quality.

1.2.2. Specific objectives:

To assess KVp affect on image quality.

To assess KVp effect on radiation patient dose.

To evaluate effect contrast.

To evaluate effect of KVp of image resolution.

1.3. Problem of study:

Exposure factor especially the KVp has high effect on image quality, by increase and decrease the contrast of an image, and also KVp has effect on radiation dose to patient. In film screen radiography increase or decrease KVp will automatic affect on image, but in digital over and under exposure can manipulated this study aid to produce image quality with acceptable radiation dose.

1.4. Thesis layout:

This study falls into five chapters, Chapter one, which is an introduction , objectives of the study, Chapter two Literature review and theoretical back ground, Chapter three material and method, Chapter fours results, Chapter five discussions, conclusion , recommendations, references. And last appendix

Chapter two

literature Review

2.1 Radiation :

The propagation of energy from a radioactive source to another medium is termed radiation, This transmission of energy can take the form of particulate radiation or electromagnetic radiation (i.e., electromagnetic waves). The various forms of radiation originating from atoms, which include (among others) visible light, X-rays and g-rays, are grouped together under the terms “electromagnetic radiation” or “the electromagnetic Spectrum”.Radio waves,which have the longest wavelengths and thus the lowest frequencies and energies of the various types of electromagnetic radiation, are located at tone end of the electromagnetic spectrum, whereas X-rays and g-rays, which have the highest frequencies and energies, are situated at the other end of this spectrum. (James E. 2006).

2.1.1 x-ray

X-radiation is a form of electromagnetic radiation. Most X-rays have a wavelength in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3×1016 Hz to 3×1019 Hz) and energies in the range 100 eV to 100 keV. X-ray wavelengths are shorter than those of UV rays and typically longer than those of gamma rays. In many languages, X-radiation is referred to with terms meaning Röntgen radiation, after Wilhelm Röntgen, who is usually credited as its discoverer, and who had named it X-radiation to signify an unknown type of radiation (oxford university ,2005).

X-rays with photon energies above 5–10 keV (below 0.2–0.1 nm wavelength) are called hard X-rays, while those with lower energy are called soft X-rays due to their penetrating ability, hard X-rays are widely used to image the inside of objects, e.g., in medical radiography and airport security ,as a result the term X-ray is metonymically used to refer to a radiographic image produced using this method, in addition to the method itself, Since the wavelengths of hard X-rays are similar to the size of atoms they are also useful for determining crystal structures by X-ray crystallography by contrast, soft X-rays are easily absorbed in air and the attenuation length of 600 eV (~2 nm) X-rays in water is less than 1 micrometer.

There is no universal consensus for a definition distinguishing between X-rays and gamma rays ,one common practice is to distinguish between the two types of radiation based on their source: X-rays are emitted by electrons, while gamma rays are emitted by the atomic nucleus .

This definition has several problems; other processes also can generate these high energy photons, or sometimes the method of generation is not known. One common alternative is to distinguish X- and gamma radiation on the basis of wavelength (or equivalently, frequency or photon energy), with radiation shorter than some arbitrary wavelength, such as 10−11 m (0.1 Å), defined as gamma radiation.

This criterion assigns a photon to an unambiguous category, but is only possible if wavelength is known. (Some measurement techniques do not distinguish between detected wavelengths.) However, these two definitions often coincide since the electromagnetic radiation emitted by X-ray tubes generally has a longer wavelength and lower photon energy than the radiation emitted by radioactive nuclei. Occasionally, one term or the other is used in specific contexts due to historical precedent, based on measurement (detection) technique, or based on their intended use rather than their wavelength or source. Thus, gamma-rays generated for medical and industrial uses, for example radiotherapy, in the ranges of 6–20 MeV, can in this context also be referred to as X-rays (gayle , 1997) .

2.2 Interactions of Ionizing Radiation :

When an x- ray beam passes through a medium, interaction between photons and matter can take place with the result that energy is transferred to the medium. The initial step in the energy transfer involves the ejection of electrons from the atoms of the absorbing medium. These high-speed electrons transfer their energy by producing ionization and excitation of the atoms along their paths. If the absorbing medium consists of body tissues, sufficient energy may be deposited within the cells, destroying their reproductive capacity. However, most of the absorbed energy is converted into heat, producing no biologic effect.

2.2.1 Interaction photon with matter :

When traversing matter, photons will penetrate, scatter, or be absorbed. There are four major types of interactions of x- and gamma-ray photons with matter, the first three of which playa role in diagnostic radiology and nuclear medicine: (a) Compton scattering, (b) photoelectric absorption, and (c) pair production (bushber et al.,2002) .

2.2.1.1 Compton scatter :

Compton scattering (also called inelastic or nonclassical scattering) is the predominant interaction of x-ray and gamma-ray photons in the diagnostic energy range with soft tissue. In fact, Compton scattering not only predominates in the diagnostic energy range above 26 keY in soft tissue, but continues to predominate well beyond diagnostic energies to approximately 30 MeY. This interaction is most likely to occur between photons and outer ("valence") shell electrons (Fig. 2.1). The electron is ejected from the atom, and the photon is scattered with some reduction in energy. As with all types of interactions, both energy and momentum must be conserved.

Thus the energy of the incident photon (Eo) is equal to the sum of the energy of the scattered photon (Ese) and the kinetic energy of the ejected electron (Ee-), as shown in Equation . The binding energy of the electron that was ejected is comparatively small and can be ignored.

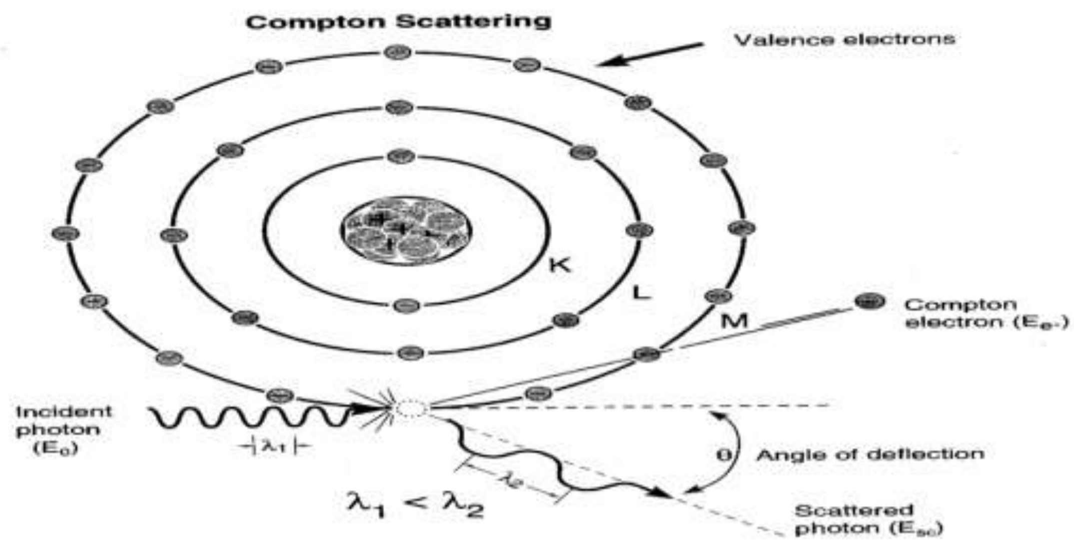


Figure 2.1 show Compton scattering(Bushber et al.,2002)

Compton scattering results in the ionization of the atom and a division of the incident photon energy between the scattered photon and ejected electron. The ejected electron will lose its kinetic energy via excitation and ionization of atoms in the surrounding material. The Compton scattered photon may traverse the medium without interaction or may undergo subsequent interactions such as Compton scattering, photoelectric absorption (to be discussed shortly) (Bushber et al.,2002) .

2.2.1.2 Photoelectric effect :

In the photoelectric effect, all of the incident photon energy is transferred to an electron, which is ejected from the atom. The kinetic energy of the ejected photo- electron (Ee) is equal to the incident photon energy (Eo) minus the binding energy of the orbital electron (Eb) .

In order for photoelectric absorption to occur, the incident photon energy must be greater than or equal to the binding energy of the electron that is ejected.

The ejected electron is most likely one whose binding energy is closest to, but less than, the incident photon energy. For example, for photons whose energies exceed the K-shell binding energy, photoelectric interactions with K-shell elec- trons are most probable. Following a photoelectric interaction, the atom is ionized, with an inner shell electron vacancy. This vacancy will be filled by an electron from a shell with a lower binding energy. This creates another vacancy, which, in turn, is filled by an electron from an even lower binding energy shell.

Thus, an electron cascade from outer to inner shells occurs. The difference in binding energy is released as either characteristic x-rays or auger electrons . The probability of characteristic x-ray emission decreases as the atomic number of the absorber decreases and thus does not occur frequently for diagnostic energy photon interactions in soft tissue.

The probability of photoelectric absorption per unit mass is approximately proportional to Z3/E3, where Z is the atomic number and

E is the energy of the inci-dent photon. For example, the photoelectric interaction probability in iodine (Z =53) is (53/20)3 or 18.6 times greater than in calcium (Z = 20) for photon of a particular energy.

The benefit of photoelectric absorption in x-ray transmission imaging is that there are no additional nonprimary photons to degrade the image. The fact that the probability of photoelectric interaction is proportional to 1/E3 explains, in part, why image contrast decreases when higher x-ray energies are used in the imaging process .

Although the probability of the photoelectric effect decreases, in general, with increasing photon energy, there is an exception. For every element, a graph of the probability of the photoelectric effect, as a function of photon energy, exhibits sharp discontinuities called absorption edges .

The probability of interaction for photons of energy just above an absorption edge is much greater than that of photons of energy slightly below the edge. For example, a 33.2-keV x-ray photon is about six times as likely to have a photoelectric interaction with an iodine atom as a 33.1-keV photon. (Bushber et al.,2002)

2.2.1.3 Pair production

Pair production can only occur when the energies of x- and gamma rays exceed 1.02 MeV In pair production, an x- or gamma ray interacts with the electric field of the nucleus of an atom. The photon's energy is transformed into an electron-positron pair . The rest mass energy equivalent of each electron is 0.511 MeV and this is why the energy threshold for this reaction is 1.02 MeV. Photon energy in excess of this threshold is imparted to the electrons as kinetic energy. The electron and positron lose their kinetic energy via excitation and ionization. As discussed previously, when the positron comes to rest, it interacts with a negatively charged electron, resulting in the formation of two oppositely directed 0.511 MeV annihilation photons .

Pair production is of no consequence in diagnostic x-ray imaging because of the extremely high energies required for it to occur. In fact, pair production does not become significant unless the photon energies greatly exceed the 1.02 MeV energy threshold.

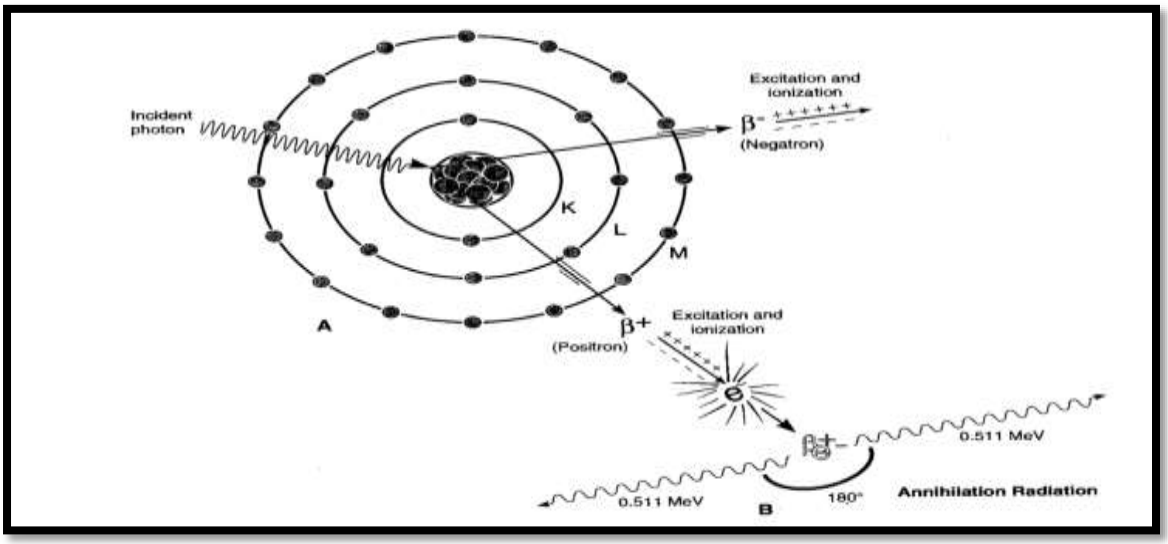


figure 2.2 show Pair Production(Bushber et al.,2002)

2.3 X-ray production

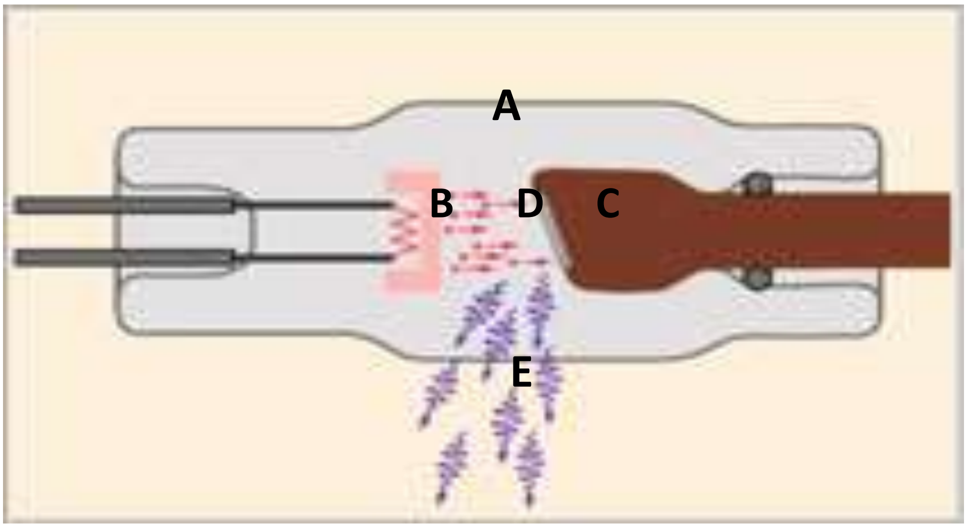


Fig. 2.3. X-ray tube. The vacuum tube (A) houses cathode (B) and anode (C). A current heats up the filament, releasing electrons (D), which are accelerated towards the anode. Interacting with either the nucleus or the shell of the target material, Bremsstrahlung and characteristic radiation are released (E), respectively

X-radiation is created by taking energy from electrons and converting it into photons with appropriate energies. This energy conversion takes place within the x-ray tube. The quantity (exposure) and quality (spectrum) of the x-radiation produced can be controlled by adjusting the electrical quantities (KV, MA) and exposure time, S, applied to the tube. In this chapter we first become familiar with the design and construction of x-ray tubes, then look at the x-ray production process, and conclude by reviewing the quantitative aspects of x-ray production.

The x-ray efficacy of the x-ray tube is defined as the amount of exposure, in milliroentgens, delivered to a point in the center of the useful x-ray beam at a distance of 1 m from the focal spot for 1 mAs of electrons passing through the tube.

2.4 X-ray tube

The x ray tube consists of an evacuated glass envelope with in which is the anode at one end and the cathode at the other. Appositive potential on the anode with respect to the cathode allows electrons to travel from the cathode to the anode at high energy. When they are stopped x rays are produced .The filament is raised incandescence by a high filament current so as to produce a space charge of electrons around the filament by thermionic emission.

A dual –focus tube has two filaments attached to the cathode. The filament is made of tungsten the compound anode of stationery anode tube is constructed of copper with a tungsten insert. The main mechanism of heat loss from stationary anode tube is conduction whilst that from a rotating anode is radiation. A line focus is produced on the anode which is smaller than the size of the filament because of the focusing effect of the focusing cup on the electron beam an electrical induction motor is used to rotate the anode by means of rotating magnetic field which induces currents in the rotor. Electrical safety is insured by earthing all metal parts and radiation safety to the operators is insured by lead lining on the inside of the shield .Radiation dosage to the patient is reduced by the use of the smallest practicable field size and aluminum filters (W.R.Hendee 2002)

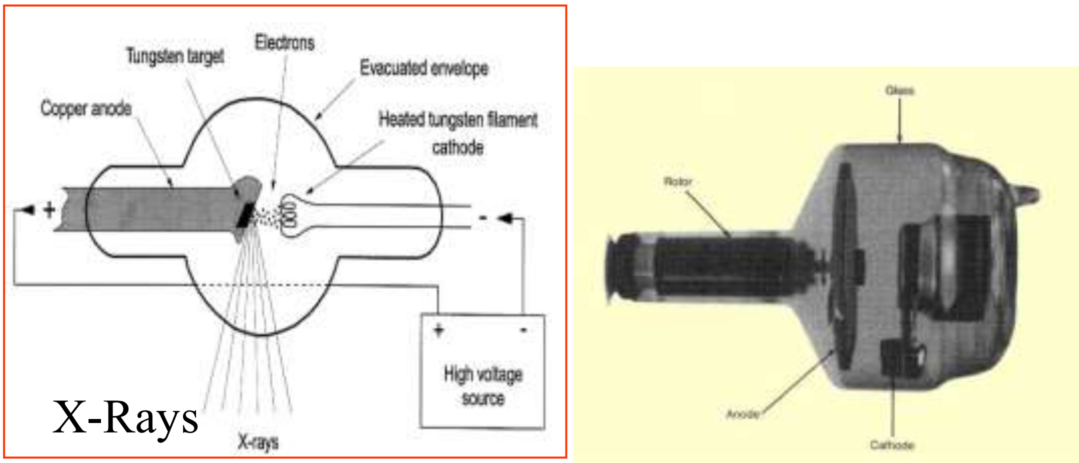


Fig 2.4 : X ray tube(Hendee 2002)

2.4 .1 Anode

The anode is the component in which the x-radiation is produced. It is a relatively large piece of metal that connects to the positive side of the electrical circuit. The anode has two primary functions: (1) to convert electronic energy into x-radiation, and (2) to dissipate the heat created in the process. The material for the anode is selected to enhance these functions.(Thomas,2004).

The ideal situation would be if most of the electrons created x-ray photons rather than heat. The fraction of the total electronic energy that is converted into x-radiation (efficiency) depends on two factors: the atomic number (Z) of the anode material and the energy of the electrons. Most x-ray tubes use tungsten, which has an atomic number of 74, as the anode material. In addition to a high atomic number, tungsten has several other characteristics that make it suited for this purpose. Tungsten is almost unique in its ability to maintain its strength at high temperatures, and it has a high melting point and a relatively low rate of evaporation. For many years, pure tungsten was used as the anode material. In recent years an alloy of tungsten and rhenium has been used as the target material but only for the surface of some anodes. The anode body under the tungsten-rhenium surface on many tubes is manufactured from a material that is relatively light and has good heat storage capability. Two such materials are molybdenum and graphite. The use of molybdenum as an anode base material should not be confused with its use as an anode surface material. Most x-ray tubes used for mammography have molybdenum-surface anodes. This material has an intermediate atomic number (Z = 42), which produces characteristic x-ray photons with energies well suited to this particular application. Some mammography tubes also have a second anode made of rhodium, which has an atomic number of 45. This produces a higher energy and more penetrating radiation, which can be used to image dense breast.The use of a rhenium-tungsten alloy improves the long-term radiation output of tubes. With x-ray tubes with pure tungsten anodes, radiation output is reduced with usage because of thermal damage to the surface. (Thomas,2004).

2.4 .2 Focal Spot:

Not all of the anode is involved in x-ray production. The radiation is produced in a very small area on the surface of the anode known as the focal spot. The dimensions of the focal spot are determined by the dimensions of the electron beam arriving from the cathode. In most x-ray tubes, the focal spot is approximately rectangular. The dimensions of focal spots usually range from 0.1 mm to 2 mm. X-ray tubes are designed to have specific focal spot sizes; small focal spots produce less blurring and better visibility of detail, and large focal spots have a greater heat-dissipating capacity.Focal spot size is one factor that must be considered when selecting an x-ray tube for a specific application. Tubes with small focal spots are used when high image visibility of detail is essential and the amount of radiation needed is relatively low because of small and thin body regions as in mammography. Most x-ray tubes have two focal spot sizes (small and large), which can be selected by the operator according to the imaging procedure(Thomas,2004).

2.4 .3 Cathode :

The basic function of the cathode is to expel the electrons from the electrical circuit and focus them into a well-defined beam aimed at the anode. The typical cathode consists of a small coil of wire (a filament) recessed within a cup-shaped region, as shown below(Thomas,2004)

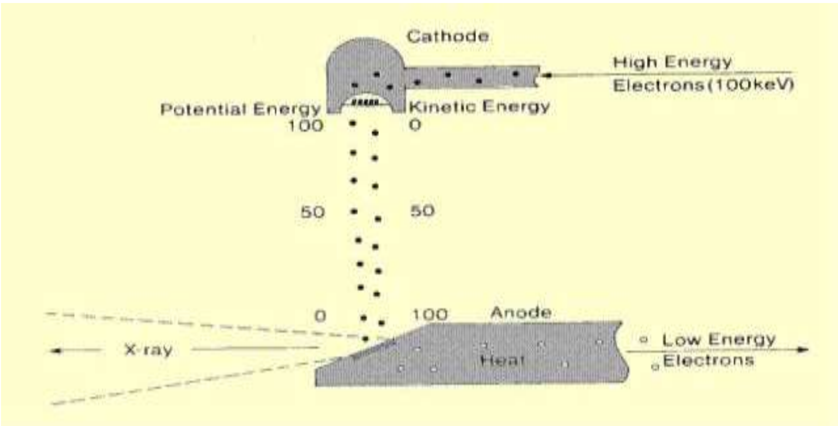


Fig 2.5. Energy Exchange within an X-Ray Tube(Thomas,2004)

2.5 Kilovoltage Effective on exposure:

kVp has the greatest effect on the radiographic image when all other factors remain constant. Because kVp is the factor that gives the rays their penetrating quality, it directly influences the quality of radiation reaching the film. This, in turn, determines the radiographic contrast and density. Kilovolt age is a major agent in the production of SR that must be controlled to prevent fogging on the film. Use of low kVp may result in images deficient in details; injudicious use of high kVp may result in fogged or high-density images in which details are obscured by excessive silver deposits and a degradation of contrast.kVp also has a limited effect on quantity of radiation. Because changing kVp varies the speed of the electrons, and therefore, the wavelength of radiation, an increase of kVp gives a corresponding increase in the number of diagnostic photons. Even though the major attribute of kVp is the variation in penetrating power kVp does affect, to a smaller degree, the quantity.

2.6. Kilovoltege and exposure latitude:

Exposure latitude varies with the kVp applied and is the range between minimum and maximum kVp that will produce a diagnostically acceptable scale of translucent densities. Exposure latitude is an important element in any standardized exposure system. Since "correct exposure" may be anyone within a fairly wide range if the kVp is adequate for thorough penetration, use of an optimum kVp is more likely to produce greater uniformity of radiographic results than would the use of relatively low variable kVp. A general rule is the longer the scale of radiographic contrast, the greater is the exposure latitude(Thomas,2004).

2.7. Influence of Kilovoltage:

The characteristics of primary radiation can be changed by kVp, with control of SR fog and favorable image quality. With the increase of kVp, the quantity of fog produced reaches a point where it exceeds many times the density produced by remnant radiation. This means that the desired image may be almost completely hidden because of the fog. The more the image is veiled by fog, the less detail is affected by factors that would normally alter it (Thomas,2004).

2.7.1. Over exposure:

When greater than necessary kVp is used, the overall density appears high with SR fog. The contrast scale is degraded and detail is obscured. Usually, a reduction of 10 to 20 kVp will correct the appearance. It may be necessary to adjust the mAs factor slightly. To avoid overexposure due to kVp (Thomas,2004).

2.7.2. Under exposure:

Use of inadequate kVp is characterized by blank, transparent areas without silver deposit and other areas having high densities--few intermediate tones of density are present. An increase of 15 to 20 kVp will usually produce sufficient penetrating radiation to obtain the necessary detail, provided the mAs is also adjusted.

2.8. X_ray Parameters :

In radiography, dose and image quality are dependent on radiographic parameters, dose optimization for the Quality Control Tests of X-Ray Equipment effect on patient dose and image quality(Sprawls, 1987;Hendee et al., 1984).

2.8.1. Absorbed dose :

Absorbed dose is the quantity that expresses the radiation concentration delivered to a point, such as the entrance surface of patient’s body. Absorbed dose in air is recognized as air kerma and it is a measure of the amount of radiation energy, in the unit of joules (J), actually deposited in or absorbed in a unit mass (kg) of air. Therefore, the quantity, kerma,

is expressed in the units of J/kg which is also the radiation unit, the gray (G) (Sprawls, 1987).

2.8.2. kVp:

The high energy of the x-ray spectrum is determined by the kilovoltage applied to the x-ray tube. The maximum photon energy is numerically equal to the maximum applied potential in kilovolts. The maximum photon energy is determined by the voltage during the exposure time. This value is generally referred as the kilovolt peak (kVp) and is one of the adjustable factors of x-ray equipment (Sprawls, 1987).

2.8.3. mAs:

The x-ray cathode is heated electrically by a current from a separate low voltage power supply. The output of this supply is controlled by the mA selector on the x-ray unit. Additionally, the duration of the x-ray exposure is controlled by the time selector. mAs is described by multiplying of these two values (mA x second) (Hendee et al., 1984).

2.8.4. Image quality

The purpose of the radiographic image is to provide information about the medical condition of the patient. A quality image is one that provides all the information required for diagnosis of the patient’s condition (Hendee et al., 1984).

Image quality is not a single factor but is described with beam alignment, collimation alignment, contrast and resolution. Contrast means differences in the form of gray scales or light intensities, whereas the resolution is a measure of its ability to differentiate between two objects a small distance apart; such that they appear distinct from one another.

An image is acceptable as qualified only if it has high resolution and high contrast(Frush ,2004).

2.8.4.1 Contrast:

Contrast is the second major feature of an image. This characteristic describes how

well the image distinguishes subtle features in the object (patient). In diagnostic imaging, the contrast of an image is a product of complex interactions among the anatomic and physiologic attributes of the region of interest, the properties of the imaging method and receptor employed, and conscious efforts to influence both the intrinsic properties of the region and its presentation as an image. These interactions are characterized as four influences on image contrast. (Harjit Singh , et al 2012).

2.8.4.2. Intrinsic Contrast:

The underlying philosophy of diagnostic imaging is that structures in the patient

can be distinguished in an image because they differ in physical composition and

physiologic behavior. These differences are referred to as intrinsic (sometimes calledsubject, object, or patient) contrast. Physical properties of the patient that contribute to intrinsic contrast. In radiography, intrinsic contrast is a reflection primarily of atomic number and physical density differences among different tissues. Some structures (e.g., breast) exhibit very subtle differences in composition and are said to have low intrinsic contrast. Other structures (e.g., chest) provide large differences in physical density and atomic composition and yield high intrinsic contrast. (Harjit Singh , et al 2012).

2.9 preview studies

Mohamed Khalifa Zayet, etc. (Effect of changing the kilovoltage peak on radiographic caries assessment in digital and conventional radiography), Abstract, This study aimed to investigate the effect of changing the kilovoltage peak (kVp) on the radiographic assessment of dental caries. Materials and Methods Seventy-five extracted posterior teeth with proximal caries or apparently sound proximal surfaces were radiographed with conventional E-speed films and a photostimulable phosphor system using 60 kVp and 70 kVp for the caries assessment. The images were evaluated by three oral radiologists and compared with the results of the stereomicroscope analysis. . Results No statistically significant difference was found between 60 kVp and 70 kVp for the caries detection, determination of caries extension into dentin, and caries severity in either the conventional or the digital images. Good to very good inter-observer and intra-observer agreements were found for both kilovoltage values on the conventional and digital images. Conclusion Changing the kilovoltage between 60 kVp and 70 kVp had no obvious effect on the detection of proximal caries or determination of its extension or severity.

Fauber TL, etc.(High kilovoltage digital exposure techniques and patient dosimetry) . Abstract . To explore digital exposure techniques during pelvic imaging on patient dosimetry, exposure indicator (EXI) values and image quality. METHODS: An experimental design was used to study the effect of varying kilovoltage peak (kVp) and milliampere-seconds (mAs) on a male phantom pelvis when using a direct digital radiography (DR) flat panel detector. The radiation intensity was varied by increasing the kVp and reducing mAs. Image quality was evaluated by assessing density, density differences, quantum noise and overall diagnostic quality. RESULTS: When the kVp was increased in 15% increments and mAs divided by half, the radiation dose to the gonads significantly decreased. The lowest and highest kVp exposure groups produced the lowest EXI values. There was no correlation between the thermoluminescent dosimeter milliroentgen (mR) measurements and the EXI values. Conclusion: The results indicate that a pelvic DR image produced at 93 kVp and 12.5 mAs will reduce the gonadal dose while maintaining an image of diagnostic quality.

Wang Kei Ma, etc. (Effects of Kilovoltage, Milliampere Seconds, and Focal Spot Size on Image Quality) May 2014 Radiologic Technology;May/Jun2014, Vol. 85 Issue 5, p479.. Academic Journal

ABSTRACT

Purpose: To determine how kilovoltage (kV), milliampere seconds (mAs), and focal spot size affect perceptual image quality using a hand phantom. Methods: Using computed radiography, 70 images of a posteroanterior (PA) oblique hand phantom were acquired with different kilovoltage and milliampere second values using large and small focal spot sizes. Images were displayed on quality-controlled monitors with dimmed ambient lighting. The look-up table for hand radiography was used for image display. Five diagnostic radiographers scored each image for perceptual image quality against a reference image using a 5-point Likert scale. Results: No significant difference in image quality was found between small and large focal spot sizes at different kilovoltage ($P = .46$) and milliampere second ($P = .56$) values. As milliampere seconds increase, perceptual image quality increases gradually from 0.4 mAs to 4 mAs, after which perceptual image quality begins to deteriorate. When kilovoltage increases to within the range of 40 kV to 55 kV, perceptual image quality increases; image quality remains stable after 55 kV.

Discussion: This study shows that both large and small focal spot sizes produce images of similar quality, and a wide range of kilovoltage and milliampere seconds can be used to produce images of acceptable quality. The implications of these findings include the potential for extending the life of radiography equipment and the potential for reducing the dose patients receive during appendicular examinations. Conclusion: Large focal spot size can be used for PA oblique hand imaging without affecting perceptual image quality. Perceptual image quality remains acceptable and stable for a wide range of kilovoltage and milliampere second values. Optimization of these technical factors to achieve image quality is critical to avoiding higher radiation doses than necessary.

Chapter Three

Materials and Methods

3.1Materials:

3.1.1. X-ray machines:

In the study two different modalities of X-ray machines from different manufactures were used the specification of the machines are shown in the table below:

Table 3.1 Type and main characteristics of X- ray machines

Center	Manufacturer	Manufacturing Date	Type	Focal spot (mm)	Total Filtration (mm Al)	Max KV_p	Max mA	Max time(s)	Year install
MMC	Toshiba FDR smart	June 2013	fixed	1.5-.6	.9/AL/75	125	320	.2	2014

3.1.2. Phantom:

Skull X-ray Phantom cover with pelxes similar to soft tissue .

3.1.3. densitometer:

PTW Densix auto T52004-No 715

D 79115 freiburg, made in germany.

3.2. Methods:

3.2.1. Study duration:

This study performed in 2015.

3.2.2. Study place:

This study was conducted in Modern Medical Center and university of Sudan, college of radiology, department of X-ray.

3.2.3. Technique used:

8 lateral X-ray skull obtain by the following exposure techniques in increase the Kvp by 15% and decrease mAs by 50% with 100 inch.

The table 3.2. show the exposure technique used

Serial	Kvp	mAs
1	43	160
2	51	80
3	60	40
4	69	20
5	79	10
6	91	5
7	105	2.5
8	120	1.25

3.3. Image Evaluation:

Contrast , D max and D min is determined by densitometer by selecting mid pintial and mid petrost for contrast, Dmax in unmask area, Dmin petrost bone Over all image quality is evaluated visually

Chapter four

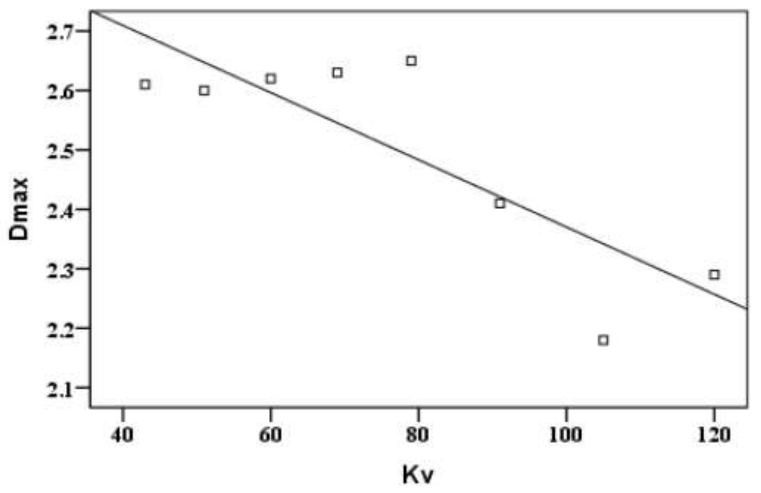
The result

The table (4-1) shows the Relation between the **Dmax**, contrast and soft tissue in skill images:

Num of image	Dmax	Contrast	Soft tissue
1	2.61	0.30	1.40
2	2.60	0.25	1.87
3	2.62	0.67	1.88
4	2.63	0.57	1.86
5	2.65	0.30	1.68
6	2.41	0.13	1.43
7	2.18	0.12	1.23
8	2.29	0.51	1.24

The table (4-2) shows the Relation between the **Kvp** and **Dmax** in skill images:

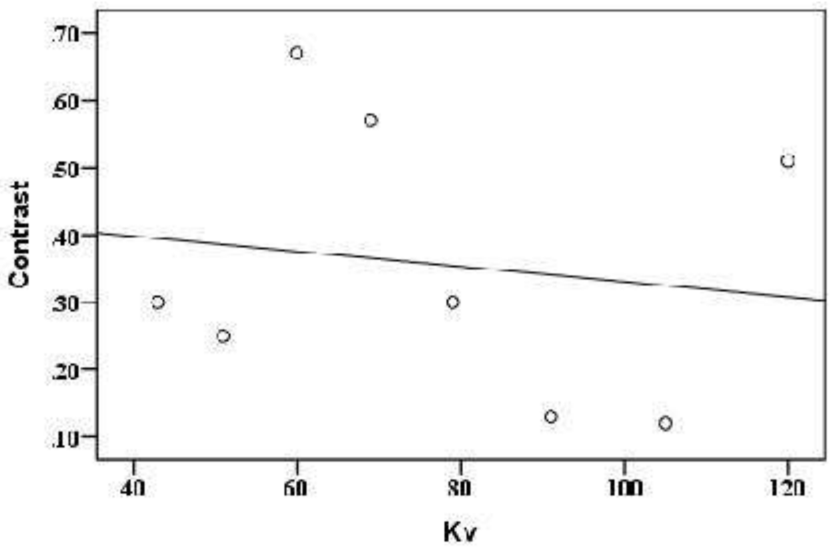
Kv	43	51	60	69	79	91	105	120
D max	2.61	2.60	2.62	2.63	2.65	2.41	2.18	2.29



The figure (4-1) shows the relation between Kvp and Dmax.

The table (4-3) shows the Relation between the **Kvp** and contrast in skill images:

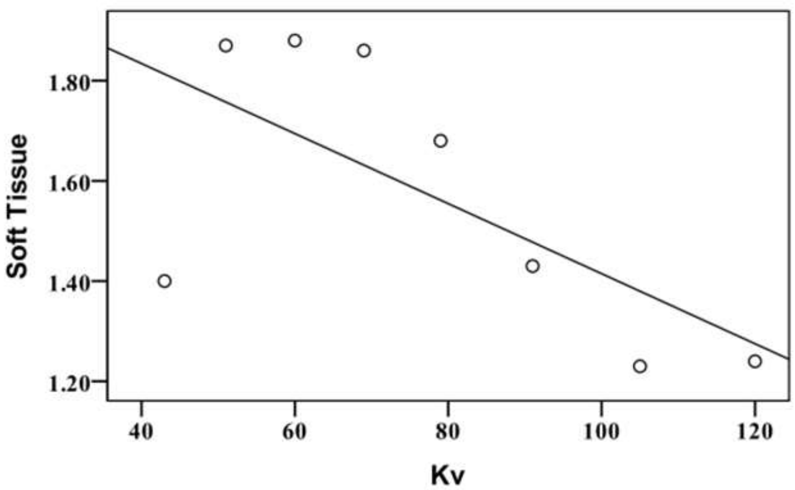
Kv	43	51	60	69	79	91	105	120
Contrast	0.30	0.25	0.67	0.57	0.30	0.13	0.12	0.51



The figure (4-2) shows the relation between Kvp and contrast.

The table (4-4) shows the Relation between the kvp and soft tissue in skill images:

Kvp	43	51	60	69	79	91	105	120
SOFT TISSUE	1.40	1.87	1.88	1.86	1.68	1.43	1.23	1.24



The figure (4-3) shows the relation between kvp and soft tissue.

Table 4-5. Showed the visual assessment of the image obtained.

No of Image	High	Acceptable	Low
Resolution	34%	28%	38%
SNR	54%	30%	16%
Contrast	62%	24%	14%

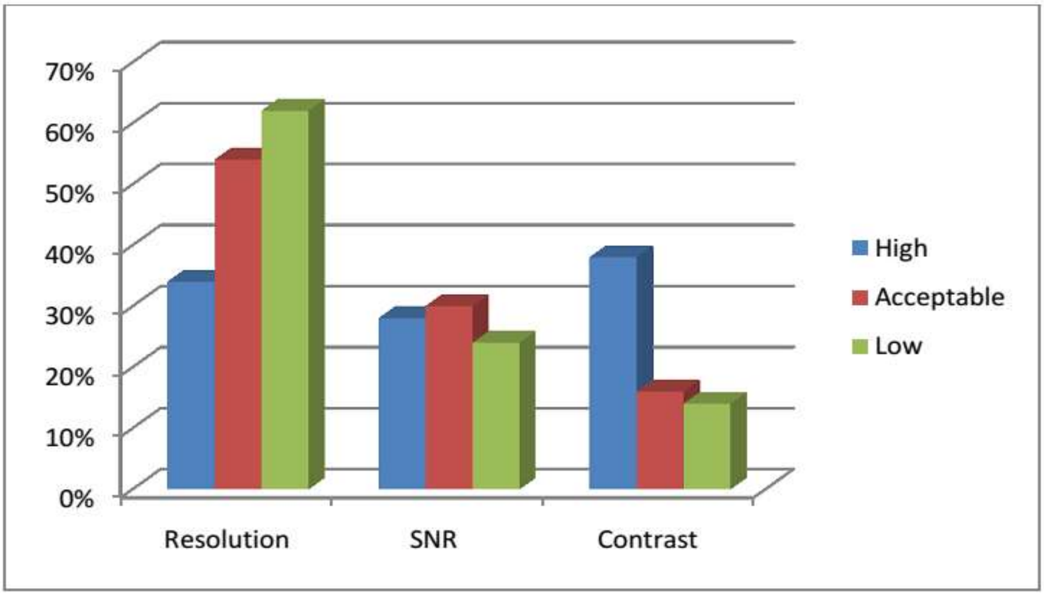


Figure 4-4. Showed the visual assessment of the image obtained.

Chapter five

Discussion, Conclusion and Recommendation

5.1. **Discussion:**

This research aimed to evaluate the effect of KVp in digital image quality , the Tube voltage (KVp) reduction results in a parallel increase in film contrast that can improve image quality. However, the lower KVp simultaneously results in higher attenuation of contrast material, thereby increasing signal intensity. 8 phantom images were scanned with the tube voltage varied between 43 and 120 KVp, and the mAs adjusted to maintain a constant exposure level between 1.25 and 160 mAs. At a constant x-ray tube voltage, the surface dose and energy imparted were directly proportional to the input exposure, the result indicating that decreasing the kilovoltage will improve image quality by improving the contrast, the image contrast substantially increased with low tube voltage. However, with identical dose, use of 60 kV and 40 mAs resulted in higher contrast compared with Contrast at 105 kV and 2.5 mAs. The dose reduction and image quality of the study using an automated kV selection tool were evaluated they observed an overall dose reduction when using law kv. The main finding of the study was there is no relation between kvp incresan and contrast , Dmax , Dmin . This finding is due to possibility of monpulatit density and contrast in digital image , and it's not like film screen system where the density and conteast were control mainly by kvp .

5.2. Conclusion:

The results demonstrate that the above approach could become e an important part of the image quality in x-ray diagnostic radiograph, tube voltage (KVp) is a scan parameter with exponential relationship to radiation exposure, which determines image quality. Lowering tube voltage decreases photon energy causing greater absorption by iodinated contrast media, thus increasing contrast between the artery lumen and surrounding tissue. Lowering KVp also increases image noise (IN).

5.3 Recommendation:

Establish protocols with a clearly defined range of exposure indicators for each exam. The exposure indicator values are then “audited” to ensure technologist compliance with ALARA and image quality. Establish protocols with a clearly defined range of exposure indicators for each exam. Digital image technique is more forgiving, so the techanqest should bellow ALARA . Feature study should to measure the effects of kvp chande in contrast , Dmax, Dmin and visual image quality should print all imade with the same grey scaly (window width and window level).

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