Sudan University of Science and Technology

College of Graduate Studies

Assessment of Entrance Skin Dose and effective Dose during Pelvis conventional X-ray Procedure Examinations

تقييم الجرعة الداخلة الى الجلد والجرعةالمؤثرة اثناء تصوير االحوض باالاشعة السينية التقليدية

Thesis submitted for partial fulfillment of M.sc degree in Medical Physics

Prepared by :Elkhair Mohammed ElameenAjbna

Supervisor: Dr: Hussein Ahmed Hassan

2017

DEDDICATION

I would like to dedicate this work to my:

Parents...

Family …

Friends …

ACKNOWLEDGMENT

First of all, I thank Allah the Almighty for helping me complete thisresearch. I thank Dr. HusseinAhmed Hassan, my supervisor, for help and guidance.

I would like to express my gratitude all staff of the radiological unit in Hospitals fortheir great help and support.

Finally I would like to thank everybody who helped me prepare and finish thisstudy.

ABSTRACT

High doses of ionizing radiation can lead to adverse health outcomes such as cancer induction in humans. Although the consequences are less evident at very low radiation doses, the associated risks are of societal importance. This study aimed to assessing entrance skin doses (ESDs) and effective dose in patients undergoing pelvis X-ray examinations.

Measured the entrance skin dose (ESD) received by 42patient (24 males and 18 females) aged between 18-69 years old undergoing pelvis X-ray examination at Radiology Departmentof (A,B,C and ,D.)in period between April 2017to October 2017.

Patient are classified in three different age groups.(18→ 19., 20→45., 46→7) years.

The entrance skin dose ESD and effective dose ED was determined via measurementsparameters: focus to skin distance (FSD), tube current (mAs)and tube voltage (kV) in CALDOSE-X5.And fouded (3.84mGy)for (ESD) and (0.26mSv) for (ED).

The mean ESD values for all hospitals obtained are found to be within the standard internationalReference, but in (A) hospital is high,On the basis of the resultsobtained in this study can conclude that use of newer equipment and use of the proper radiological parameter cansignificantly reduce the absorbed dose

ملخصالبحث

الجرعات العالية من الإشعاع المؤين يمكن أن تؤدي إلى نتائج صحية سلبية مثل تحريض السرطان في البشر.وعلى الرغم من أن العواقب تكون أقل وضوحا عند الجرعات الإشعاعية المنخفضة جدا، فإن المخاطر المرتبطة بها ذات أهمية اجتماعية.وتهدف هذه الدراسة إلى تقييم جرعة الجلد المدخلة في المرضىوالجرعة الفعالة الذين يخضعون لامتحانات الحوض لأشعة إكس.

وقياس الجرعة الجلد المدخلة تلقى من قبل 42 مريضا (24 ذكور و 18 إناث) الذين تتراوح أعمارهم بين 18-69 سنة تحت اختبارفحص الحوض بالأشعة السينية في قسام الأشعة(A,B,C,and,D)في الفترة من ابريل الى اكتوبر 2017

تم تصنيف المرضى حسب اعمارهم واجناسهم الى ثلاث مجموعات ,.45→20 ,.19 →18) . (46→7سنة

تم تحديد جرعة مدخل الجلد والجرعة المؤثرة من خلال قياسات الكميات المتغيرة: التركيز على مسافة الجلد ،التعرض الزمني بالنسبة للتيار(mAs) و أنبوب الجهد (kv) في CALDOSE-X5تم العثور على3.84 ملي غري ذلك بالنسبة للجرعة المدخلة للجلد و0.26 ملي سيفر بالنسبة للجرعة المؤثرة

ووجد أن متوسط قيم الجرعة المدخلة للجلد التي تم الحصول عليها تكون ضمن المعيارالمرجعي العالمي.*ماعدا في المستشفى (A) عالية على اساس النتيجة المتحصل عليها في الدراسة يمكن تخفيض باستخدام اجهزة جيدة والاستخدام الصحيح لقياس الاشعاع ويكون له اهمية في خفض الجرعة الممتتصة*.

CONTENTS

List of table

List of Figure

List of abbreviation

Abbreviation	Phrase
AEC	Automatic exposure control
DAP	dose-area product
DNA	Deoxyribonucleic acid
DRL	diagnostic reference Level
ESD	Entrance surface dose
FFD	Focus to film distance
FSD	Focus skin distance
Gy	Gray
HVL	Half value layer
IAEA	International Atomic Energy Agency
ICRP	International Commission On radiation protection
KVP	Kilo voltage peak
mAs	Milli ampere second
MeV	Mega electron volt
NRPB	National radiation protection board
OP	Out put
PDD	Percentage depth dose
QC	Quality control
SID	Source to image distance
SOD	Source to object distance
SSD	Surface skin distance
Sv	Severt
TIC	Transmission Ionizing Chamber
TLD	Thermo luminescence dosimeter

Chapter one

1.1 Introduction

X-ray is the most frequently used ionizing radiation for diagnostic imaging and it plays a significant role in effective health care delivery both in developed and developing countriesx-ray is said to be the major contributor to the collective effective dose of the general public (personnel and patient). The need for radiation dose assessment of the patient during diagnostic x-ray examinations has been highlighted by increasing knowledge of hazard of ionizing radiation.Because of the deleterious effects of x-rays, it is necessary to protect patients undergoing diagnostic procedures. The aim of any diagnostic x-ray examination is to produce images of sufficient and optimum quality. However, a good quality radiograph is not the one that is most appealing to the eye but, that in which sufficient details can be easily elicited. In keeping radiation dose to patients to a minimum in hospitals, it is useful to be able to estimate prior to medical examination the dose to patients as a function of radiographic exposure parametersRadiation dose to patients from diagnostic x-ray machine assures a simple functional dependence on radiographic exposure parameters of kVp, mAs, FSD,filetration and thickness(Dlama et al ,2014).

Entrance surfacedose(ESD) ,(named skin absorbed dose in current article), and dose-area product (DAP) are the most important parameters measured in diagnostic Radiology due to increasing radiological examinations, patient protection against X-rays is important. Therefore, all national and international forums have specific recommendations to further protection of patients. Being able to accurately assess the radiation dose patients receive during proceduresis a crucial step in the management of dose. Since the introduction of the term

"diagnostic reference Level (DRL)" by (ICRP,1996), there have been continuing worldwide efforts to develop and implementDRLs in diagnostic radiology as well as nuclear medicine,ICRP in its 1996 publication recommends that to set DRLs while no DRLs are proposed for panoramic radiographies by International Atomic Energy Agency(IAEA), Selection of a DRL using a percentile point on the observed distribution of dose for patients, should be specific to a country or region ICRP 2002(Ehsan et al 2014).

ESD is amount of skin absorbed dose at the entrance point of the X-ray Beam.ESD measurement can be performed directly or indirectly. Thermo luminescent Dosimeter (TLD) measures the ESD directly.

Many departments do not use recommended radiographic parameters for patient. Furthermore, wide variations have been found in techniques, equipment performance and radiation doses among different hospitals over the world. The study is the first attempt at measuring ESDs for patient in the area of study and will, with the information obtained earlier, add to the pool of data available in national records for general use It will provide guidance on where efforts on dose reduction will need to be directed to fulfill the requirements of the optimization process and serve as a reference for future work, as well as provide information for comparison with patients of the same category in other countries(H. Osman et al 2014)

The aim of this work is to assessment the entrance skin doses (ESD)and effective dose ED(mSv) for pelvisX-ray examination, the measurements will carry out in several hospitals The results obtained from all hospitals will compare with reference dose levels (RDLs)

1.2**Problem of the stuudy:**

Many departments do not use recommended exposure factors parameter for x- ray examination Wide variation will have found in techniques, equipment performance and radiation dose in difference hospital over the world

1.3 Objective:

1.3.1 General objective

The goal of the study is measurement of entrance skin dose (ESD)and effective dose ED(mSv)for patient who's exposed to radiation during pelvic examinations in diagnostic radiology department

1.3.2 Specific Objectives

To compares the results with reference dose levels (DRLs)in NRPB and IAEA, EU.

1.4 Significance of the study:

Radiation dose to patients and its management have become important Considerations in diagnostic radiographic imaging procedures,
Therefore, current clinical thinking dictates that dose in patient radiography be minimized, while simultaneously ensuring sufficient diagnostic information in the image, and reducing the need for repeat exposures.

1.5 Thesis layout

This study falls into five chapters, Chapter one, which is an introduction, deals with theoretical frame work of the study. andit presents the statement of the study problems, objectives of the study, chapter two deals with back ground radiological physics and literature review. Chapter three deal with material and method, Chapter fours deals with results. Chapter fivediscussions. conclusionrecommendations and references.

Chapter Two

Background and LiteratureReview

Part one: Background radiological physics

2.1 Radiation:

Radiation is energy that travels through space or matter. Twocategories of radiation of importance in medical imaging are electromagnetic (EM) and particulate(Bushberg el al, 2012).

2.1.1 Electromagnetic Radiation

Radio waves, visible light, x-rays, and gamma rays are different types of EM radiation.

EM radiation has no mass, is unaffected by either electric or magnetic fields, and has a constant speed in a given medium.

EM radiation is commonly characterized by wavelength,frequency, and Energy per photon (E). EM radiation over a wide range of wavelengths, frequencies, and energy per photon comprises the EM spectrum.

Several forms of EM radiation are used in diagnostic imaging. Gamma rays, Emitted by the nuclei of radioactive atoms, are used to image the distributions of Radiopharmaceuticals. X-rays, produced outside the nuclei of atoms, are used in radiography, fluoroscopy, and computed tomography(Bushbergel al, 2012).

2.1.2 Wave-Particle Duality:

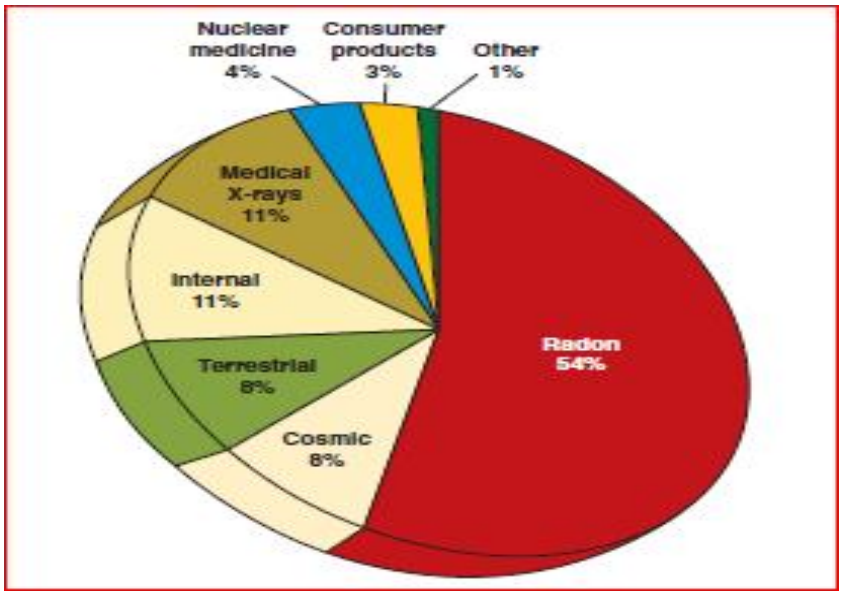
There are two equally correct ways of describing EM radiation—as waves and as discrete particle-like packets or quantaof energy

2.2 Radiation sources:

Sources of radiation can be divided into two categories

2.2.1 natural radiation sources:

It is the radiation exposure to man occurs from natural sources e.g. cosmic rays, and terrestrial sources that comes from radionuclide's in the earth's crust, air, food and water and the human body itself.



Figure(2-1) radiation sources (Steve 2011)

2.2.2 man-made sources:

Exposure to populations occurs mainly from medical uses ofRadiation and radioisotopes in health care, occupational sources in the generation of electricity from nuclear power reactors, industrial uses of nuclear techniques, and in the past from nuclear weapons testing.

2.3 Discovery of X-rays and its characteristics:

X-rays were accidentally discovered in 1895, when William C. Roentgen was experimenting with a cathode ray tube. Roentgen was working in his laboratory at Wurzburg University in Germany.

He had darkened his laboratory and completely enclosed his tube with a Black paper so that he could better visualize the effects of the cathode rays in the tube a plate coated with barium platinocyanide (a fluorescent Material) happened to be laying on a bench top several feet's from the tube he was using. No visible light escaped from his tube because of the black paper enclosing the tube, but Roentgen noted that the barium platinocyanide Fluorescedregardless of its distance from the tube. Because the Cathoderays .Roentgen was studying could not travel more than a few centimeters in air he concluded that the source of that glow of the plate he noted was another kind of unknown rays. He called these unknown rays as X-rays (Bushbergel al, 2012).

X-rays now play an important role in health life of all communities. Its examinations are now the most common examination in all hospitals.

2.4 Interaction of x-ray

2.4.1 Excitation:

In this interaction, the projectile electrons interact with the outer Shell electrons of the target atoms, the outer shell electrons get excited and

raised to higher energy levels. The outer shell electrons then immediate drop back to the normal energy state with the emission of infrared radiation. In the X-ray tube This emitted infrared radiation heat the anode of the X-ray Tube(Sami 2015,) .

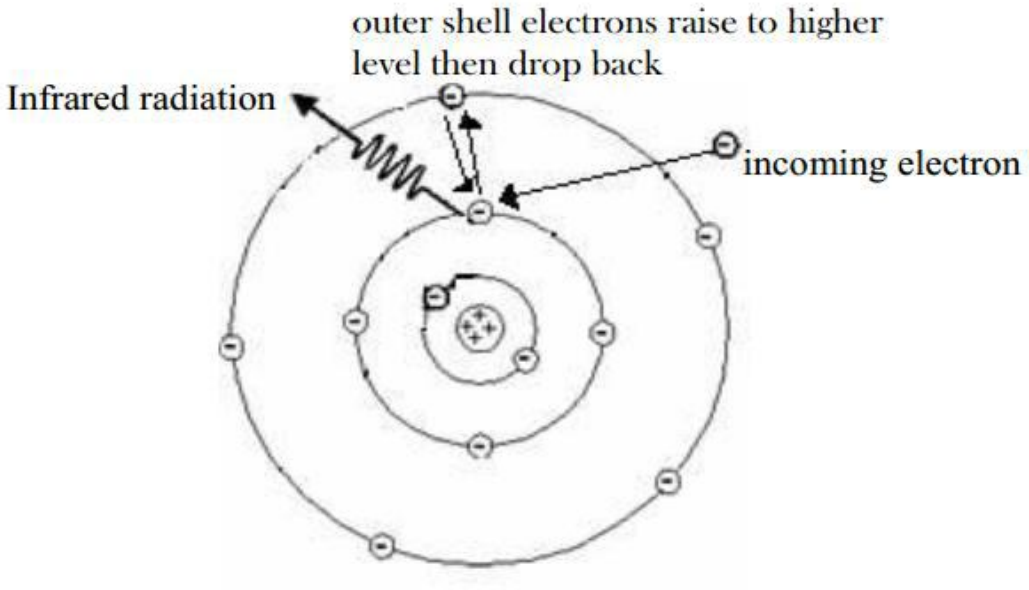


Figure 2.2Excitation process (Sami 2015,).

2.4.2 Ionization:

In this interaction the projectile electrons interact with inner
Shell electrons where the energy of the incident electrons exceed the binding Energy of the electrons in their shells, these inner shell electrons as a result gets ejected from their inner orbits of the target atom and the atom gets Ionized and a hole is created in the place of the ejected electron. This hole is Then filled by an electron from a higher energy level and characteristic X-ray Lines are produced. These X-rays are called characteristic because its energy is specific to the target element(Sami 2015),

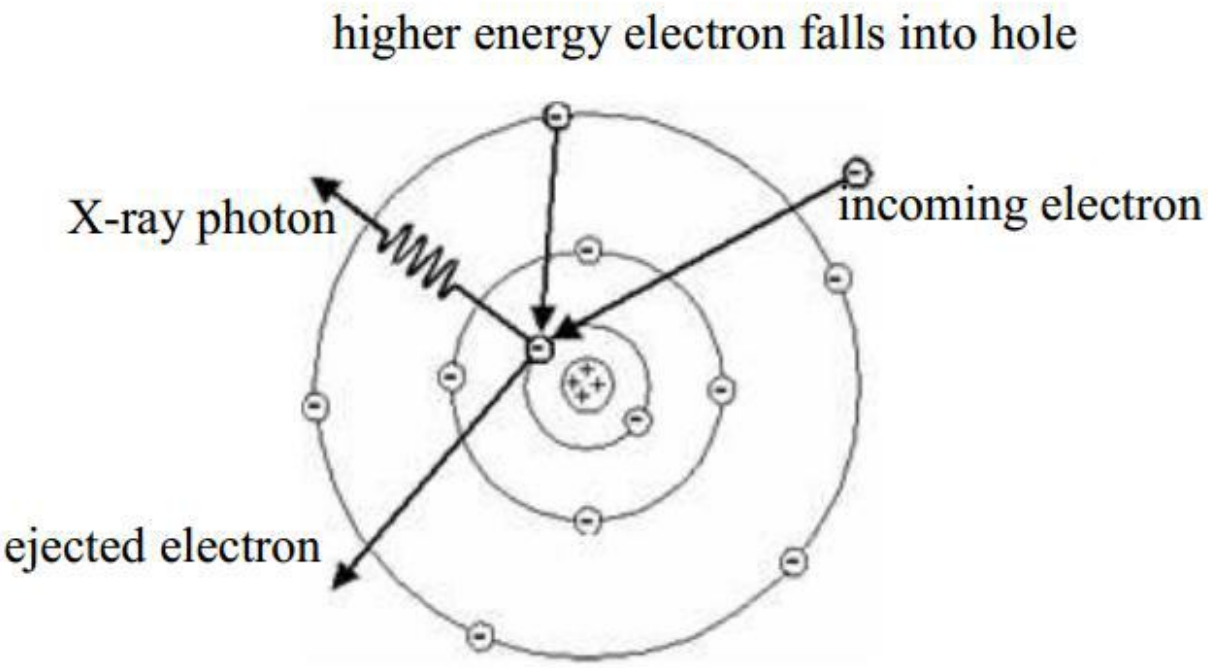


Figure 2.3 Ionization process (Sami 2015,).

2.4.3 Bremstrahlung:

In this interaction the electrons completely avoid the orbital

Electrons and come sufficiently close to the nucleus of the atom. The electrons are attracted by the strong electric field of the nucleus which causes a sudden change in the motion of the electrons and constitutes a violent deceleration that disturbs the electromagnetic field and a photon is emitted. At each interaction an X-ray is produced, which may have energy between zero and a maximum value equal to the initial kinetic energy of the incident electron (Sami 2015,).

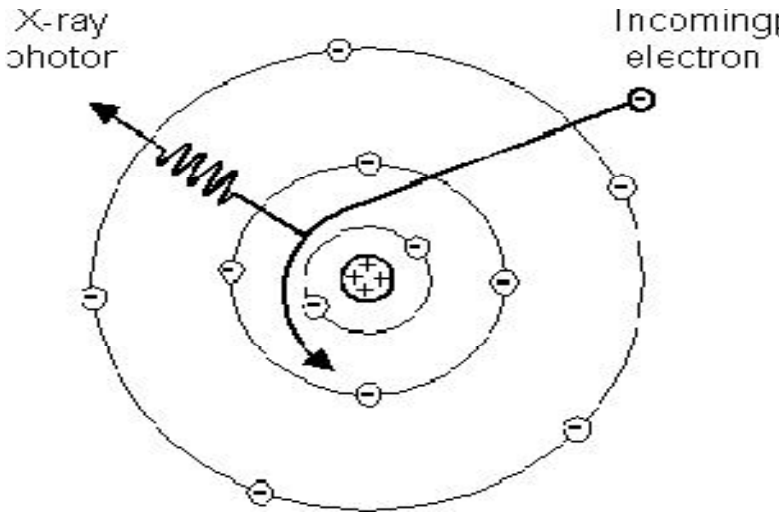


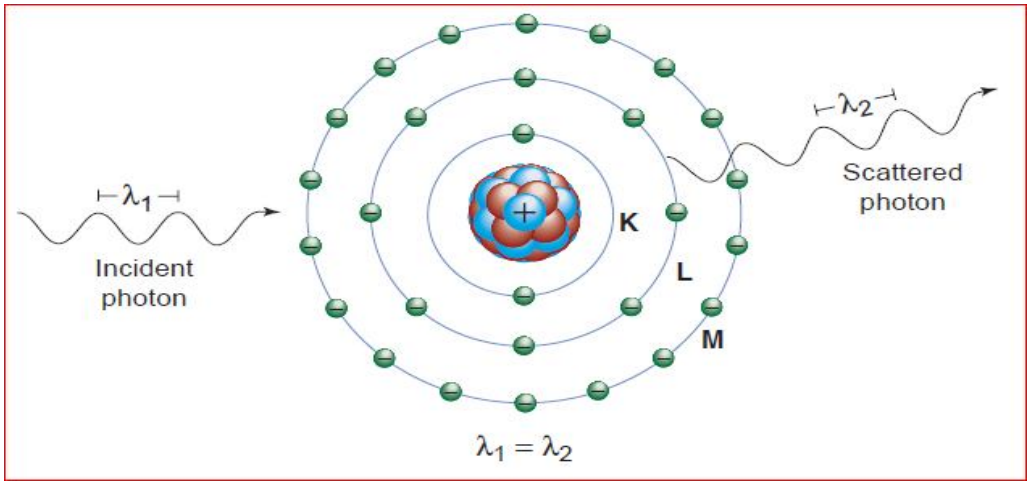
Figure 2.4Bremstrahlung process (Sami 2015,).

2.5Photon Interaction with matter:

2.5.1 Rayleigh scattering:

In Rayleigh scattering, the incident photon interacts with and excites the total atom, as opposed to individual electrons as in Compton scattering or the photoelectric effect. This interaction occurs mainly with very low energy x-rays, such as those used in mammography (15 to 30 keV). During the Rayleigh scattering event, the electric field of the incident photon's electromagnetic wave expends energy, causing all of the electrons in the scattering atom to oscillate in phase. The atom's electron cloud immediately radiates this energy, emitting a photon of the same energy but in a slightly different direction (Fig. 2-6). In this interaction, electrons are not ejected, and thus, ionization does not occur. In general, the average scattering angle decreases as the x-ray energy increases. In medical imaging, detection of thescattered x-ray will have a deleterious effect on image quality. However, this type of interaction has a low probability of

occurrence in the diagnostic energy range. In soft tissue, Rayleigh scattering accounts for less than 5% of x-ray interactions above 70 keV and at most only accounts for about 10% of interactions at 30 keV. Rayleigh interactions are also referred to as “coherent”“classical” scattering (Bushbergel al, 2012).

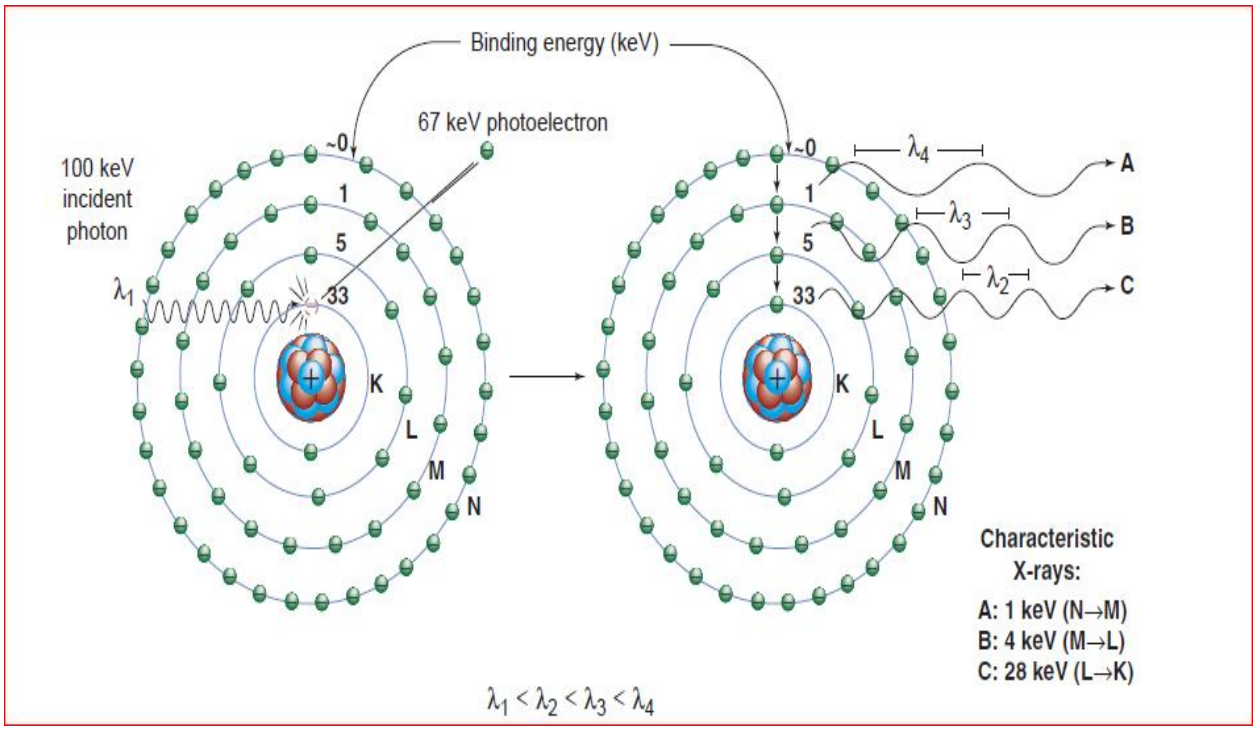


figure(2.5)Rayleigh scattering (Bushberg el al, 2012)

2.5.2 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 photoelectron (Epe) is equal to the incident photon energy (E_o) 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 (Bushbergel al,

2012).



Figure(2.6)photoelectric effect(Bushberg el al, 2012).

2.5.3Compton scattering:

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 keV in soft tissue but also continues to predominate well beyond diagnostic energies to approximately 30 MeV. This interaction is most likely to occur between photons and outer (“valence”)-shell electrons (Fig. 2-5). The electron is ejected from
the atom, and the scattered photon is emitted with some reduction in energy relative to the incident photon. As with all types of interactions, both energy and

momentum must be conserved. Thus, the energy of the incident photon (E0) is equal to the sum ofthe energy of the scattered photon (Esc) and the kinetic energyof the ejected electron(Ee2),. The binding energy of the electron that was ejected iscomparatively small and can be ignored. Compton scattering results in the ionization of the atom and a division of the incident photon's energy between the scattered photon and the ejected electron. Theejected electron will lose its kinetic energy via excitation and ionization of atoms in the surrounding material (Bushbergel al, 2012).

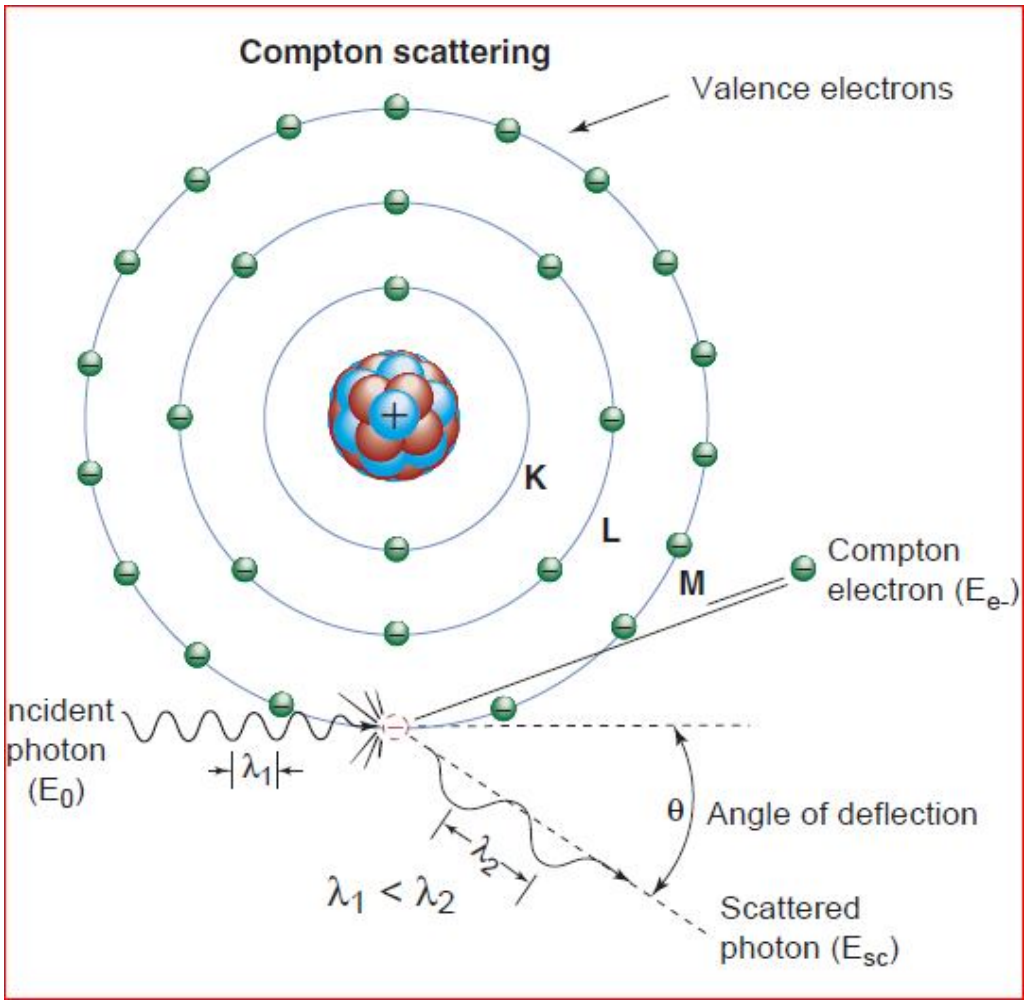
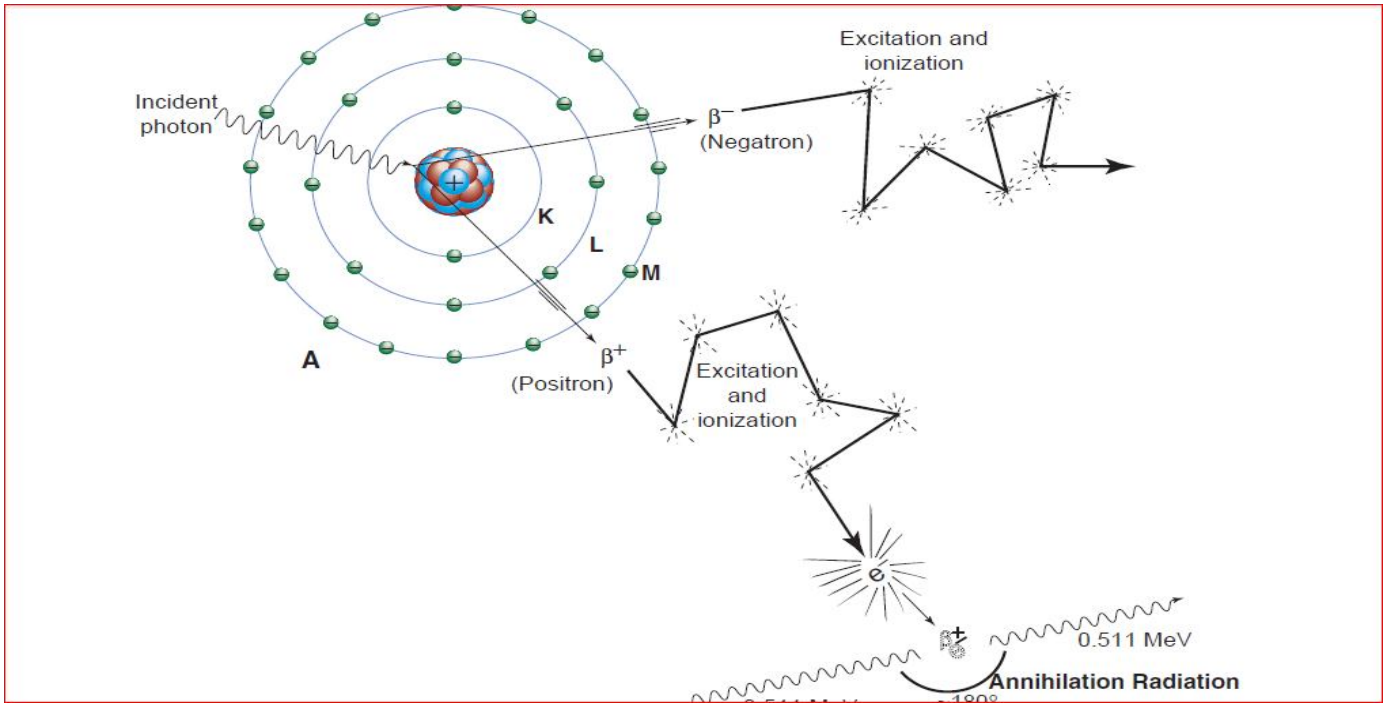


Figure (2.7) Compton scattering(Bushberg ,2012)

2.5.4 Pair production:

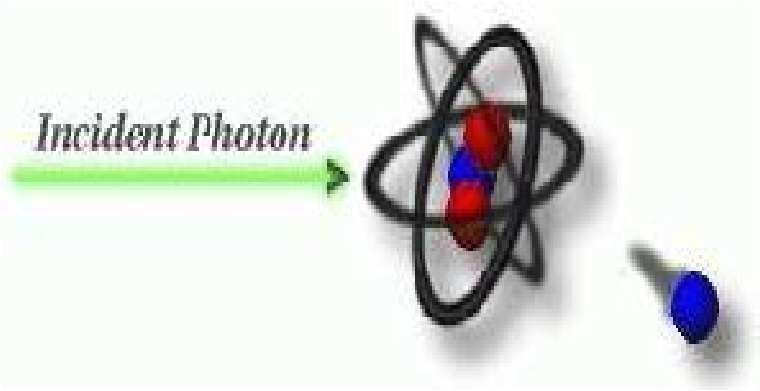
Pair production can only occur when the energies of x-rays and gamma rays exceed 1.02 MeV. In pair production, an x-ray or gamma ray interacts with the electric field of the nucleus of an atom. The photon's energy is transformed into an electron-positron pair (Fig. 2-8). The rest mass energy equivalent 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 electron (also referred to as a negatron or beta minus particle) and positron as kinetic energy. The electron and positron loosen their kinetic energy via excitation and ionization(Bushberg el al,2012).



Figure(2.8)pair production(Bushberg el al ,2012).

2.5.5 Photodisintegration:

In this interaction (figure 2.9) the incident photon has energy greater than 10 MeV and hence it interacts directly with the nucleus and split it in Parts with emission of neutrons. Because of the high photon energy requiredfor this interaction this interaction does not occur in diagnostic X-ray and assuch plays no role (Sami 2014).



Figure(2.9) Photodisintegration(Hanan2014)

2.6 X-ray beam characteristics:

X-ray beam can be described by its quality and or its quantity. Each of these characteristics is discussed separately in the following sections

2.6.1 X-ray beam quantity:

The X-ray beam quantity is the X-ray intensity (number of photons per unit Area per unit time)or the radiation exposure; and is affected by the change in any of the following factors: Milliampere seconds, kVps and distance and filtration.

Milliamper seconds: (mAs) is the product of X-ray tube current by the time of exposure, it controls the number of electrons accelerated towards the anode. If the

current is doubled, twice as many electrons will flow from thecathode to the target, and hence twice as much X-ray photons will beproduced(Sami 2014).
Thus, X-ray quantity is directly proportional to the mAs Thus:

$$\frac{I_1}{I_2} = \frac{mAs_1}{mAs_2}$$ 2.1(Hanan2014).

Where I_1 is the X-ray intensity that is produced when a current mAs_1, is Applied on the tube, and I_2 is the X-ray intensity that is produced when current mAs2 is applied on the X-ray tube. Thus increasing X-ray tube current will also increase X-ray quantity with the same ratio (see figure 2.11)

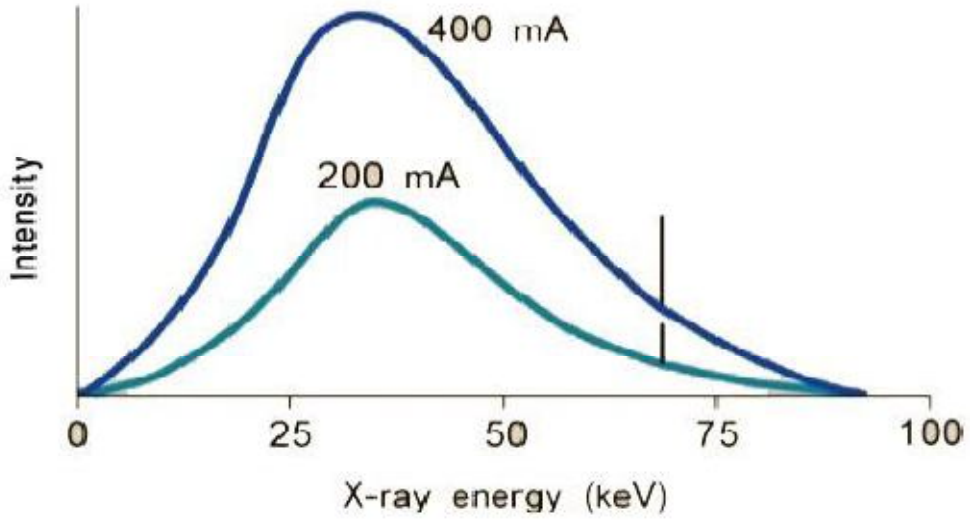


Figure (2.10): Effect of Tube current on X-ray spectrum (Hanan 2007)

Applied voltage (kVp)**:** The increase in the applied voltage will
Increase the probability of bremstruhlung interaction and hence more X-ray Photons will be produced. It was found that X-ray quantity is approximately Proportional to the square ratio of the applied voltage, thus

$$\frac{I_1}{I_2} = \left(\frac{kVp_1}{kVp_2}\right)^2$$

2.2(Hanan2014).

Where $I_1$is the intensity of the beam produced when kVp_1 voltage is applied on the tube and $I_2$is the intensity of the beam when kVp_2voltage is Applied on the tube. Any change in the potential will affect both the amplitude and the position of the X-ray spectrum. The area under the curve increases With the square of the factor by which kVp is increased and the relative Distribution of emitted X-ray photons shifts to the right (higher Energies. Thus for the same mAs increasing the applied Voltage will increase X-ray beam quantity (Hanan2014).

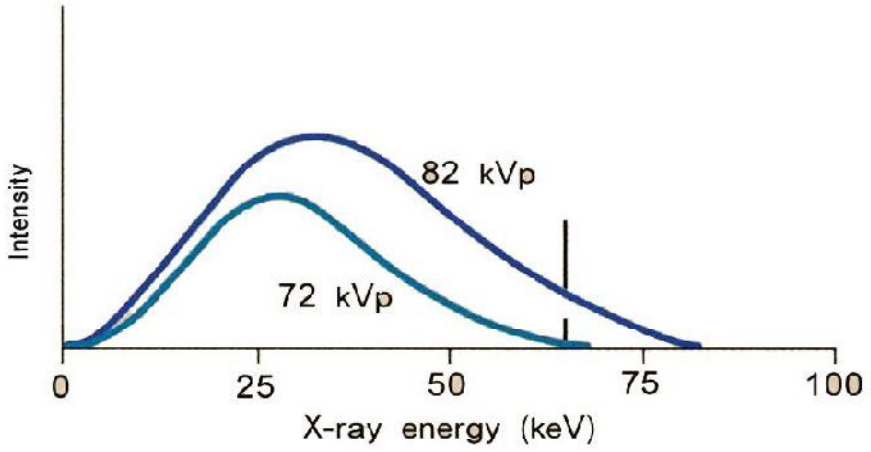


Figure (2.11): Effect of Tube potential on X-ray spectrum (Hanan 2007)

Distance**:** The intensity of X-rays is inversely proportional to the square Distance from the target(Hanan2014).Thus:

$$\frac{I_1}{I_2} = \left(\frac{d_2}{d_1}\right)^2$$

2.3(Hanan2014).

Where $I_1$is the intensity of the beam when a distance $d_1$is used and $I_2$is the Intensity of the beam when a distance $d_2$is used.

Filtration**:** Any material that lies in the path of the X-ray beam is called Filtration. There are two types of filtration; inherent and added filtration. The X-ray tube housing for example is an inherent filter material. Any added Material to the beam is called added filtration. Filtration reduces the X-ray Quantity by selectively removing low energy X-ray photons that do not add any information to the diagnosing image and hence improving the X-ray Beam quality (Sami 2015)

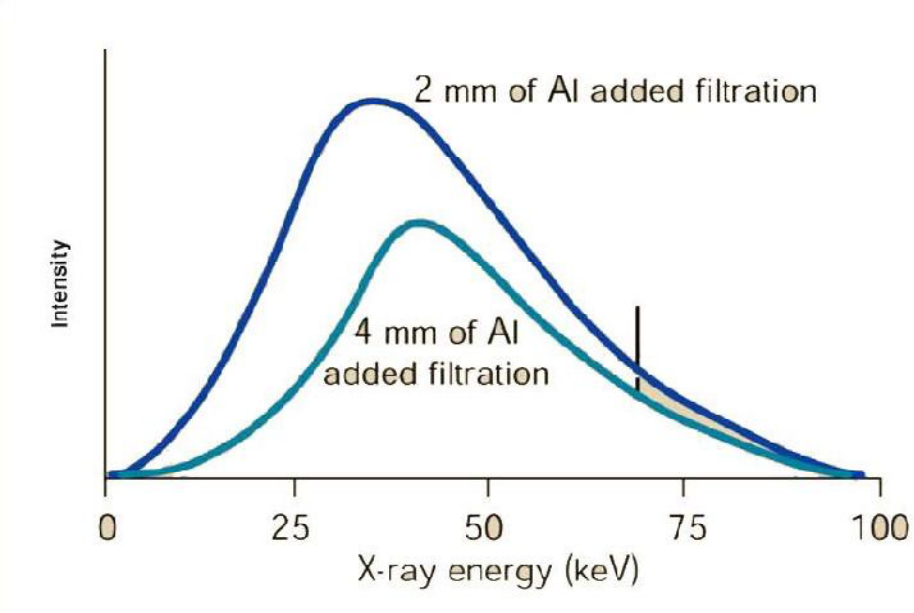
Thus the total effect of filtration on the X-raybeams:

– The minimum energy shifts towards higher energies

– Change in the X-ray spectrum shape (figure 2.13)

– The peak of the spectrum shifts towards higher energies

– The maximum energy remains unchanged



Figure(2.12) Effect of filtration on X-ray spectrum (Hanan 2007)

2.6.2 X-ray beam quality:

The X-ray quality is a measure of the penetrating ability of the X-ray beam and it is measured by the half value layer (HVL) of the beam. HVL is the Thickness of a substance needed to reduce the intensity of the beam into half of its original value. The larger the HVL, the higher the beam quality. Applied voltage (Kvp) The kVp controls the speed of the accelerated electrons and therefore controls the energy of the produced X-rays and the half value layer (Hanan2014).

Target material**:** The atomic number of the target material affects both the number and the effective energy of the X-rays. When the atomic number of the target is increased, the spectrum is shifted to the right (figure 2.14)

Filtration**:** the increase of total filtration will increase the beam quality by removing low energy photons (Sami 2015).

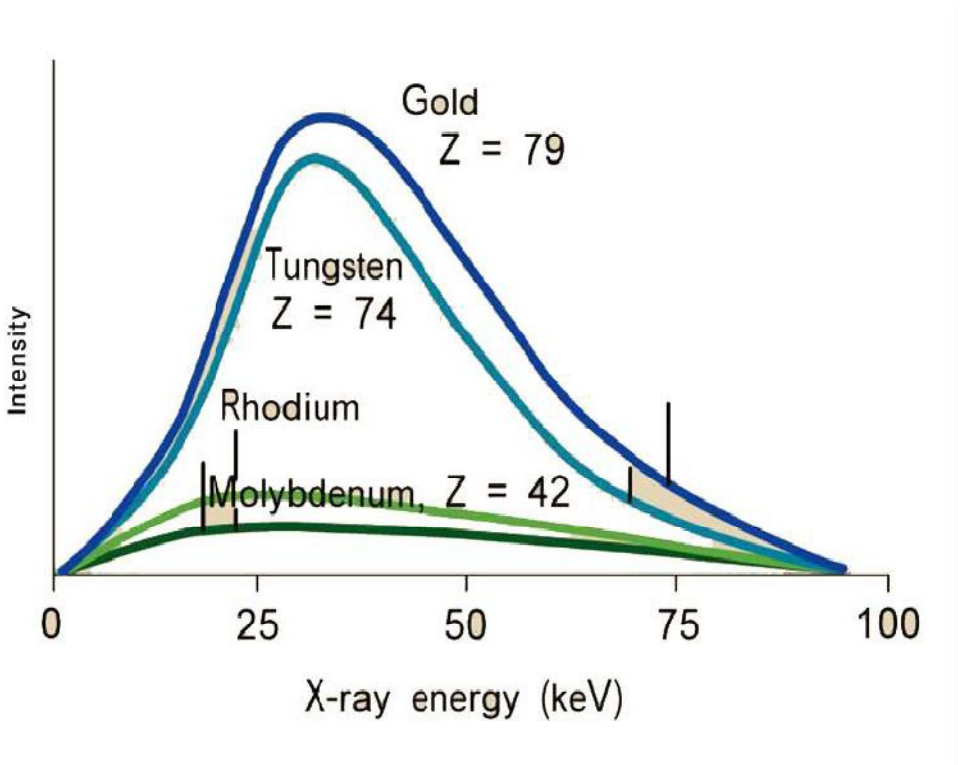


Figure (2.13): Effect of atomic number of target material on X-ray (Hanan 2007) spectrum (Tungsten atomic number = 74, Molybdenum atomic number = 42

2.7x-ray generator:

The principal function of an x-ray generator is to provide current at a high voltage to an x-ray tube. Electrical power available to a hospital or clinic provides up to about 480 V, much lower than the 20,000 to 150,000 V needed for x-ray production. Transformers are principal components of x-ray generators; they convert low voltage into high voltage through a process called electromagnetic induction.

Electromagnetic induction is a phenomenon in which a changing magnetic field induces an electrical potential difference (voltage) in a nearby conductor and also in which a voltage is induced in a conductor moving through a stationary magnetic field. As the magnet moves in the opposite direction away from the wire, the

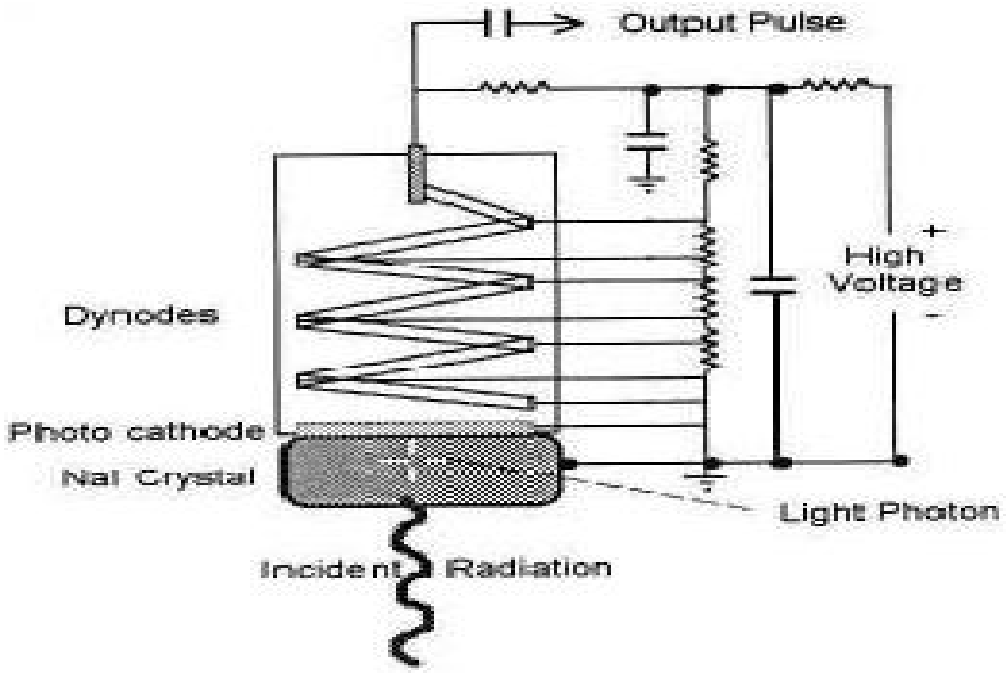
induced current flows in the opposite direction. The magnitude of the induced voltage is proportional to the rate of change of the magnetic field strength. Electrical current, such as the electrons flowing through a wire, produces a magneticfield whose magnitude (strength) is proportional to the magnitude of the current(Bushberg el al ,2012).

1.8Radiation detectors:

Radiation detectors are based on either scintillation, ionization or chemical process to detect radiation.

1.8.1 Scintillation detectors:

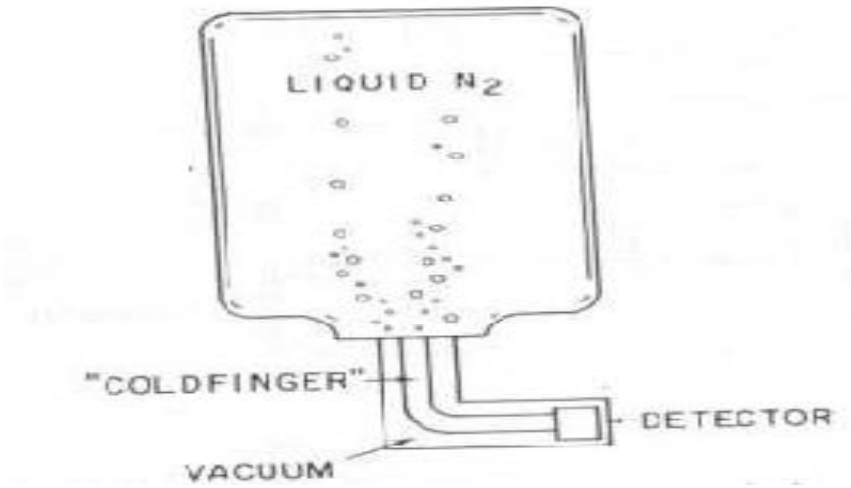
Scintillation detectors emit visible light when ionizing radiation passes through them. The light intensity is proportional to the energy of the incident radiation. The emitted light is then detected by a light detector called photomultiplier tube (figure 2.15). The photomultiplier tubes convert the light output into electric pulses, where the energy of the released photon is absorbed by an electron in a light sensitive material (photocathode) and leaves the photocathode and get amplified by a series of dynodes. This kind of detectors is sometimes used as a detector in automatic exposure control system to optimize patient dose (Hanan 2007).



Figure(2.14) Schemed diagram of photomultiplier tube(Hanan 2007).

1.8.2 Ionization detectors:

Detectors based on ionization could be semiconductor detectors or gas filled detectors. Semiconductor detectors (figure 2.16) have a very strong stopping power and are very efficient in detecting X-rays and gamma rays . When an X-ray photon strikes a semiconductor detector it raises some electrons to the conduction band and leaves an electron hole in the valence band. Because the presence of an electron hole in the valence band is unstable, itattracts an electron from the valence band of a neighboring atom, leaving an electron hole in that atom which is filled from the valence band of its neighbor and so on . The detector is enclosed in its own vacuum, and maintained at liquid nitrogen temperature with a cold finger and liquid nitrogen drawer. This kind of detector was not used in the current work(Hanan 2007).



Figure(2.15)Schemed diagram of a semiconductor detector (Hanan 2007).

Gas filled detectors on the other hand consist of a chamber filled with gas and two voltage plates (electrodes) (figure 2.17) .

Radiation interacts with the gas and produces ion pairs and because of the Applied voltage, the positive ions are attracted towards the cathode and the negative ions towards the anode causing change in voltage which can be Converted into apulse.The pulse height varies with the applied voltage and the variation in the pulse height shows different regions (figure 2.18)

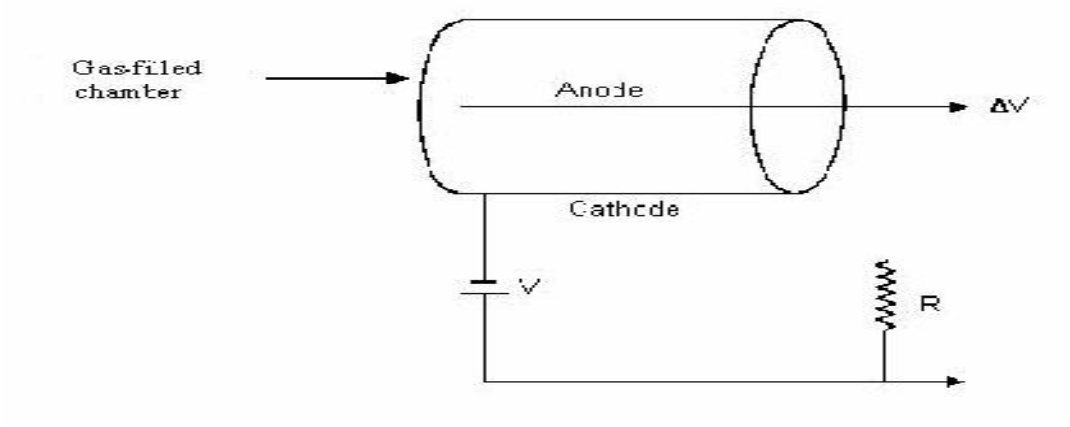
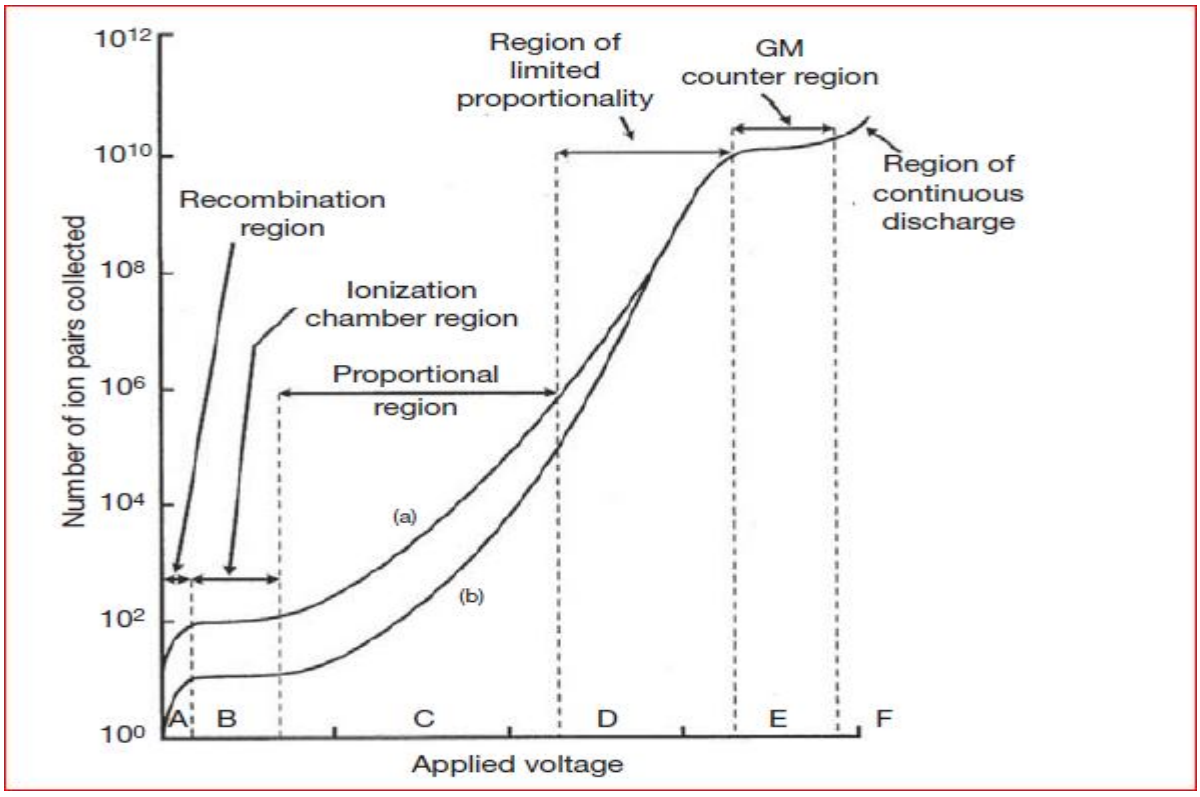


Figure 2.16: Schemed diagram of a gas filled detector(Hanan 2007).



Figure(2.17) Variation of pulse height with voltage(E. B. Podgorsakn 2005).

1.8.2.1 The recombination region:

When the applied voltage is low, the force on the ions is also low. This Means that, after an ion has been formed it may recombine before it can be Collected by the electrodes. Gas-filled detectors are not normally operated in This region

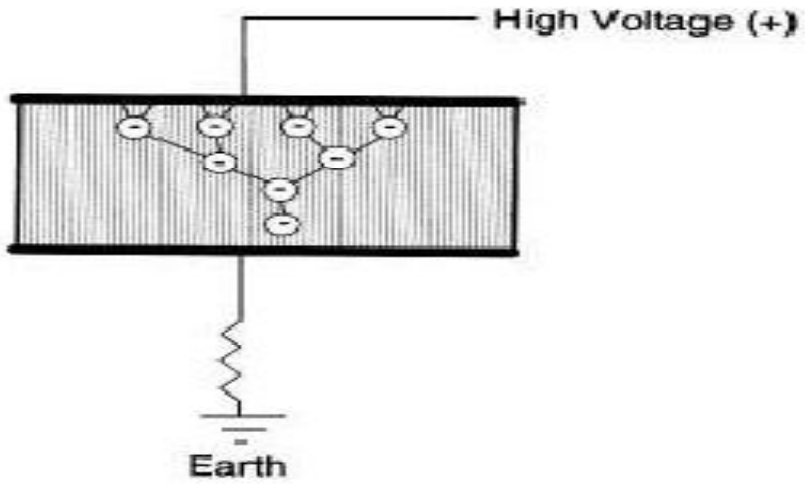
1.8.2.2 The ion chamber region:

When the voltage is large enough, almost all ions are collected and the Number of ions recombining is negligible and the pulse stops increasing with the voltage and gives a plateau shape where the current

Reaches a maximum value (saturation current) which is proportional to the amount of incident radiation (Hanan 2007).

1.8.2.3 The proportional region:

When the voltage increases beyond the ion region the pulse height starts Increasing again. The ions gain enough energy to get accelerated and these accelerated ions causes more ion pairs to be produced through secondary ionization.



Figure(2.18) Schemed diagram of gas multiplication process(Hanan 2007).

1.8.2.4 The Geiger Muller region:

When the applied voltage is increased, the gas multiplication is so great that a single ionizing particle produces multiple avalanches resulting in a very large pulse. The size of the pulse is the same, regardless of the quantity of Incoming energy.

1.8.2.5 The continuous discharge region:

When the voltage is increased beyond the Geiger-Muller region, the voltage is high enough to ionize the gas molecules directly and a large signal is Generated even when the radiation field is removed. This is called the

Continuous discharge region and radiation detectors should not be operated in this region .

In the current work all the X-ray machines were equipped with an automatic exposure control (AEC) which uses ionization chamber in their operation(Hanan 2007).

1.8.3 Chemical based detectors:

An X-ray photographic film is one of the most important chemical X-ray Detectors, it consists of a radiation sensitive emulsion coated on both sides of atransparent sheet of plastic (base), the film base should provide strong Support for the emulsion and must not absorb too much light when viewed and must be thick, flexible and strong enough to allow ease developing and to be conveniently snapped into the view box repeatedly .

When X-ray beam passes through the body tissues, variable fractions of the Beam will be absorbed, depending on the composition and thickness of the Tissues and the quality of the beam. The information content of this X-ray image must be transformed into a visible image. The X-ray image is first Converted into a light image using an intensifying screen which absorbed the energy in the X-ray beam that has penetrated the patient and convert this Energy into a light pattern which has as nearly as possible the same information as the original X-ray beam. The more light a screen produces for a given input of X-radiation, the less X-ray exposure and thus shorter exposure time are needed to expose the film.

2.9Radiation biological effects:

The human body consists of tissues and organs. These tissues and organs are Composed of cells which consist of molecules and other biological materials.

The molecules are a combination of atoms. The cell is composed mainly of nucleus, a surrounding liquid known as the cytoplasm and a membrane which forms the cell wall. The cytoplasm is the factory of the cell while the nucleus contains all the information which the cell needs to carry out its function and reproduce itself. The nucleus contains the chromosomes which are small threadlike structures made of genes. Then genes consist of deoxyribonucleic acide (DNA) and protein molecules and carry the information, which determines the characteristics of the daughter cell. Radiation may cause changes in complex molecular systems, such as living cells, in two ways direct interaction with the DNA in the cells and indirect interaction where the radiation may interact with other atoms or molecules in the cell (particularly water) to produce free radicals Biologic effects of radiation exposure can be classified as either stochastic or deterministic (Hanan,2007)

2.9.1 A stochastic effect:

A stochastic effect is one in which the probability of the effect, rather than its severity, increases with dose. Radiation-induced cancer and genetic effects are stochastic in nature. For example, the probability of radiation-induced leukemia is substantially greater after an exposure to 1 Gy (l00 rad) than to 0.01 Gy (l rad), but there will be no difference in the severity of the disease if it occurs. Stochastic effects are believed not to have a dose threshold, because injury to a few cells or even a single cell could theoretically result in production of the disease(Bushberg,2012).

2.9.2 deterministic effect:

If a radiation exposure is very high, the predominant biologic effect is cell Killing that results in degenerative changes in the exposed tissue. In this case, the severity of the injury, rather than its probability of occurrence, increases with dose. These so-called deterministic effects differ from stochastic effects in that they

require much higher doses to produce an effect. There is also a threshold dose below which the effect is not seen. Cataracts, erythema, fibrosis, and hematopoietic damage are some of the deterministic effects that can result from large radiation exposures(Bushberg el al ,2012).

2.9.3 Somatic effects:

Somatic effects are harm that exposed individuals suffer during their lifetime, such as radiation induced cancers (carcinogenesis), sterility, pacification of the eye lens and life shortening(E. B. Podgorsakn 2005).

2.9.4 Genetic effects:

Genetic or hereditary effects are radiation induced mutations to an individual's genes and DNA that can contribute to the birth of defective descendants (E. B. Podgorsakn 2005).

2.10 Protection of the Patient in Diagnostic Radiology:

An important goal in diagnostic imaging is to achieve an optimal balance between image quality and dose to the patient.

Increasing the kVp will result in a greater transmission (and therefore less absorption) of X-rays through the patient. Even though the exposure per mAs increases as the kVp is increased, an accompanying reduction in the mAs will decrease the incident exposure to the patient. Unfortunately, there is a concomitant reduction in image contrast due to the higher effective energy of the X-ray beam. Within limits, this compromise is acceptable. Therefore, the patient exposure can be reduced by using a higher kVp and lower mAs. Filtration of the polychromatic X-ray energy spectrum can significantly reduce exposure by selectively attenuating the low-energy X-rays in the beam that would otherwise be absorbed in the patient with little or no contribution to image formation. These low-energy X-rays mainly impart dose to the skin and shallow tissues where the beam enters the patient. As the tube filtration is increased, the beam becomes

hardened i.e. the effective energy increases andthe dose to the patient decreases because fewer low energy photons are in the incident beam.

Increasing the source-to-object distance (SOD) and the source-to-image distance (SID) helpsreduce dose. As the SOD and SID are increased, a reduced beam divergence limits thevolume of the patient being irradiated, thereby reducing the integral dose. The exposure dueto tube leakage is also reduced since the distance from the tube to the patient is increased,although this is only a minor consideration (Ernest,et ,al 2014)

2.11 Literature Review:

Protecting the gonads of patient is of particular importance during diagnostic imaging of the pelvis since evidence suggests that X-rays could cause direct damage to the gonad which could result in mutation. Gonad shielding during diagnostic X-ray procedures is an effective way of reducing dose to patients' reproductive organs and reduces the risk of genetic effects in future generations. Given the potential harmful effects associated with exposure to ionizing radiation, it is important not just to provide gonad shielding, but also to measure patient doses, and reduce them where possible (Ofori, et al 2013).

Diagnostic X-ray examinations play an important role in the health care of the population in worldwide. These examinations may involve significant irradiation of the patient and probably represent the largest man-made source of radiation exposure for the population.

Radiationhas been long known to be harmful to humans. The radiation exposurereceived in X-ray examinations is known to increase the risk of malignancy aswell as, above a certain dose, the probability of skin damage and cataract.

The biological effect of radiation depends on the total energy of radiationabsorbed (in joules) per unit mass (in kg) of tissue or organ. This quantity iscalled absorbed dose and is expressed in Gray (Gy).

If a patient is exposed to an X-ray beam, some X-ray photons will pass Through the patient without any interaction, and therefore will produce no Biological effect. On the other hand X-ray photons which are absorbed may produce effects. Absorbed dose of radiation can be measured and/or Calculated and form basic evaluation of the probability of radiation induced Effects. In evaluating biological effects of radiation after a particular exposure of the body, further factors such as the varying sensitivity of different tissues

And absorbed doses to different organs have to be taken into consideration.
To compare risks of partial and whole body irradiation in diagnostic Radiology effective dose is commonly used, and is expressed in severed(Sv)(Hanan,2007).

In today's diagnostic radiology, there is a growing concern about radiation exposure. This can be seen in the recommendations of the International Commission on Radiation Protection (ICRP) and many other National publications (Hanan,2007) . All these recommendations advice that X-ray Examinations should be conducted using techniques that keep patients doses As low as compatible with the medical purposes of the examinations.

In order to achieve this recommendation, it is necessary to understand the factors that affect the exposure and to be able to evaluate patients doses.

Intensive studies in the field of patient dose were conducted in the United Kingdom (UK) these studies eventually lead to the introduction of the European Union Council Directive which made it compulsory that patients dose be measured in every hospital and that doses should be compared to reference dose levels established by the competent authorities.

The need for standardization of radiation exposure and guidance levels for Various radiographic examinations has also been proposed by the International Atomic Energy Agency (IAEA) as a safety standard. The guidance levels by IAEA are based on UK and European studies. Several guidelines and dose reference levels were also published by number of International organizations and was recently summarized by ICRP.

These guidelines have stimulated worldwide interest in patients' doses and Several major dose surveys have been conducted (Hanan,2007) . Patient dose has often been described by the entrance skin dose (ESD) as measured in the centre of the X-ray beam including backscatter radiation. Because of the simplicity of its

measurement, ESD is considered widely as the index to be assessed and monitored. ESD is measured directly using Thermo luminescence Dosimeter (TLD) placed on the skin of the patient or indirectly from the measurements of dose-area product using a large area Transmission Ionization Chamber (TIC) placed between the patient and the X-ray tubeThe use of TLD method in ESD assessment is a time consuming process.

TLD technique requires prolonged annealing and reading process, Furthermore, the use of TLD technique requires special equipments and Thorough calibration facilities which may not be available in most X-ray Departments. On the other hand TIC method does not provide direct Measurement of skin dose and mathematical equations are needed to Convert TIC reading into Skin dose.

Because of the limitations associated with both TLD and TIC, several Mathematical equations have been suggested to relate skin dose to the used Exposure factors such as the applied mAs, focus to skin distance (FSD),filtration, output, and the applied kVp .

These equations provide an easy and more practical mean of estimating skin dose even before exposure. They also provide the easiest and cheapest technique can be employed in any kind of patient dose survey or audit. Despite the attractive nature of the calculation methods of patient dose, one should make sure that the used X-ray equipment has an adequate QC protocol that ensures the accuracy of the measured exposure factors (Hanan,2007).

For the purpose of dose estimate, charts and monograms have beenpublished . These monograms and charts allow skin dose to be determined graphically over the diagnostic range of kVp, source to skin distance SSD and filtration. The use of those monograms and charts may be difficult and time consuming. An easier approach is to develop a functional relation between skin dose and the radiographic

parameters such as kVp, mAs, SSD and filtration. Such an equation would make skin dose estimation much easier and practical.

Although ESD may be sufficient for quality control measurements where the Stability of the X-ray equipment is often of concern, the entrance dose is notsufficient for comparison or evaluation of actual patient dose and associated risk. If the risk involved in an X-ray examination is to be estimated, ESD is not sufficient and patient dose needs to be described by other quantity that is More directly related to radiation effect. At present, it is considered that Radiation-induced effect can be assessed by virtue of the radiation doses in Different organs or tissues in the body.Such data (organ dose) cannot be Measured directly in patients undergoing X-ray examinations, and are Difficult and time consuming to be obtained by experimental measurements Using physical phantoms.

One way of estimating internal dose of a patient is the percentage depth dose Method. Percentage depth dose(PDD) is defined as the ratio of the absorbed doseat a certain depth to the dose at a reference depth (usually skin dose).

Percentage depth dose is usually measured using a water phantom and ionization chamber. The dose is measured at the surface of the phantom and at various depths within the phantom. The percentage depth doses at various depths are then calculated. Patients organ dose is then calculated from the Knowledge of the organ depth and the previously calculated percentage depth.Provided that sufficient information regarding the exposure technique and patient size are available, organ doses can be calculated to a reasonable Approximation using Monte Carlo simulation or depth-dose techniques.

2.12 Calculation methods of entrance skin dose:

Measurement of ESD is usually required for a specific type of radiograph if deterministic effects are possible. Entrance surface dose can be measured directly on the patient with TLDs or can be derived from measurements of incidence absorbed dose (ID) by multiplying by the backscatter factor(Tuokye felix2016).

2.12.1 Determination of ESD from TLD measurements:

TLD's are considered as the gold standard for determination of the entrance surface dose in practice. Measurements are made with thermo-luminescent dosimeters, TLDs, attached to the patient or phantom at points where the x-ray beam enters the patient. TLDs are read in a standard manner and the value read is used as an estimate of the ESD received by the patient. If correctly calibrated to measure air kerma free in air, the TLD should give a direct reading of the entrance surface dose, and no correction is needed for back scattered radiation or distance from the tube focus,(Ibrahim , 2007 and Chilton,Didcot,1992).

2.12.2 Calculation of ESD from tube output data:

ESD may be calculated in practice by means of knowledge of the tube output. The relationship between x-ray unit current time product (mAs) and the air kerma free in air is established at a reference point in the x-ray field at 80 kVp tube potential. Subsequent estimates of the ESD can be done by recording the relevant parameters (tube potential, filtration, mAs and FSD) and correcting for distances and back scattered radiation according to the following equation

$$ESD = OPx \left(\frac{kV}{80}\right)^2 xmAsx \left(\frac{100}{FSD}\right)^2 xBSF \quad \textbf{….(2.1)}$$

where OP is the tube output per mAs measured at a distance of 100 cm from the tube focus along the beam axis at 80 kVp, kV is peak tube voltage (kVp) recorded

for any given examination (in many cases the output is measured at 80 kVp, and therefore this appears in the equation as a quotient to convert the output into an estimate of that which would be expected at the operational kVp. The value of 80 kVp should be substituted with whatever kVp the actual output is recorded at in any given instance).

mAs is the tube current-time product which is used in any given instant. FSD is the focus-to-patient entrance surface distance and BSF is the backscatter factor.

The second trace of skin dose can be use formulas published by Tung and Tsai in 1999. Tung and Tsai studied the relationship between entrance skin dose and X-ray tube potential and between entrance skin dose and Aluminum filtration(Ibrahim , 2007).

$$ESD = c\left(\frac{KVp}{FSD}\right)^2\left(\frac{mAs}{mm.Al}\right) \quad \textbf{(2- 2)}$$

2.12.3 Calculation of ESAK and ESD from Tube Output Data:

The relationship between x-ray unit current time product (mAs) and the air kerma free in air is established at a reference point in the X-ray field for the range of tube potentials encountered. Subsequent estimate of the entrance dose can be done by recording the relevant parameters (tube potential, filtration, mAs and FSD) and correcting for distances (and back scattered radiation in case of ESD estimation) as implied in the formula bellow (Ibrahim , 2007).

$$ESAK = K_{air}(100cm).(100/FSD)^2 \quad \textbf{(2 -3)}$$

$$ESD = ESAK.BSF \quad \textbf{(2 -4)}$$

2.13Previous studies:

(Ofori el al2013),Protecting the gonads of patient is of particular importance during diagnostic imaging of the pelvis since evidence suggests that X-rays could cause direct damage to the gonad which could result in mutation. Gonad shielding during diagnostic X-ray procedures is an effective way of reducing dose to patients' reproductive organs and reduces the risk of genetic effects in future generations. Given the potential harmful effects associated with exposure to ionizing radiation, it is important not just to provide gonad shielding, but also to measure patient doses, and reduce them where possible.

The most reliable dosimeter quantities commonly used in diagnostic Radiology to give an indication of the typical dose that is being delivered to an average adult patient are the patient Entrance Surface (skin) Dose (ESD) including backscatter for simple X-ray projections, and the Dose Area Product (DAP) for complex examinations. The ESD, in particular, is recommended as the most appropriate dosimeter quantity For simple X-ray projections since it meets the three basic conditions Set out by the International Atomic Energy Agency (simple to measure, Permits direct measurement on patient during the examination, Patient radiation protection in pelvis X-ray examination has not been given much attention in Ghana. Therefore this study was set out to provide an estimate of patient dose in pelvic examination being undertaken at selected diagnostic centers in Ghana as a baseline data for pelvic dose optimization in Ghana. The estimated mean ESD values were compared with the International Atomic Energy Agency], the European Commission (EC) guidance on diagnostic reference levels for medical exposures [8], and the 2005 United Kingdom reviewed and is representative of the dose received by the patient). It is also recommended by the Commission of the European Communities (CEC) in the document on quality criteria for the most

common radiographic images. In addition, the measurement of ESD permits easy comparison with published diagnostic guidance or reference levels. This comparison was felt to be appropriatebecauseat the time of the study, there were no accepted local or nationaldiagnostic level values in Ghana for comparison.
The aim of this study was to provide patient dose estimates for pelvic examination being undertaken at selected diagnostic centers in Ghana as a baseline data for pelvic dose optimization in Ghana. Dose measurements
Were calculated on 323 patients (137 (42%) male, 186 (58%) female, ages, 38.56 yr ± 9.0; range 20–68).
The Entrance Surface Dose (ESD) was determined by an indirect method, using the patient's anatomical data and exposure parameters utilized for the specific examination is the(6.85µGy)

(Akbarel al ,2015) The knowledge of the radiation dose received by the patient during the radiological examination is essential toprevent risks of exposures. The aim of this work is to study patient doses for common diagnostic radiographicexaminations in hospitals affiliated to Kashan University of Medical sciences, Iran. The results of this survey arecompared with those published by some national and international values. Entrance surface dose (ESD) was Measured based on the exposure parameters used for the actual examination and effective dose (ED) wascalculated by use of conversion coefficients calculated by Monte Carlo methods. The mean entrance surface doseand effective dose for examinations of the chest (PA, Lat), abdomen (AP), **pelvis**are 0.37, 0.99, 2.01, **1.76mGy**,and 0.04, 0.1, 0.28, 0,28,mSv respectively.
The ESDs and EDs reported in this study, except for examinations of the chest,

are generally lower than comparable reference dose values published in the literature. On the basis of the resultsobtained in this study can conclude that use of newer equipment and use of the proper radiological parameter can significantly reduce the absorbed dose.

Kofi Ofori(2014),The Caldose_x 5.0 software has been used to assess the entrance skin doses (ESD) andeffective doses (ED) of adult patients undergoing x-ray examinations of the thorax/chest(PA/RLAT), **pelvis** (AP), cervical spine (AP/LAT), thoracic spine (AP) and lumber spine (AP) inthree public hospitals each equipped with constant potential generators (no ripple), an x-rayemission angle of 17 and a total filtration of 2.5 mm Al. In all, 320 patients were surveyedwith an average of over 100 patients per a hospital. The patients' data and exposureparameters captured into the software included age, sex, examination type, projectionposture, tube potential and current-time product. The mean ESD and ED of seven differentexaminations were calculated using the software and compared with published works andinternationally established diagnostic reference levels. The mean ESD calculated were0.27 mGy, 0.43 mGy, **1.31 mGy**, 1.05 mGy, 0.45 mGy, 2.10 mGy, 3.25 mGy and the meaneffective doses were 0.02 mSv, 0.01 mSv, 0.09 mSv, 0.05 mSv, 0.03 mSv, 0.13 mSv, 0.41 mSvfor thorax (PA), thorax/chest (RLAT), **Pelvis (AP)**, cervical spine (AP), cervical spine (LAT),thoracic spine (AP) and lumber spine (AP) respectively.

CHAPTER THREE

Material and methods:

3.1 Patient data:

The patient anthropometrical data(age and gender) and technical parameter (KV, mAs FSD) used were collected at the time of the examination

3.2 equipment:

Four x-ray machines were used in thise study all apparatus namelyshimadzu(Omdurman(A) ,Elobeid(B) and blue nile(D) hospital)arebut in Asia(C) hospital are listem.

3.3 Method of measurement:

To calculate the entrance surface doses (ESD) for patients undergoing common x-ray examination by using the Dose Cal software. The ESD is defined as the absorbed dose measured in air on the x-ray beam axis at the point where the x-ray beam enters the patient.

Dose calculation is a software system designed to calculate and report entrance surface dose manually the tube output data and exposure factors entered. The exposure factors were fed in excel program and then the mean, standard and also minimum and maximum values for kV, mAs, age were decided (in tables). The ESD was calculated in the present work using the following relation

$$ESD = OPx \left(\frac{kV}{80}\right)^2 xmAsx \left(\frac{100}{FSD}\right)^2 xBSF$$

Where (OP) is the tube output per mAs measured at a distance of 100 cm from the tube focus along the beam axis. kV is peak tube voltage recorded for any given examination. mAs is the tube current and time product, FSD is the focus-to-patient entrance surface distance and BSF is the backscatter factor, ESD values were measured, using CALDose_X5 program.

The software used in this study was specially developed for the evaluation of ESD dose. It was developed by the radiological protection center of saint georges hospital London. It is computer based system by which by patient doses can be determined from exposure factors recorded at the time of the examination. The use of software program to perform patient doses is modern resource in dosimetery and is being widely used in hospital. In this program, ESD, body organ dose, effective dose, risk of cancer incidence and risk of cancer-related mortality can be determined, based on prior knowledge of factors related to examination techniques and the output data. This program is able to process large volumes of data within a short time, without the need for invasive measurements on patients

For CALDose_X5 to function, it was necessary to furnish the output in mGy/mAs in all X-rays machines, used for dose evaluation. Once the tube potential, tube current, exposure time, FDD and FSD were determined, ESD could be calculated by equation above.

The kV and mAs was changed according to thetype of examination and patient age and Weight.The data was analyzed using excel program andthen the tables were created in chapter four.

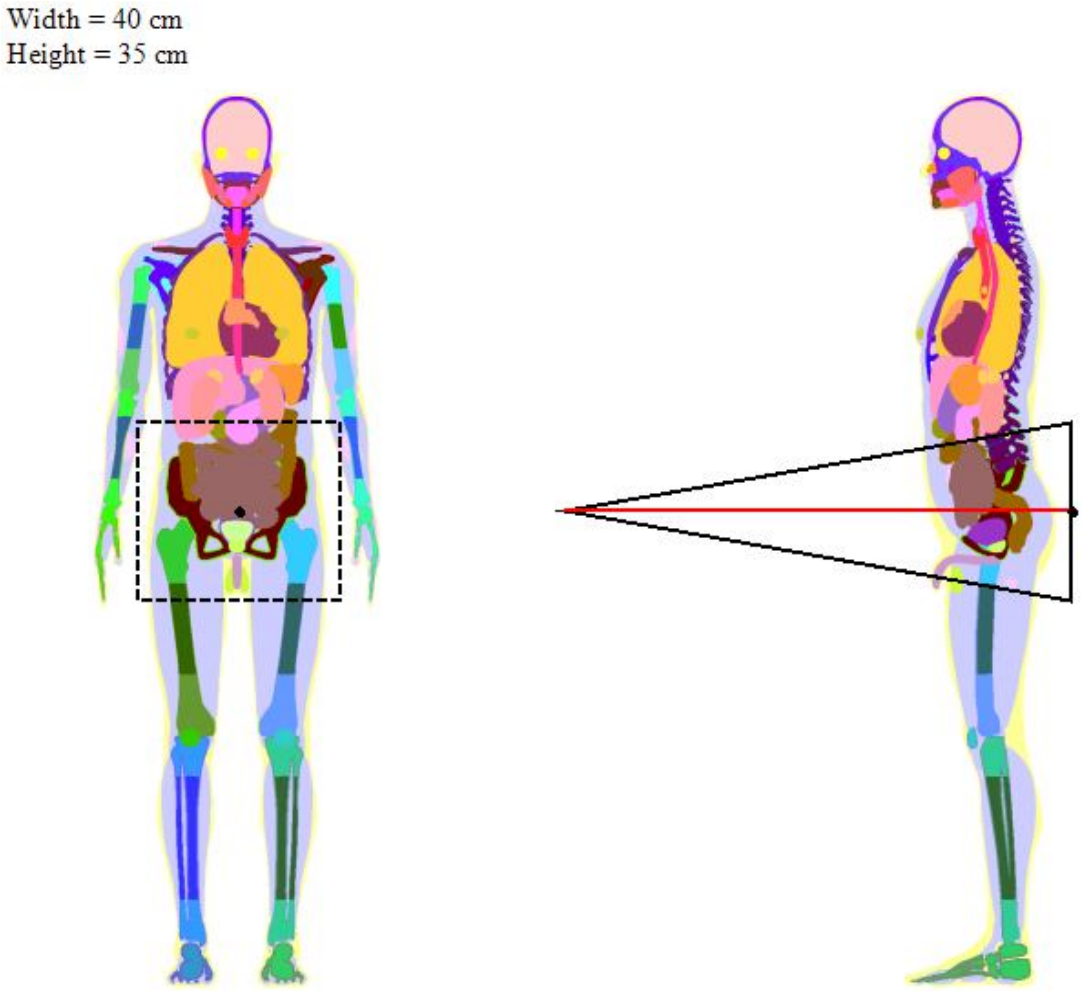


Figure (3-1) the set-up patient for examination

Chapter four

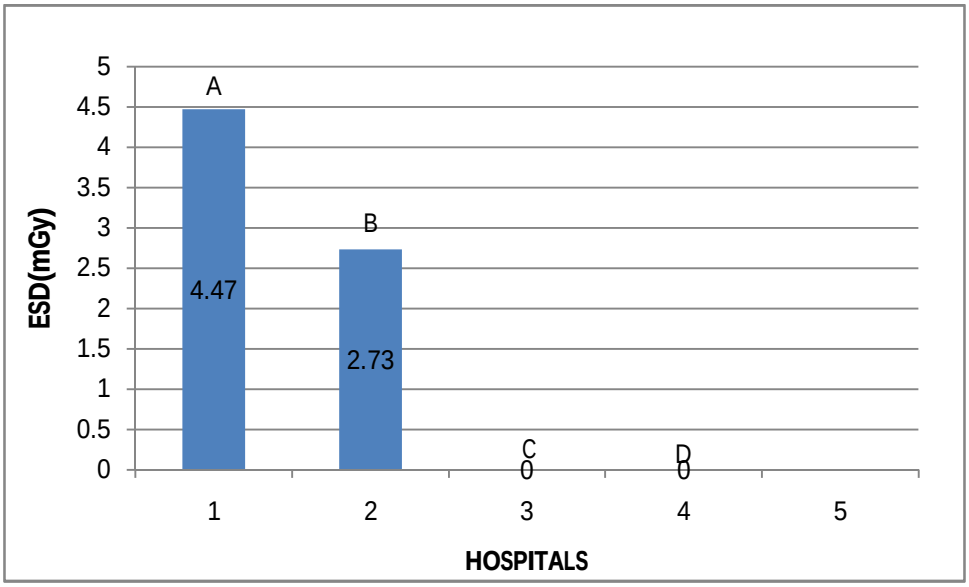
Results:

This work was carried out in four hospitals (A, B ,C,andD; four x-ray units were includedin this study. The results obtained were recorded intables and figures shown below. The results includedthe mean, the stander deviation, the minimum and themaximum for (ESD) and ED(mSv) taken mean only for alldifferent cases in the four units. The results of ESD(mGy) and ED(mSv) for the pelvis x-ray examination obtained for the four hospitals are tabulated according to the exposure parameters for anterior- posterior(AP) and age and gender groups are presented in table (4-1)to table (4-5).

Table(4-1) ESD(mGy) and ED (mSv)for age range 0→19 year in four hospital

age		A	B	C	D
0->19	ESD(mGy)	4.47	2.73	0	0
	Sample size	1	1	0	0
	ED(mSv)	0.29	0.17	0	0
	gender	M	F	0	0

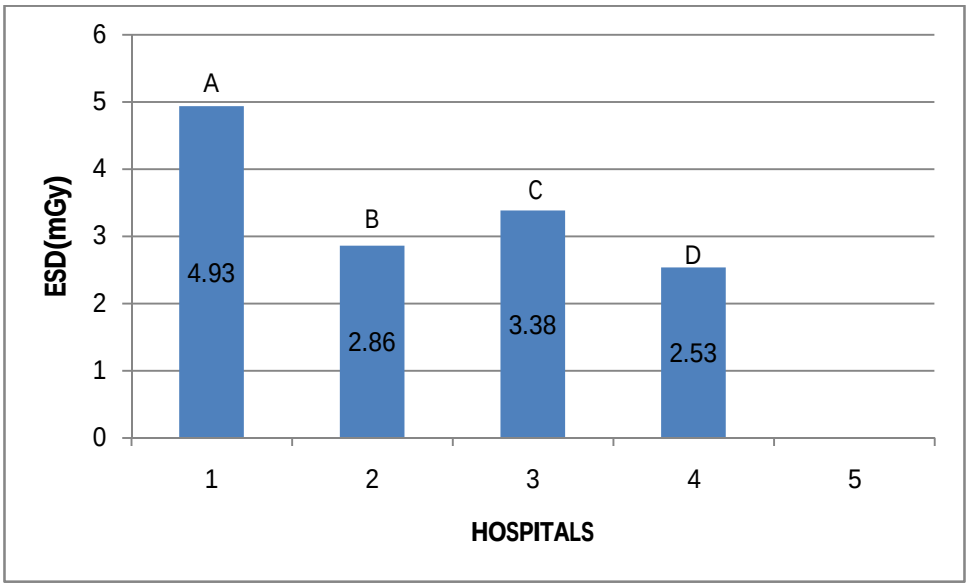
figure(4-1)show the ESD(mGy) for male and female age range between 0→19 year in four hospital



Table(4-2) ESD (mGy) and ED(mSv) for male age range between 20→45 years in four hospital

age		A	B	C	D
20->45	ESD(mGy)				
	Mean	4.93	2.86	3.38	2.53
	SD	0.63	0.28	0	0.17
	MAX	5.97	3.18	3.38	2.63
	MIN	4.20	2.65	3.38	2.43
	Sample size	6	3	1	2
	ED(mSv)	0.32	0.23	0.21	0.14

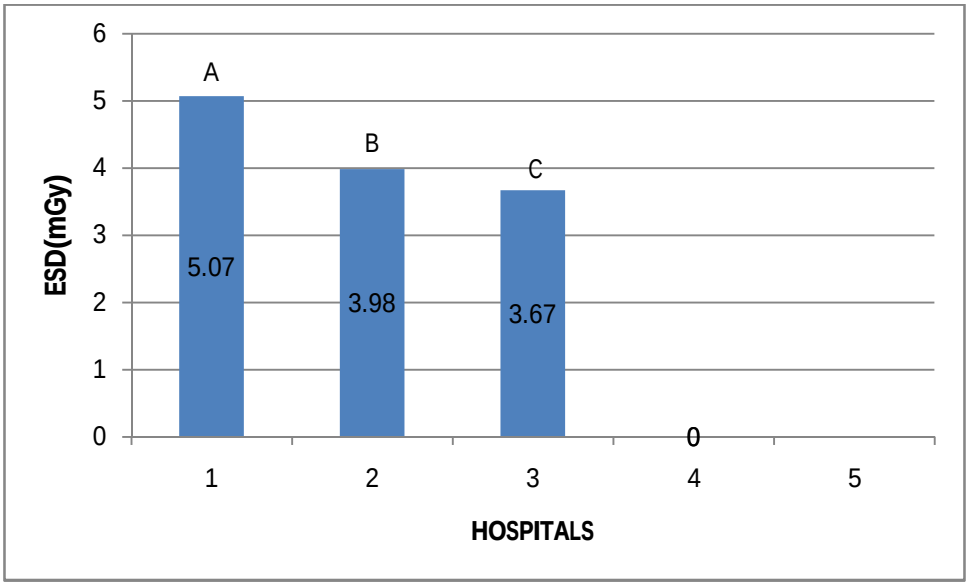
Figure (4-2)show the mean ESD (mGy) for male ,age from (20 to 45) in four hospital



Table(4-3) ESD (mGy) and ED (mSv)for female age range between 20→45 year in four hospital

age		A	B	C	D
20->45	ESD(mGy)				
	Mean	5.07	3.98	3.67	0.00
	SD	2.17	0.22	0	0.00
	MAX	6.99	3.48	3.67	0.00
	MIN	2,71	3.04	3.67	0.00
	Sample size	3	2	1	0
	ED(mSv)	0.34	0.20	0.24	0

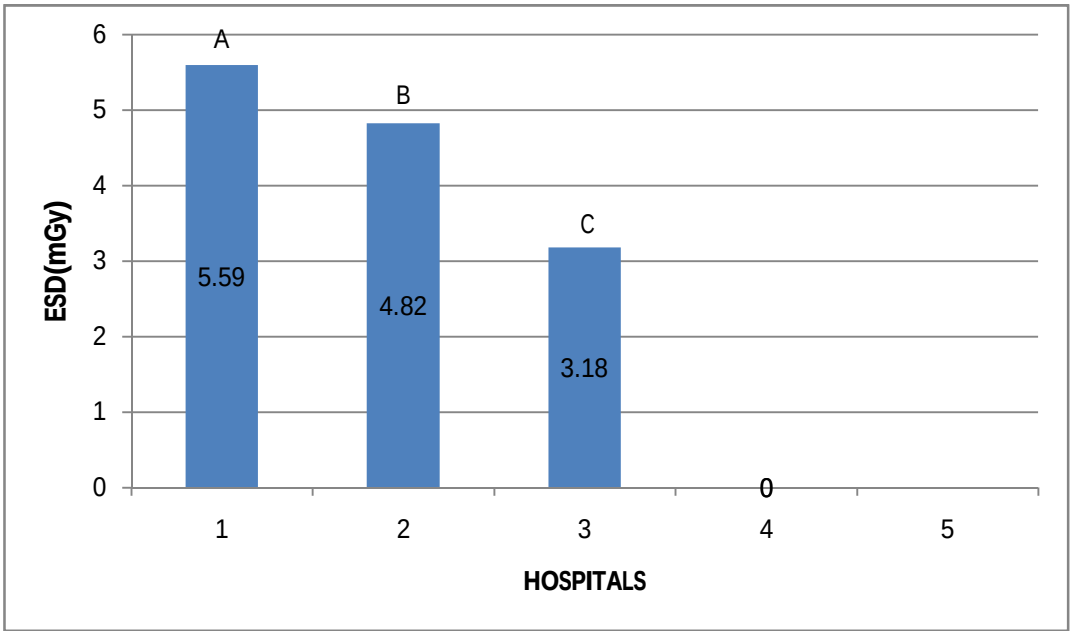
Figure (4-3)show the mean ESD (mGy) for female ,age from (20 to 45) in four hospital



Table(4-4) ESD (mGy) and ED(mSv) for male age range between(46→70) years in four hospital

age		A	B	C	D
20->45	ESD(mGy)				
	Mean	5.79	4.82	3.18	0
	SD	1.41	1.46	0	0
	MAX	6.72	6.82	3.18	0
	MIN	4.38	3.58	3.18	0
	Sample size	5	4	2	0
	ED(mSv)	0.35	0.29	0.22	0

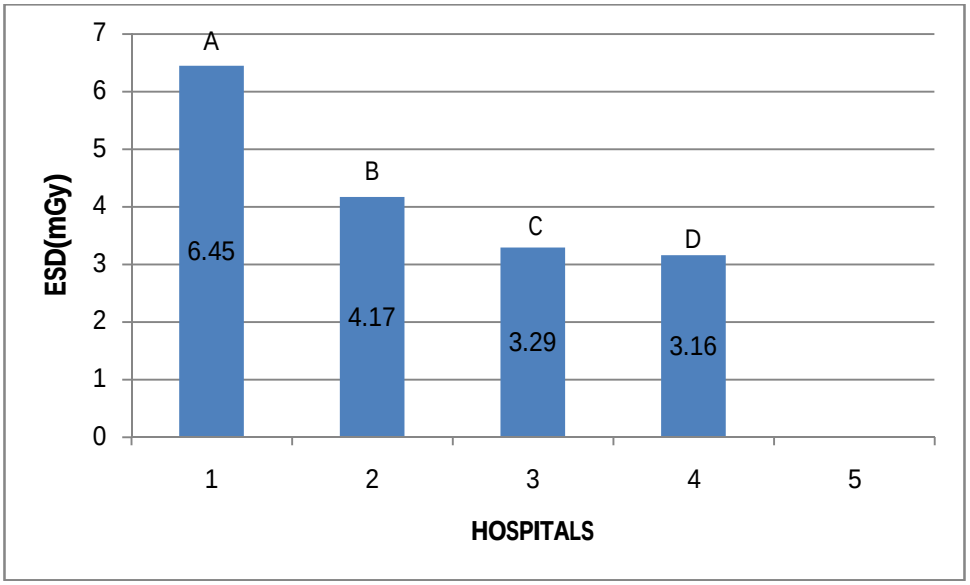
Figure (4-4)show the mean ESD (mGy) for male ,age range between (46 to 70) years in four hospital



Table(4-5) ESD (mGy) and ED(mSv) for female age range between 46→70 year in four hospital

age		A	B	C	D
20->45	ESD(mGy)				
	Mean	6.45	4.17	3.29	3.16
	SD	0.78	0.42	0.68	0.32
	MAX	7.15	4.47	4.06	3.38
	MIN	5.46	3.87	2.78	2.93
	Sample size	4	2	3	2
	ED(mSv)	0.48	0.21	0.21	0.18

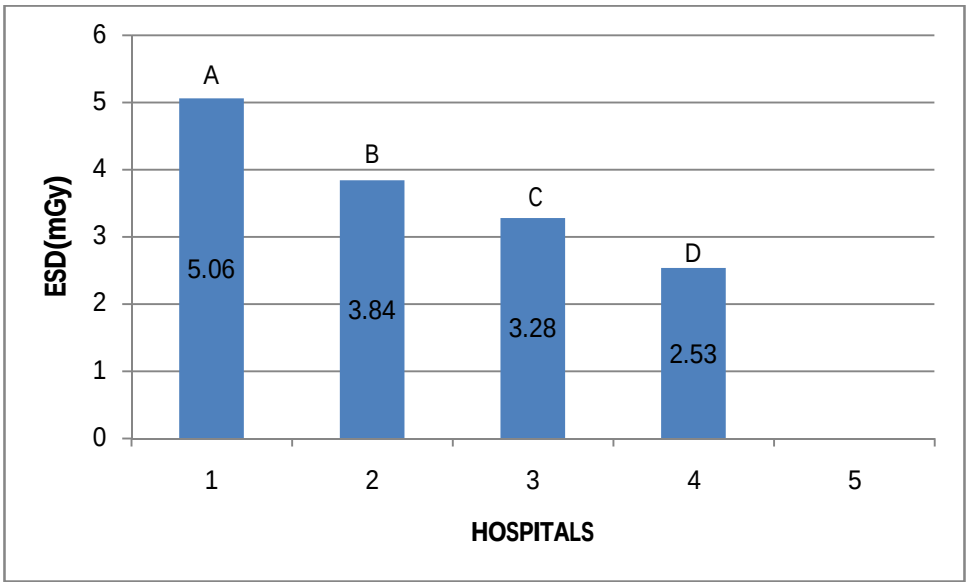
Figure (4-5)show the mean ESD (mGy) for pelvis x-ray for female ,age from (46 to 70)



Table(4-6)mean ESD (mGy) for male in four hospital

ESD(mGy)	A	B	C	D
Mean	5.06	3.84	3.28	2.53
SD	0.67	1.39	0.22	0.00
MAX	5.79	4.82	3.38	2.53
MIN	4.47	2.86	3.18	2,53
Sample size	12	7	3	2

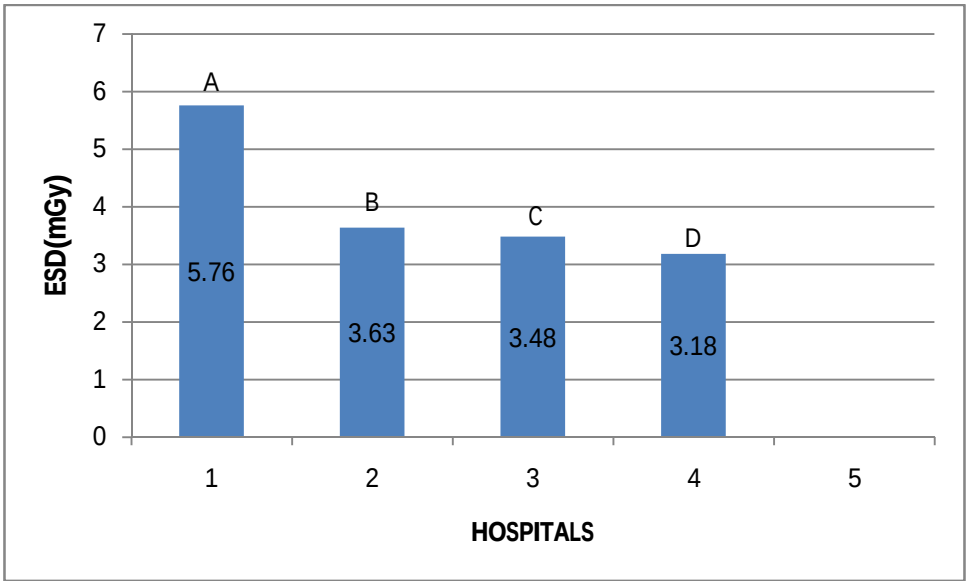
figure (4-6)mean ESD (mGy) for male in four hospital



Table(4-7)mean ESD (mGy) for female in four hospital

ESD(mGy)	A	B	C	D
Mean	5.76	3.63	3.48	3.16
SD	0.69	0.74	0.04	0.00
MAX	6’45	4.17	3.67	3.16
MIN	5.07	2.73	3.29	3.16
Sample size	7	5	4	2

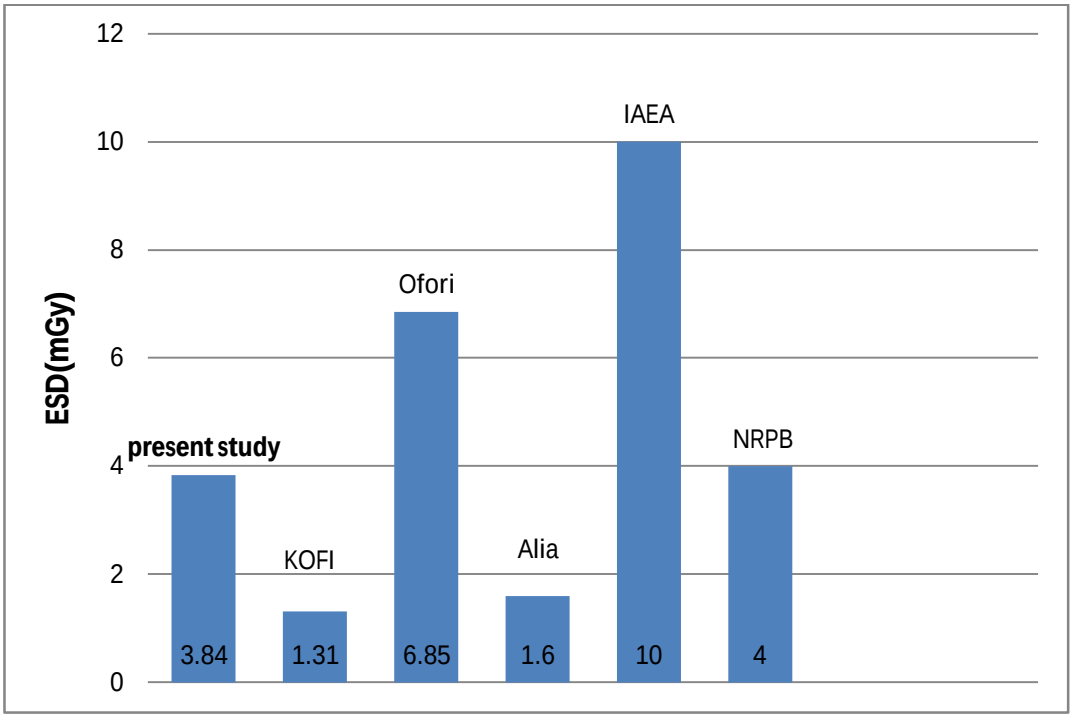
figure (4-7)mean ESD (mGy) for female in four hospital



Table(4-8)mean ESD (mGy) for all gender in present study and previous study and comparative with DRLs for (IAEA, EU,1996) and (UK,2005),

countries	ESD(mGy)
Present study	3.84
Kofi Ofori(2014)	1.31
Ghana(Ofori EK,2013)	6.85
Aliasgharzadeh(2015)	1.76
IAEA, EU	10
(NRPB, (Uk2005),	4

Figure (4-8):Mean ESD for pelvis in present study and prepiuos study and DRL for (IAEA, EU,1996) and (UK,2005),



Chapter five

5 Discussions, conclusions, Recommendation, and References

*5.*1Discussions:

(ESD) for patients underwent pelvis X-ray examinations atradiology department. The selected sample in this investigationincluded 42 patients. The data collected from four centers. The patient information and exposure technical parameter for pelvis AP projection considered are tabulated. Patient are classified in three different age groups. 18→ 19 years. 20→45years. 46→70 years.According the age and gender intable(4-1) to table (4-5). These is wide variation in technical parameter (kv- mAs) use in these hospital, the results of statistical ESD for the pelvis AP projection , were presented in each table.the mean , maximum , minimum, were presented.

the range of ESD in all hospital is (5.56-2.78 mGy)with mean is(3.92 mGy)are presented in table (4-5).

from (4-1) to table (4-5) presented the values of ESD(mGy)and effective ED(mSv) according to age group and gender obtained at four hospital .

Table(4-6)the presented the meanESD for all male age group.

Table(4-77)the presented the mean ESD for all female age group.

The percent ofThe mean ESD for all female age groups and all male age Group is 4.00 to 3.68

The mean ESD in(A)hospital for female is always the high than the mean ESD in others hospitals(B,C,D)but it comparative withDRL is the ideal.

Table(4-8) show the mean ESD for the study and previous study and DRLS for (IAEA, EU,1996) and (UK,2005),

5.2 conclusions:

Entrance surface doses were estimated in the present study for patients undergoing selected pelvis x-ray examinations in some Sudanese hospitals.Mean ESDs of hospital (A)male or female were found not to be within the DRLs established by NRPB and UK. But the IAEA EUare within the DRLs but in others hospitals is accept.

The mean ESD values in all the hospital were also compared with the reference level recommended by NRPB and European Commission

The results were found to be optimal in all other hospital except for(A) hospital comparative with DRLsof IAEA,EU Either results will needed for quality assurance (QA) programs to be undertaken to avert considerable cost and high patient doses.

The recommendations to avoid unnecessary radiationexposure are also given without lose of image quality.

The mean ESDdoses when compared with DRLs are lower. This mean that the radiation risk to an average patient in the hospitals included in this work is low and the risk to workers in the hospitals will be generally low. Although the mean ESD is lower than the reference levels, data shows that ESD is still above reference levels in some hospitals.

Therefore adherence to guidelines should be demonstrated and it is also important to correct operative modalities, which will enable doses to become lower while quality of image is still preserved.

Finally, the study of local diagnostic reference levels (LDRL) is important so that users can compare their work and change their attitude and philosophy for the one that is safer to the staff and the patients

5.3Recommendation:

- Diagnostic radiology should be governed with high professional's techniques to minimize radiation hazard on patient while they are examined by X-ray**.**
- Dose to the patient should be at the lowest level that still guarantees a Sufficient diagnostic image quality.
- We must follow the NCRP recommendations that dealing with minimizing Patient dose.
- Further studies are needed to assess and measure ESDs to keep it at Reference levels.

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