Chapter one

1.1 Introduction:

X-rays have been in use for over a century since the report of their discovery by Roentgen (1896). In the health and medical areas, X-rays have been used for both diagnosis and treatment of patients' conditions. In diagnostic medical imaging (radiography), X-rays are used in a wide variety of examinations. (Johns 1983)

X-rays are electromagnetic (EM) radiation with characteristics of short wavelengths, very high frequencies and very high energy. High energy EM radiation exhibits characteristics of both waves and discrete bundles of energy called photons. X-ray photon energy is usually measured in kilo-electron volts (kev) and diagnostic X-ray energies are typically 10 to 150 kev. Such high energy EM radiation is ionizing. (Johns 1983)

Ionizing radiation has potential harmful effects when it irradiates human tissue the exit intensities of the X-ray photons will depend on the properties of the body with in the irradiated area and the characteristics of the X-ray beam. (J.T Bush berg etal , 2002)

The mechanisms that result in reduction of x-ray intensities are the types of interaction with matter ,X-rays with photon energies above 5-10 KeV are called hard x-rays, while those with lower energy are called soft. Due to their penetrating ability, hard X-ray is similar to the size of atoms they are also useful for determining crystal structures by X-ray crystallography. By contrast, soft X-rays are absorbed in air.

In conventional or transmission radiography the object is placed between the source of radiation and the image receptor .The object is exposed to the X-ray and the image or radiograph, of the object is formed on the film due to the differential attenuation of beam by the image. X-ray can penetrate the body, which allows a radiologist to produce pictures of internal structures ,the radiologist can view these on radiographic film or computer monitor . X-ray examinations provide valuable information and play an important role in diagnosis. (James , 2012).

The children chest radiography is the most frequent exam ordered, or referred to the department of Radiology Pediatric patients are a specific group regarding radiation protection in radiology because of the elevated risk for radiation detriment. As pediatric patients have higher probability for late radiation effects, they are assumed to be 2_3 times more radiation sensitive compared to adults, since the longer expected life span is combined with higher radiation sensitivity of the developing organs. To be able to keep doses as low as reasonably achievable

(ALARA), fundamental knowledge of factors concerning patient doses is needed. Pediatric X-ray examinations comprise approximately 10% of all radiological examinations, which may result in situations in which pediatric examinations are not well optimized due to a lack of knowledge in choosing the proper acquisition parameters. Many departments do not use recommended radiographic parameters for neonates and children. Furthermore, wide variations have been found in techniques, equipment performance and radiation doses among different hospitals over the world.(Whitley etal , 2005)

Patients can undoubtedly obtain enormous benefit from these examinations, although the ionizing nature of the X-rays means that their use is not entirely without risk. For this reason, all exposures to diagnostic X-rays need to be justified and optimized in terms of benefit and risk. One of the basic requirements for such requirement is the knowledge of patient doses.(Gaetano etal ,2004)

Effects of ionizing radiation**:**

The deleterious effect of ionizing radiation on human tissue can be divided into two types: - non-stochastic (deterministic)and stochastic effects.

1- Deterministic (Non-Stochastic) Effects:

Deterministic effects only occur once a threshold of exposure has been exceeded. The severity of deterministic effects increases as the dose of exposure increases. Because of an identifiable threshold level, appropriate radiation protection mechanisms and occupational exposure dose limits can be put in place to reduce the likelihood of these effects occurring. (e.g.: cataract, Erythema)

2- Stochastic Effects:

Current thinking is that stochastic effect occurrence follows a linear non-threshold hypothesis. This means that although there is no threshold level for these effects, the risk of an effect occurring increases linearly as the dose increases. (e.g.: induction of cancer and genetic effects). (imagewisely.com)

1.2 Problem of Study:

Pediatric examinations in the Military Hospital of Omdurman result in high radiation dose to patients due to repetition and a lack of knowledge in choosing the proper acquisition parameters.

1.3 Objectives of the study:

1.3.1 General Objective:

- To estimate the Entrance skin dose during chest examination for pediatric patients in Military hospital of Omdurman.

1 .3.2 Specific objectives:

- to determine the radiographic parameters (Kvp, mAs, FSD) for both AP and PA projections.

- to measure the patient data (weight, height, age).

-to calculate the entrance skin dose resulting from chest X-ray examinations

- to find the correlation between ESD and Kvp.

- to find the correlation ESD and mAs .

1.4 Research outlines:

This research is concerned with assessment of entrance skin dose for pediatric patients from chest X-ray examinations. It is divided into five chapters:-

Chapter one deals with introduction, the problem of the study, and the objectives of the study. Chapter two deals with background and literature review to previous studies. Chapter three consists of materials and methods, Chapter four shows the results .chapter five shows the discussions ,conclusion and recommendations.

Chapter two

Background and literature review

2.1 Background:

X-ray is a form of electromagnetic radiation. Most X-rays have a wavelength ranging from 0.01to10 nanometers, corresponding to frequencies in rang 30 terahertz to 30exahertz (3x 10^{16} Hz to3x 10^{19} Hz) and energies in the range100ev to 100kev. X-ray wavelengths are shorter than those of UV rays and typically longer than those gamma rays.

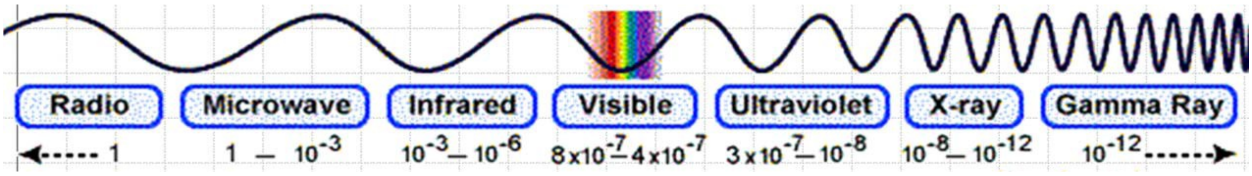


Figure (2-1) the Electromagnetic Spectrum.

X-rays with photon energies above 5-10 kev are called hard x-rays, while those with lower energy are called soft. Due to their penetrating ability, hard X-ray is similar to the size of atoms they are also useful for determining crystal structures by x-ray crystallography. By contrast, soft X-rays are absorbed in air.

William Roentgen discovered X-ray in 1895 and determined they had the following properties:-

-X-ray has a very short wavelength.

- It́ s causes ionization (adding or removing electrons in atoms and molecules).

- It́ s affects photographic film in the same way as visible light (turning black).

-It́ s absorbed (stopped) by metal and bone.

- It́ s transmitted by healthy body tissue.

These properties make X-ray very useful for medical diagnosis and treatment.. (Bush berg etal , 2002)

2.1.1Description of an X-ray machine:-

The main component of X-ray is:

- Source of electrons: A tungsten filament is heated with an electric current to approximately 2000^o C to emit electrons. The temperature is sufficiently high incandescence .the greater the filament current the higher is its temperature, and the greater are the numbers of electrons emitted.

- High voltage supply: this gives energy to the electrons emitted by the source by accelerating them in an electric field .the voltage will vary between 0 and a peak value.

- Target, including focusing system: The energetic from source are made to collide with a suitable target such as tungsten, set in molybdenum or copper to conduct heat away. Source and target are enclosed in sealed tube that is held under high vacuum so the electrons accelerated by the applied high voltage will not collide with gas molecules and lose energy or be deflected .the collision of electrons and deflection in vicinity of target atoms result production of the useful x- rays beam.

- Collimator : when human beings x-rayed ,the beam must be confined to the region under examination , this is no expose tissue unnecessarily to radiation .Accordingly, modern x- ray machines have spatial collimators that can be adjusted the limit the abeam to the area Being studied .

- Filter: we have already mentioned that the X- rays emitted from the X-ray tube target include many low energy photons that do not penetrate enough to contribute to the image but can impart appreciable dose to the subject .the dose from these useless photons can be reduced through use of selective absorbers or filters.

-Tube housing: All the components previously described are incorporated with in a tube housing that prevents the radiation not emitted in direction of the subject from irradiating the surrounding area. (Jacob Shapiro , 2002)

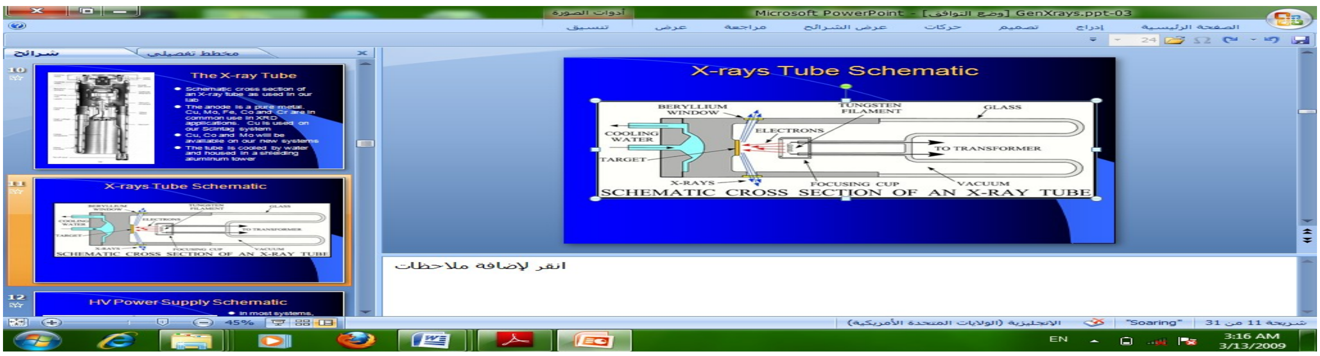


Figure (2-2) component of the x-ray tube.

2.2 Generation of x-ray:-

X-ray can be generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate the electrons released by a hot cathode to a high velocity .The high velocity electrons collide with a metal target, the anode creating the X-ray. When the electrons hit the target, X-rays are created by two different atomic processes:(hyperphysics.com)

2.2.1 Characteristic X-ray emission:

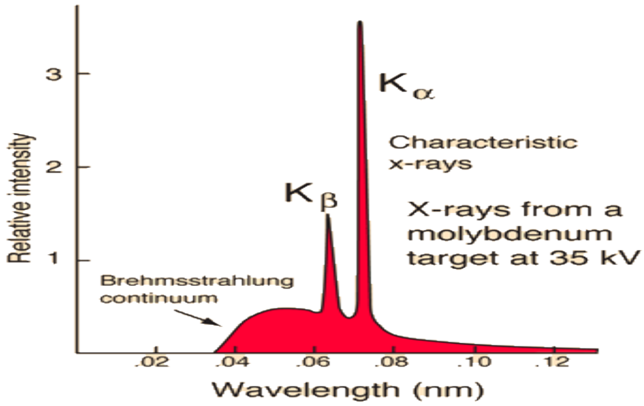


Figure (2-3) characteristic x-ray

Characteristic X-rays are emitted from heavy elements when their electrons make transitions between the lower atomic energy levels. The characteristic X-ray emission which is shown as two sharp peaks in the illustration at left occur when vacancies are produced in the n=1 or K-shell of the atom and electrons drop down from above to fill the gap. The x-rays produced by transitions from the n=2 to n=1 levels are called K-alpha X-rays, and those for the n=3→1 transition are called K-beta x-rays.

Transitions to the n=2 or L-shell are designated as L X-rays (n=3→2 is L-alpha, n=4→2 is L-beta, etc.). The continuous distribution of X-rays which forms the base for the two sharp peaks at left is called "bremsstrahlung" radiation.

X-ray production typically involves bombarding a metal target in an X-ray tube with high speed electrons which have been accelerated by tens to hundreds of kilovolts of potential. The bombarding electrons can eject electrons from the inner shells of the atoms of the metal target. Those vacancies will be quickly filled by electrons dropping down from higher levels, emitting X-rays with sharply defined frequencies associated with the difference between the atomic energy levels of the target atoms. The frequencies of the characteristic X-rays can be predicted from the Bohr model. Moseley measured the frequencies of the characteristic X-rays from a large fraction of the elements of the periodic table and produced a plot of them which is now called a "Moseley plot". Characteristic X-rays are used for the investigation of crystal structure by X-ray diffraction. Crystal lattice dimensions may be determined with the use of Bragg's law in a Bragg spectrometer. (IAEA, 2005)

2.2.2.Bremsstrahlung X-ray :

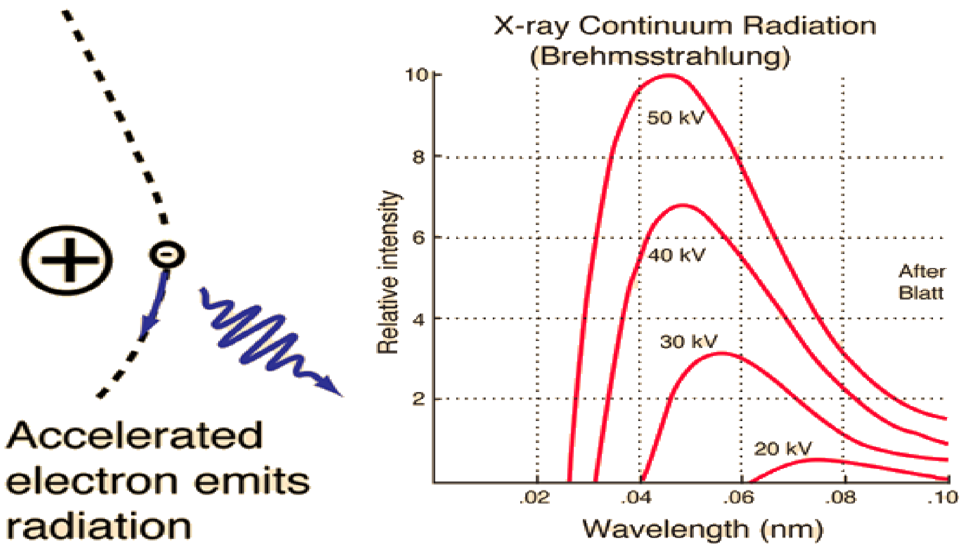


Figure (2-4) Bremsstrahlung X-ray

"Bremsstrahlung" means "braking radiation" and is retained from the original German to describe the radiation which is emitted when electrons are decelerated or "braked" when they are fired at a metal target. Accelerated charges give off electromagnetic radiation, and when the energy of the bombarding electrons is high enough, that radiation is in the X-ray region of the electromagnetic spectrum. It is characterized by a continuous distribution of radiation which becomes more intense and shifts toward higher frequencies when the energy of the bombarding electrons is increased. The curves above are from the 1918 data of Ulrey, who bombarded tungsten targets with electrons of four different energies. The bombarding electrons can also eject electrons from the inner shells of the atoms of the metal target, and the quick filling of those vacancies by electrons dropping down from higher levels gives rise to sharply defined characteristic x-rays. (IAEA , 2005)

2.3 Interaction of X-ray with matter:

X-rays interactions with matter are very important in diagnostic examination for many reasons. For example, the X-rays photographs are produced by particular interactions of X-rays with the structure of human body. As X-rays are photons, when an X-ray beam passes through material (e.g. human body), there are three possible fates awaiting each photon: it can penetrate the section of the matter with no interaction, it can interact with the section of the matter and be absorbed completely by depositing its energy, and also it can interact with the section of the matter and be scattered or deflected from its original direction and hence deposits X-ray photon and matter. In this section we discuss brie y these interactions (James etal , 2006).

2.3.1 **Coherent scattering:**

Coherent scattering, also known as classical scattering, occurs when a low energy X-ray photon interacts with the whole atom. The photon is scattered without change in the internal energy of both the interacting atom and the X-ray photon. Mainly this scattering happens in the forward direction. Although this type of interaction happens at low energy photons, it is generally not signification most diagnostic procedures. However, it may contribute to graying the image called film fog (blurring in the image) (James etal , 2006), (IAEA , 2007).

2.3.2 **Photo electric effect:**

Also known as photo effect, take place when an X-ray photon interacts with a tightly bond orbital electron (from the inner shell). These photons attenuates and disappear while the orbital electron which absorbs the photon energy ejects from the atom as a photo-electron with a kinetic energy equal to the difference between the photon energy and the binding energy of the electron this kinetic energy is given by:

$$E_k = h\nu - E_b$$

Where ν is the frequency of the incident photon h is Planck’s constant and E_b is the binding energy of the electron within the atom. The energy transfer here is a two-step process. First, there is the photoelectric interaction in which the photon transfers its energy to an electron. Secondly, this electron deposits its energy in the surrounding matter. Photoelectric interactions are most probable when the electron binding energy is slightly less than the incident photon energy. This implies that the photon energy is divided into two part which is used to overcome the electron binding energy and the remaining energy is transferred to the electron as kinetic energy (James etal , 2006), (Reilly Sutton, 1997).

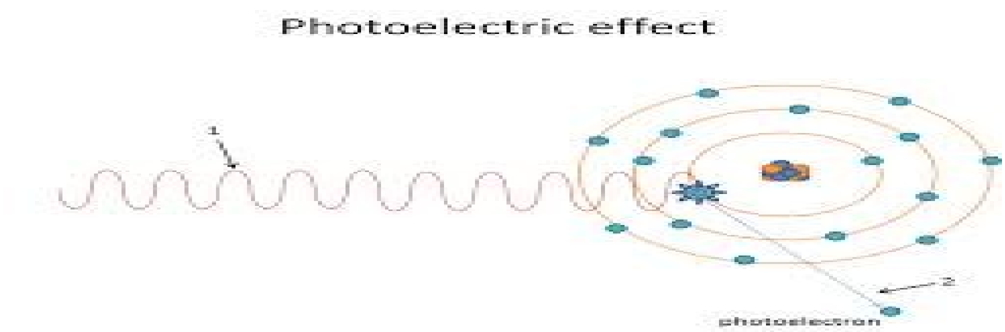


Figure (2-5) the photoelectric effect.

2.3.3 Compton scattering:

Compton scattering also known as inelastic scattering, is the predominant interaction of X-rays photons in the diagnostic energy range (30-150) KeV with soft tissue. This interaction most likely occurs between an X-rays photon and the outer shell electrons (valence electrons). The electron which absorbs part of the photon’s energy is ejected from the atom. The photon is scattered with some reduction in energy with scattering angle.

This change in photon energy according to Compton equation is represented as a deviation in the wavelength as follows:

$$\Delta\lambda=\lambda c(1- \cos\theta)$$

Where λc is the Compton wavelength of the electron, 0 is the scattering angle. According to the laws of conservation of energy and momentum, the energy of the incident photon E0 is equal to the sum of the scattered photon energy E scatter and the kinetic energy of the ejected electron Reject (Reilly Sutton, 1997).

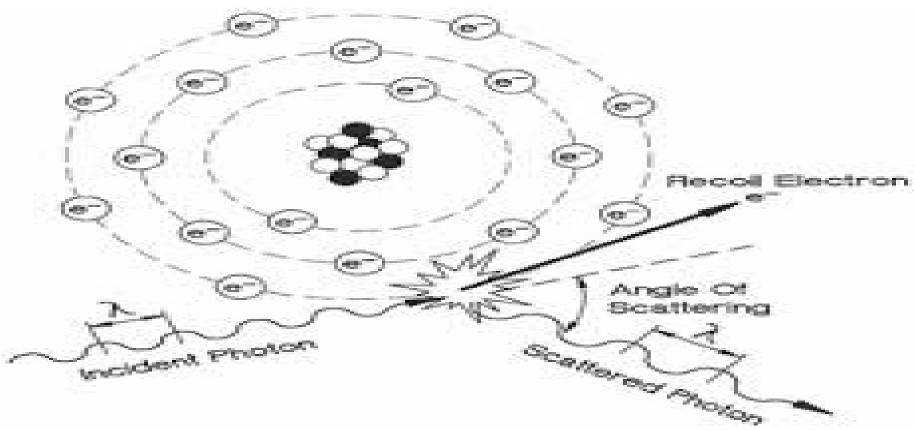


Figure (2-6)The Compton scattering.

2.4 Image quality:

measure of the quality of a radiologic image is its usefulness in determining an accurate diagnosis. The principal components of image quality are contrast, spatial resolution, and noise.

1- Contrast:

Contrast is the difference in the image gray scale between closely adjacent regions on the image. The contrast present in a medical image is the result of a number of different steps that occur during image acquisition, processing, and display.

2- Spatial resolution:

A two-dimensional image really has three dimensions: height, width, and gray scale .The height and width dimensions are spatial (usually), and have units such as millimeters spatial resolution is a property that describes the ability of an imaging system to accurately depict objects in the two spatial dimensions of the image. Spatial resolution is sometimes referred to simply as the resolution. The classic notion of spatial resolution is the ability of an image system to distinctly depict two objects as they become smaller and closer together. (Williams , *2002)*

2.5. Radiation quantities and units:

2.5.1 Radiation quantities:

Radiation measurement and investigation of radiation effect require various specification Of the radiation field at the point of interest. Radiation dosimeter deals with methods for a quantitative determination of energy deposited in a given medium by directly or indirectly radiations. Number of international accepted quantities used for radiation measurement and radiation protection has been defined by international commission for radiation protection (ICRP) and the international commission on radiation units and measurements (ICRU). In addition the international standard organization (ISO) provides guidance on calibration and uses of dosimeters and instruments in terms of these quantities. The International Atomic Energy Agency uses the recommendations and definition of ICRP, ICRU and ISO as a basic for its guidance in radiation protection. Quantities and units have been defined for describing the radiation beam (IAEA, 2005).

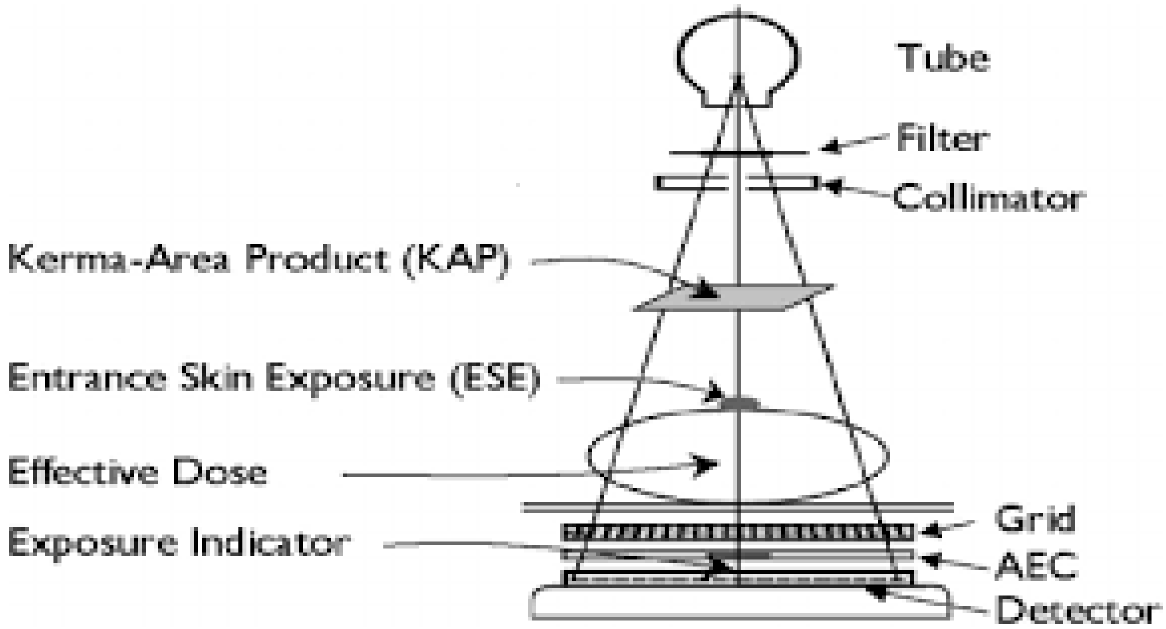


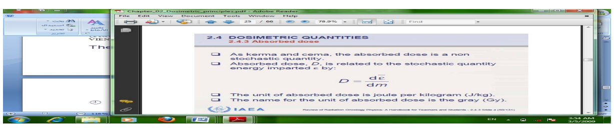
Figure (2-7) the radiation quantities.

2.5.1.1 Exposure:

Is radiation quantity expresses the concentration of radiation delivered to specific point ,such as surface of the human body . there are two units for expressing exposure . the conventional unit which is the Rontgen (R) and the SI unit which is the coulomb⁄ kg of air (c⁄ kg of air). The Rontgen is officially defined in term of ionization produced in specific quantity of air . the ionization process produces an electrical charge that is expressed in the unit of coulombs there by measuring the amount of ionization in a known quantity of air the exposure in (R) can be determined (jams etal , 2006)

2.5.1.2 Air Kerma: Air kerma is the kerma to air from an incident X ray beam measured on the central beam axis at the position of the patient or phantom surface Unit: J/kg. The name for the unit of kerma is gray (Gy) (IAEA , 2007).

2.5.1.3 Absorbed Dose :is related to the stochastic quantity energy imparted The absorbed dose is defined as the mean energy e– imparted by ionizing radiation to matter of mass m in a finite volume V by:



The unit of absorbed dose is joule per kilogram (J/kg).

The name for the unit of absorbed dose is the gray (Gy).

1 rad = 0.01 J/kg (IAEA , 2005)

2.5.1.4 Entrance surface dose (ESD) :

This is defined as the exposure in (R) at the skin surface of the patient excluding the backscatter contribution from the measurement in popular because entrance skin exposure is easy to measure, but unfortunately the entrance skin exposure is poorly suited for specifying the radiation received by patients understanding radiographic examination. The entrance skin exposure does not take into account the radio sensitivity of individual organs or tissues, the area of an X-rays beam, or the beam’s penetrating power, therefore, entrance skin exposure is poor indicator of the total energy imparted to patient (James etal , 2006).

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

Where (OP) is the output in mGy/ (mAs) of the X-ray tube measured at distance of 100 cm from the tube focus along the beam axis at 80 kVp , peak tube voltage (kVp), (mAs) is the product of the tube current (in mA) and the exposure time in (S), (FSD) the focus-to-skin distance (in cm) and (BSF) the backscatter factor Unit is gray (Gy) (IAEA, 2007). (Jaypee et al, 2001).

Or

ESD =C $\left(\frac{Kvp}{FSD}\right)^2\left(\frac{mAS}{mmAL}\right)$

Where ESD is Entrance skin dose, C is constant=0.2775 , FSD is focus to skin distance **,** mAS is is the product of the tube current (in mA) and the exposure time in (S)kVp , peak tube voltage, AL is aluminum filtration . (Tung etal , 1999)

2.5.1.5 Entrance surface air kerma (ESAK):

The kerma to air measured on the central beam axis at the position of the patient or phantom surface .The radiation incident on the patient or phantom and the backscattered radiation are included (IAEA , 2007).

Unit: J/kg. The name for the unit of kerma is gray (Gy) .

2.5.1.6 Equivalent dose H_T **:**Is defined by the organ dose D_{TR} multiplied by a radiation weighting factor W_R to account for the effectiveness of the given radiation in inducing biological detriment or harm:

H $H_T = W_R D_{TR}$

D_{TR} is the absorbed dose delivered by radiation type R averaged over a tissue or organ T. W_R is the radiation weighting factor for radiation type R.

2.5.1.7Effective dose E:

Is defined as the summation of tissue equivalent doses, each multiplied by the appropriate tissue weighting factor W_T , to indicate the combination of different doses to several different tissues in a way that correlates well with all stochastic effects combined.

E = $\sum W_T H_T$

The unit of effective dose E is J/kg and its name is the sievert (Sv). (john et al)(introduction of radiobiological physics and radiation dosimtery)

Tissue weighting factors W_T are tabulated in ICRP Publication 60 and in the IAEA Basic Safety Standards (BSS).

Despite depending on the sex and age of a person, for purposes of radiation protection the values for W_T are assumed constant and applicable to the general public:

Organ	W_T
Gonads	0.20
lung, red bone marrow, colon, stomach	0.12
bladder, breast, liver, oesophagus, thyroid	0.05
skin, bone surface	0.01
whole body	1.0
Total	2.9

2.5.2 Radiation units :

2.5.2.1 The Rontgen (R):

Is a unit used to measure a quantity called exposure. This can only be used to describe an amount of gamma and X-rays, and only in air. Where (IR) is equal to depositing in dry air enough energy to cause 2.58x104 coulombs per kg. it is a measure of the ionization of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition energy in air, and only for gamma and X-rays (Jaypee etal, 2001).

2.5.2.2 Radiation absorbed dose (Rad):

The rad is unit used to measure a quantity called absorbed dose this relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. The Rad is defined as the absorption of 100 ergs per gram of material. The unit Rad can be used for any type of radiation, but it does not describe the biological effects of the different radiations (Japee etal , 2001).

2.5.2.3 Rem (Rontgen equivalent man):

Is a unit used to measure a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Taking into account that not all radiation has the same biological effect, even for the amount of absorbed dose. Equivalent dose is often expressed in terms milirems. To determine equivalent dose (rem), we multiply the absorbed dose (rad) by a quality factor (Q), which is unique for the type of incident radiation (Jaypee etal , 2001)

2.5.2.4 Gray (Gy):

Is unit used to measure a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of micro sievert .to determine equivalent dose (Sv), we multiply absorbed dose (Gy) by a quality factor (Q) which is unique for the type of incident radiation. One sievert is equivalent to 100 rem. (Jaypee etal , 2001).

2.6 Radiation protection:

Radiation protection in diagnostic radiography is essential if medical exposure to ionizing radiation is to be maintained at a level of minimal acceptable risk1.The concept of risk is an important one and it is essential that we reduce risks to patient and staff through the justification, optimization and limitation of radiation.

Radiation protection requirements:

Justification : The dose reduction measures achieved by improving radiographic practice are insignificant compared with doses saved from not performing the examination at all.

Justification is the essential first step in radiation protection ,and it is the duty of all radiographers and radiologists to ensure that every investigation performed is correct examination and is essential in the management of the patient . (Whitley etal, 2005).

Optimization : Once it has been decided that an investigation needs performing , choice of the most appropriate technique is essential. In view of the plethora of imaging techniques now available , radiologists and radiographers are best placed to give clinicians advice . however, due to the pressures on most departments , individual advice is not possible for every case , and agreed written guidelines between clinicians and x-ray staff be compiled . justification and optimization need good clinic-radiological cooperation .(A.S Whitley etal , 2005).

2.7 Medical applications of X-ray:

Medical imaging using X-rays began with the first photograph that Rontgen took from his wife’s hand. Since then, X-rays imaging allows improvements in diagnosis and treatment of numerous medical issues. There are different medical imaging procedures; each of them uses a different technique and technology which gets improved upon time. They include radiography (conventional X-rays and mammography), Fluoroscopy, and computed tomography. All these modalities have the same basic principle.

When an X-ray beam passes through the human body, a portion of the beam is either absorbed or scattered by the internal structure (soft tissue or bones). And the remaining X-ray beam which passes through the body is transmitted to a detector (e.g. a 1m or a computer screen). This transmitted part is very important in medical imaging as it forms the image (James etal , 2006), (Reilly Sutton, 1997).

2.7.1 Radiography:

Radiography is an imaging technique that uses X-rays to view the internal structure of none uniformly composed and opaque object (a non –transparent object with a variation in density and composition) such as the human body. Radiographyis used in many type of medical examinations and procedures where a record of a static image is desired. Examples of radiology include, dental examination verification of correct placement of surgical markers prior to invasive procedure mammography we use low dose imaging at low energies to detect tumors in the breast with high resolution, approximately 40 micrometer with best soft tissue contrast at low energies (James etal , 2006).

2.7.2 Fluoroscopy:

In fluoroscopy a continuous X-rays imaging is displayed on monitor (a fluorescent screen or phosphor). This allows real-time monitor of the procedure or passage of a contrast agent (dye) through the body. This live X-ray view of the patient can be used to get real-time imaging and for aligning the patient to the X-ray tube for imaging (Jaypee etal, 2001). The main disadvantage of fluoroscopy is that it can result in relatively high radiation dose. Especially, in the case of complex intervention procedure e.g. during the operation to put some devices inside the body. However to reduce this disadvantages, the radiation dose modern system use image intensifiers and a closed circuit TV system (James etal , 2006)

2.2 literature review:

K. E. M Mhamadain, et al 2004,The aim of their work was to estimate the entrance skin dose (ESD), the body organ dose (BOD) and the effective dose (E) for chest x-ray exposure of pediatrics patients in five large units, three in Sudan and two in Brazil, and to compare the results obtained in both countries with each other and with other values obtained by some European countries. Results of mean ESD for the age interval 1–5 years and

AP projection are: 66 μGy (Institutode Pediatria e Puericultura Martag˜aoGesteira—IPPMG Hospital), 41, 86 and 68 μGy (InstitutoFernandesFigueira—IFF Hospital), 161 μGy (Omdurman Hospital), 395 μGy (Khartoum Hospital) and 23 μGy (Ahmed Gasim Hospital). In the case of the IFF Hospital, the results refer, respectively, to rooms 1, 2 and for the six mobile equipment's. The mean E for the same age interval was11μSv in the IPPMG , 6 , 15 and 11 μSv in the IFF , respectively for rooms 1 , 2 and the 6mobiles ,25 μSvin the Omdurman Hospital , 45 μSv in the Khartoum Hospital and 3 μSv in the Ahmed Gasim Hospital.

M.A.Halato et al , 2008 estimated the entrance skin doses ESDs for patients undergoing selected diagnostic x-ray examinations in tow large public hospitals in Khartoum state , Sudan . the study included the examinations of the chest postero – anterior(PA), skull anterior – posterior (AP) , skull lateral (LAT) lumber spine AP/LAT, abdomen intravenous urogram (IVU) and pelvis AP . totally 241 patients were included in this study . ESDs were estimated from patients specific exposure parameters using established relation out put (μGy/mAS) and tube voltage (KVp). The estimated ESDs ranged from 0.18-1.05mGy for chest AP , 0.98 – 3.48 mGy for skull (AP) , 0.66 – 2.275 mGy for skull (LAT) , 1.22 -4.35mGy for abdomen (IVU),1.18 -5.75 mGy for pelvis , 1.52

-5.01 mGy lumbar spine AP and 2.48 – 10.41 mGy lumbar spine(LAT).These values compare well with the international reference dose levels . This study provides additional data that can help the regulatory authority to establish reference dose level for diagnostic radiology in Sudan .

Sulieman et al 2011 measured the radiation doses to pediatric patients and comforters undergoing chest x-ray .the study aims were determine the entrance surface dose(ESD) organ ,effective dose and propose a local diagnostic reference level. Patients were divided in to three groups organ and effective doses were estimated using National Radiological Protection Board software . the ESD was determined by thermoliminescent dosimeter , the result show the radiation dose to the patients is well within dose constraint.

M.Dahab 2013 , measured the entrance skin dose and effective dose during chest x-ray for pediatrics (Khartoum –Ahmed Gasim) hospitals . the result show wide dose vibration and the most above recommended limits levels .

H.Osman, et al. 2014, The objectives of this study were to evaluate Entrance skin dose (ESD) in pediatric chest X-ray posterior-anterior (PA) and lateral (Lat) projection and also to estimate organs radiation doses.100 patients underwent chest x-ray, in Taif pediatric hospital, KSA, their age range from 0-15 years, The results of radiation dose for pediatric chest in this study matched and compatible with literature.

Caroline et al 2015 estimated the entrance skin doses ESDs in digital radiology x-ray examinations in Asser central hospital – Saudi Arabia . the study included 50 patients undergoing 12 types of digonostic X-ray examination .The mean ± SD for ESDs were founded 0.16 ±0.003 , 0.21 ±0.01, 0.63± 0.26, 0.55 ±0.09 , 0.15± 0.05, 0.27 ±0.06 , 0.41 ± 0.19 , 0.46 ±0/18 ,0.46±0.12, 0.20±0.02, 0.39±0.01, 0.29± 0.03 for chest (PA), foot , pelvis(AP) , skull (PA) , hand (PA), Arm(AP) , ankle, shoulder (AP), abdomen ,forearm , femur (AP) and elbow(AP) . the result show the radiation dose to the patients is well within the standard reference.

Chapter three

Materials and Methods

:Materials 3.1

This study was done in the military hospital of Omdurman. Included two X-ray machine Initially, questionnaires were distributed to radiographers in charge of the diagnostic facilities. Each radiographer was asked to provide information with respect to his X-rays radiography unit, including manufacturer, model, type and lm speed. To calculate the ESD, the radiographer was asked also to provide the typical exposure parameters used for 64 patients. The parameters were: peak tube voltage (kVp), exposure current-time product (mAs), focus-to- lm distance (FFD), the dose values were obtained with the use of the mathematical equation that provides the ESD. In the present study, two different modalities X-ray machines from different manufacture were used as described in Table 3.1

Table 3.1 the specification of two X-ray machines in the Military .hospital

(Hospital (unit	Unit 1	Unit 2
Manufacture	Swissray	Toshiba
Model	ATLAS	Kxo-32s

Type	Fixed	Fixed
Year of manufacture	1993	2011
Year of installation	2000	2012
Type of film	Fuji	Fuji + PRIMAX
Film speed	400	400
Total filtration	1.8	(2.2mm(AL
Max KVp	150	150
Max mAs	500	200

3.1.1 Patient sample:

A total of 64 patients were examined in two units in military Hospital Omdurman . The main purpose of this study to estimate the entrance skin dose during chest examination for pediatric patients.

The data were collected using sheet for all patient in order to maintain consistency of the information. The following parameters were recorded weight(kg) , height (cm) and exposure parameters were recorded tube voltage (Kvp), and tube current-time product setting exposure parameters (mAs) were recorded.

3.2. Methods:

3.2.1. Imaging technique:

Routine x-ray examinations consist of two projection :posterior – anterior (PA) and anterior – posterior (AP) .

3.2.2. Dose calculation:

The following parameters were recorded age, weight, thickness and exposure parameters kV and mAs was changed according to the patient size ,patient ESD was determined by using (SPSS) which calculate entrance surface dose. By determining the tube output data and exposure factors encountered. Using the equation below:

$$ESD = c\left(kvp/FSD\right)^2 \times \left(mAS/AL\right)$$

Where (C) is Constant = 0.2775 , (kvp) the tube potential,(mA s) the product of the tube current (in mA) and the exposure time(in S), (FSD) the focus-to-skin distance (in cm) and (AL) Aluminum filtration in mm. (Carolline 2015)

3.2.3. Method of data analysis:

The data analyzed with standard Statistical Package for the Social Sciences (SPSS) and Microsoft excel for analysis.

Chapter four

Results

4.1. Results:

The results of Entrance Skin Dose in µGy (ESD)for chest x-ray examination for pediatrics , obtained for two units in the Military Hospital are tabulated according to age group for the AP Ad PA projections. the median value of Age, weight, height, KV, mAs, and , FSD were sample in given in (Table 4.1), The minimum , maximum , mean and stander deviation values of the entrance skin dose in µGy (ESD) for chest AP and PA projections Compared with Dose radiation Levels reference (DRLS) and was presented in (Table 4.2) and (Table4 .3) respectively.

Table (4.1)The Median values of all patients information and radiographic parameters

Unit	Examination	Patient information			Radiographic parameters		
		Age(m)	Weight(cm)	Height(cm)	Kvp(Kv)	mAs(AS)	FSD(cm)
Unit(1)	Chest AP	11	7	69.15	50	20	109.5
	Chest PA	84	18	114	54	24	162.5

Unit(2)	**Chest AP** 22	8.75	79.5	45	5	98.1
	Chest PA 93	17.5	119	49	5	117.3

Table (4.2) The Minimum , maximum , mean and stander deviation(S.D) values of the entrance skin dose in µGy (ESD) for chest AP Compare with Dose radiation Levels reference (DRLS)

Unit	Age(years)	Frequency	Min	Max	Mean	S.D	DRLS
Unit (1)	1 day ≥1	3	46.15	152.38	86.99	57.79	50
	1≥ 5	9	120.55	279.15	157.64	52.46	50
	5≥10	8	73.16	277.18	117.37	62.51	60
Unit (2)	1 day ≥10	2	75.48	99.21	87.34	16.878	50
	1≥5	6	64.2	115.84	72.57	11.83	50
	5≥10	14	67.28	149.22	83.24	22.57	60
	10≥15	2	101.73	124.1	112.91	15.82	120

Figure 4-1: correlation between entrance skin dose ESD (mGy) and tube potential kVp for the (AP) projection of the study sample in Military hospital .

Figure 4-2: correlation between entrance skin dose ESD (mGy) and the product of the time tube current (mAs) for the (AP) projection of the study sample in Military hospital .

Table (4.3) Minimum , maximum , mean and stander deviation(S.D) values of the entrance skin dose µGy (ESD) for chest PA Compare with Dose radiation Levels reference (DRLS)

Unit	Age(years)	Frequency	Min	Max	Mean	S.D	DRLS
Unit (1)	5≥10	4	70.58	183.35	83.52	18.29	60
	10≥15	5	41.80	165.89	139.18	37.79	120
	15	3	119.97	275.03	200.36	105.60	150
Unit (2)	5≥10	3	51.89	231.41	141.65	136.94	60
	10≥15	3	47.59	150.98	64.78	66.74	120
	15	2	47.02	82.82	64.93	25.33	150

Figure 4-3: correlation between entrance skin dose ESD (mGy) and tube potential kVp for the (PA) projection of the study sample in Military hospital .

Figure 4-4: correlation between entrance skin dose ESD (mGy) and the product of the time tube current (mAs) for the (PA) projection of the study sample in Military hospital

Chapter five

5.1 Discussion:

The data of this study was collected for two units in military hospital in Omdurman where the patients have been subjected to chest X-ray, the result included 64 patients .the data of this study were collected using Seven variables they include : sex , age , weight , height , Kvp , mAs and FSD with median in chest AP and PA projections. The result of this study showed that there is difference in radiographic parameters between two units as show in table (4.1) this difference due to thickness of patients and type of machine.

The mean and stander deviation (SD) value of the ESD at the ages (1 day ≥1 year,1 ≥5 ,5 ≥ 10) years in two units found to be: (86.99± 57.79,157.64±52.49,117.37±62.51)µGy and (87.34±16.87, 72.57±11.83 ,83,24± 22.57 ,112.91±15.82) µGy as showed in table (4.2).In chest PA at unit (1),(2) respectively .The mean and stander deviation (SD) value of the ESD at the all ages were found to be (83.52±18.29,139.18±37.79,200,36±105.60)µGy and (141.65±136.94,64.78±66.74 ,62.93±25.3) µGy as showed in Table (4.3).

The above figures from (4-1) to (4-4) showed that the ESD increase with the age & the exposure parameters (Kv , mAs) and ESD is weak in figure (4-1) than the figure(4-4) .

According to NRPB (1999) Reference Dose Levels for ESD for chest AP and PA chest radiographic in children are : 60 µGy for newborn and 1 year, 60 µGy for 5 years, 120 µGy for 10 year and 150 µGy for 15year old children.

The results that mentioned above that the ESD of pediatrics patients in Military Hospital during chest (AP/ PA) Projections lies within The Reference Dose Levels In Table (4.2) and (4.3) we also found the when the ESD for the children in unit (1) high than the ESD of unit (2) one of reasons of changes appear in ESD values is wide variation of technical parameter which is found in military hospital of tow type of the machine were different and selection of the exposure factors.

The ESD for the military hospital was compared with previous studies (K .E.M. Mohamadain et al (2004)), (M .A. Halato et al , (2008)) and (H.Osman et al (2014)), the result showed that the

ESD was lower than which recorded in the previous studies for all ages . this is probably due to the fact that the two units in this study are due to the few data population in this study or the difference also could be due to the state of some of the equipment used in two unit for military hospital and differences in exposure parameters used.

5.2 Conclusion :

This study was intended to estimation the radiation doses for patients undergoing diagnostic chest examinations in military hospital to help in applying radiation protection procedure of the patient. The most of the estimated ESDs values were within the range of reference level and below the range at some previous studies .The ESD depend on the exposure parameters and the filtration, Patient radiation dose is a very important parameter to control the quality of the X-ray services within the hospital.

The data obtained may add to the available information in national records for general use and it will provide guidance efforts on dose reduction .

5.3 Recommendations:

-The Importance of quality control program in radiology departments , and high training for the staff, in addition to all intervention team members , training in radiological physics and radiological protection. In fact specific level of training in radiation protection, additional to that undertaken in diagnostic radiology, is desirable. Also, specific additional training should be planned when new X-ray systems or techniques are implemented in a Centre. Radiographers who utilize the technology should also receive proper training on developing professional skills.

- In pediatric radiology department, Knowledge concerning the correct use of appropriate radiographic exposure factors, e.g., focal spot size, filtration, focus to image plane distance, and tube voltage is necessary because, they reduce the patient exposure to the patient, by increasing the distance between the source and the patient (FSD) and decrease the exposure time. To achieve good image detail maintaining a balance between the use of a small focal spot size and a short exposure time is important.

- Reference dose levels for diagnostic radiology should be established on national scale, in order to reduce the patient exposure and to maintain a good diagnostic imaging.

- For children with very low-birth weight premature infants who difficult cannot be transported to the radiology department, mobile units using a very low exposure with little scattered radiation be often utilized.

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