

CHAPTER ONE

INTRODUCTION

(1-1)Research Problem:

The problem of this research is related to the fact that; not all the hospitals in Sudan have all the devices of medical imaging technique to diagnostic disease for patients. Most hospitals have x-rays device, it read quickly because it takes in about 10 minutes to read the image of any parts of the body. Not all the hospitals have CT scan; although it is more accurate in diagnostic diseases. But it cost more than x-ray; that's why x-ray is available in small hospitals.

(1-2) Objectives:

The aim of the research is to measure radiation dose for patients by CT scan and x-rays. Find the best method for detecting many different cancers, such as lymphoma and cancers of the lung, liver, kidney, ovary and pancreas since the image allows a physician to confirm the presence of a tumor, measure its size, identify its precise location and determine the extent of its involvement with other nearby tissue.

invaluable in diagnosing and treating spinal problems and injuries to the hands, feet and other skeletal structures because it can clearly show even very small bones as well as surrounding tissues such as muscle and blood vessels.

(1-3)Methodology:

The beam of x-ray directed at the area being examined. After passing through the body, the beam falls on a piece of film. Different tissues in the body absorb the radiation differently. Dense tissue, such as bone, blocks most of the radiation and appears white on the film. Soft tissue, such as muscle, blocks less radiation and appears darker on the film. Often multiple images are taken from different angles so a more complete view of the area is available. The images obtained during X-ray exams may be viewed on a film. In CT, a penetrating beam of X-rays spins around an object. The X-ray tube moved from point "A" to point "B" above the patient, while the cassette holder. A computer then analyses information received from the scanner's detectors and generates an image. CTA takes about 10 to 25 minutes from the time the actual examination begins. Overall, you can expect to be in or near the examining room for 20 to 30 minutes. You may feel warm all over when contrast material is injected before the scan, but you should not feel pain at any time. Any CT study requires that you remain during the exam. Pillows and foam pads may help make it more comfortable. At the same time, the nurse or technologist may use pads or Velcro straps to keep the area from moving. The examination table will move into and out of the scanner opening, but it is not enclosed and only a small part of your body will be inside at any one time. You may be asked to hold your breath for 10 to 25 seconds to be sure that the images will not be blurred. During the time that no actual imaging is taking place you are free to ask questions or talk to the technologist, but friends or relatives will not be allowed in the examining room. Once the needed images have been recorded, you will be free to leave. You can eat immediately and it is a good idea to drink plenty of fluids in the hours after the exam to help flush contrast material out of the system.

(1-4)Literature review:

Since the introduction of helical computed tomography (CT) in the early 1990s, the technology and capabilities of CT scanners have changed tremendously (helical and spiral CT are equivalent technologies; for consistency, the term “helical” will be used throughout). The introduction of dual-slice systems in 1994 and multi slice systems in 1998 (four detector arrays along the z-axis) has further accelerated the implementation of many new clinical applications^{1–3}. The number of slices, or data channels, acquired per axial rotation has increased, with 16- and 64-slice systems now available (as well as models having 2, 6, 8, 10, 32, and 40 slices). Soon even larger detector arrays and axial coverage per rotation (>4 cm) will be commercially available, with results from a 256-slice scanner having already been published. These tremendous strides in technology have resulted in many changes in the clinical use of CT. These include, but are not limited to, increased use of multiphase exams, vascular and cardiac exams, perfusion imaging, and screening exams (primarily the heart, chest, and colon, but also self referred “whole body “screening exams. Each of these applications prompts the need for discussion of radiation risk versus medical benefit. In addition, the public press in the United States, following publication by the American Journal of Roentgenology of two articles^{5, 6} on risks to pediatric patients from CT, has begun to scrutinize radiation dose levels from all CT examinations. Subsequent reports in the popular media have increased the concern of patients and parents of pediatric patients undergoing medically appropriate CT examinations. The importance of radiation dose from x-ray CT has been underscored recently by the attention given in the scientific literature to issues of dose and the associated risk^{5, 6, 8–13}. The dose levels imparted in CT exceed those from conventional radiography and fluoroscopy and

the use of CT continues to grow, often by 10% to 15% per year^{14, 15}. According to 2006 data, approximately 62 million CT examinations were performed in hospitals and outpatient imaging facilities in the United States. Thus, CT will continue to contribute a significant portion of the total collective dose delivered to the public from medical procedures involving ionizing radiation¹. The rapid evolution of CT technology and the resultant explosion in new clinical applications, including cardiac CT, combined with the significance of CT dose levels, have created a compelling need to teach, understand, and use detailed information regarding CT dose. All of these factors have created a need for the AAPM to provide professional, expert guidance regarding matters related to CT dose. Fundamental definitions of CT dose parameters require review and, perhaps reinterpretation, as CT technology evolves: some parameter definitions are not being used consistently, some are out of date, and some are more relevant than others with respect to patient risk or newer scanner designs.

(1-5)Layout:

The research contains three chapters; chapter one talks about problem and objectives of research. Chapter two consists of definition and production of x-rays and how to produce it, benefits and risks. Chapter three contains definition, types, and risks of CT. How CT scan are performed, the scan, contrast medium and definition quantities assessing dose in CT. Chapter four contains results and discussion. Chapter five contains recommendation, future work and references.

CHAPTER TWO

INTRODUCTION OF X-RAYS

(2-1) Definition of X-rays:

X-radiation (composed of X-rays) is a form of electromagnetic radiation. Most X-rays have a wavelength ranging from 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3×10^{16} Hz to 3×10^{19} Hz) and energies in the range 100 eV to 100 keV. X-ray wavelengths are shorter than those of UV rays and typically longer than those of gamma rays. In many languages, X-radiation is referred to with terms meaning Rontgen radiation, after Wilhelm Rontgen [1], who is usually credited as its discoverer, and who had named it *X-radiation* to signify an unknown type of radiation [2].

X-rays with photon energies above 5–10 keV (below 0.2–0.1 nm wavelength) are called *hard X-rays*, while those with lower energy are called *soft X-rays*^[3]. Due to their penetrating ability, hard X-rays are widely used to image the inside of objects, e.g., in medical radiography and airport security. As a result, the term *X-ray* is metonymically used to refer to a radiographic image produced using this method, in addition to the method itself. Since the wavelengths of hard X-rays are similar to the size of atoms they are also useful for determining crystal structures by X-ray crystallography. By contrast, soft X-rays are easily absorbed in air and the attenuation length of 600 eV (~2 nm) X-rays in water is less than 1 micrometer [4]. There is no universal consensus for a definition distinguishing between X-rays and gamma rays. One common practice is to distinguish between the two types of

radiation based on their source: X-rays are emitted by electrons, while gamma rays are emitted by the atomic nucleus^{[5][6][7][8]}. This definition has several problems; other processes also can generate these high energy photons, or sometimes the method of generation is not known. One common alternative is to distinguish X- and gamma radiation on the basis of wavelength (or equivalently, frequency or photon energy), with radiation shorter than some arbitrary wavelength, such as 10^{-11} m (0.1 Å), defined as gamma radiation^[9]. This criterion assigns a photon to an unambiguous category, but is only possible if wavelength is known. (Some measurement techniques do not distinguish between detected wavelengths.) However, these two definitions often coincide since the electromagnetic radiation emitted by X-ray tubes generally has a longer wavelength and lower photon energy than the radiation emitted by radioactive nuclei^[10]. Occasionally, one term or the other is used in specific contexts due to historical precedent, based on measurement (detection) technique, or based on their intended use rather than their wavelength or source. Thus, gamma-rays generated for medical and industrial uses, for example radiotherapy, in the ranges of 6–20 MeV, can in this context also be referred to as X-rays.

(2-2)Production Of X-rays:

Whenever charged particles (electrons or ions) of sufficient energy hit a material, x-rays are produced.

(2-2-1)Production By Electrons:

X-rays 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-rays [11]. In medical X-ray tubes the target is usually tungsten or a more crack-resistant alloy of

rhodium (5%) and tungsten (95%), but sometimes molybdenum for more specialized applications, such as when softer X-rays are needed as in mammography. In crystallography, a copper target is most common, with cobalt often being used when fluorescence from iron content in the sample might otherwise present a problem.

The maximum energy of the produced X-ray photon is limited by the energy of the incident electron, which is equal to the voltage on the tube times the electron charge, so an 80 kV tube cannot create X-rays with energy greater than 80 keV. When the electrons hit the target, X-rays are created by two different atomic processes:

(2-2-2)Production by fast positive ions:

X-rays can also be produced by fast protons or other positive ions. The Proton-induced X-ray emission or particle-induced X-ray emission is widely used as an analytical procedure. For high energies, the production cross section is proportional to $Z_1^2 Z_2^{-4}$, where Z_1 refers to the atomic number of the ion, Z_2 to that of the target atom.^[12] An overview of these cross sections is given in the same reference.

(2-3)Characteristic of x-ray emission:

If the electron has enough energy it can knock an orbital electron out of the inner electron shell of a metal atom, and as a result electrons from higher energy levels then fill up the vacancy and X-ray photons are emitted. This process produces an emission spectrum of X-rays at a few discrete frequencies, sometimes referred to as the spectral lines. The spectral lines generated depend on the target (anode) element used and thus are called characteristic lines. Usually these are transitions from

upper shells into K shell (called K line), into L shell (called L lines) and so on.

(2-4)X-ray machine:

An X-ray machine produces a controlled beam of radiation, which is used to create an image of the inside of your body. This beam is directed at the area being examined. After passing through the body, the beam falls on a piece of film or a special plate where it casts a type of shadow. Different tissues in the body block or absorb the radiation differently. Dense tissue, such as bone, blocks most of the radiation and appears white on the film. Soft tissue, such as muscle, blocks less radiation and appears darker on the film. Often multiple images are taken from different angles so a more complete view of the area is available. The images obtained during X-ray exams may be viewed on film or put through a process called “digitizing” so that they can be viewed on a computer screen.

Sometimes an X-ray exam includes contrast. For a contrast study, you will receive a drug called a contrast agent, which will highlight or contrast parts of the body so they show more clearly on the X-ray image.

(2-5)Example of Uses:

X-ray exams can be used to view, monitor, or diagnose:

- bone fractures
- joint injuries and infections
- artery blockages
- abdominal pain
- cancer

(2-6)Preparation for an X-ray exam:

For most X-ray exams, there is no special preparation needed. You will be asked to wear a hospital gown and remove all jewelry and metal objects before the test. For contrast X-ray exams, you will be given a dose of contrast agent by mouth, as an enema, or as an injection or by catheter (thin tube) into a specific area of the body. Your physician will provide any specific instructions necessary for your contrast study.

(2-7) During the Exam:

You will be asked to either lie on an exam table or stand next to the X-ray machine. The room may be cool in order to keep the equipment from overheating. The technologist, or person performing the exam, may use pillows or sandbags to help you hold the proper position. You will be asked to hold very still, without breathing for a few seconds. The technologist will step behind a radiation barrier and activate the X-ray machine. Often multiple images or views are taken from different angles, so the technologist will reposition you for another view and the process will be repeated. You will not feel the radiation.

A mammogram is an X-ray exam of the breast. A special machine designed specifically to examine breast tissue is used. It takes a different form of X-ray and uses lower doses of radiation than a usual X-ray. Because these X-rays do not go through breast tissue as easily, the mammogram machine has two plates that compress the breast to spread the tissue apart. A more accurate image is obtained with less radiation this way.

Time Required: 5 to 60 minutes

Noise During Exam: Minimal clicking or buzzing noises.

Space During Exam:

You will either lie on an exam table or stand next to the X-ray machine with ample space around you.

(2-8)Benefits:

- X-ray exams are fast and easy.
- The equipment used is relatively inexpensive and widely available.

(2-9)Risks:

X-ray exams exposure patients to radiation. The amount of radiation exposure is variable depending upon the X-ray type (for example, of the brain, lungs, or abdomen) and the X-ray machine type (for example, different models and manufacturers). Because the radiation exposure is variable, the risks are also variable.

Women should inform their doctor if they are or may be pregnant or nursing prior to any radiological imaging. Your doctor may recommend another type of test to reduce the possible risk of exposing your baby to radiation. There is a rare risk of a major allergic reaction to the contrast agent.

CHAPTER THREE

INTRODUCTION OF CT

(3-1)Definition of CT:

Computed tomography (CT) is a type of imaging. It uses special x-ray equipment to make cross-sectional pictures of your body.

Doctors use CT scans to look for:

- Broken bones
- Cancers
- Blood clots
- Signs of heart disease
- Internal bleeding^[13]

(3-2)CT uses:

- Visualize blood flow in the renal arteries (those supplying the kidneys) in patients with high blood pressure (hypertension) and those suspected of having kidney disorders. Narrowing (stenosis) of a renal artery is a cause of high blood pressure in some patients, and can be corrected. A special computerized method of viewing the images makes CT renal angiography a very accurate examination. It is also done in prospective kidney donors.
- Identify aneurysms in the aorta or in other major blood vessels. Aneurysms are diseased areas of a weakened blood vessel wall that bulges out like a bulge in a tire. Aneurysms are life-threatening because they can rupture.

- Identify dissection in the aorta or its major branches. Dissection means that the layers of the artery wall peel away from each other like the layers of an onion. Dissection can cause pain and can be life-threatening.
- Identify a small aneurysm or arterio-venous malformation inside the brain which can be life-threatening.
- Detect atherosclerotic disease that has narrowed the arteries to the legs.
- CTA also is used to detect narrowing or obstruction of arteries in the pelvis and in the carotid arteries bringing blood from the heart to the brain.
- Proper function of a stent that has been placed to restore blood flow in a diseased artery, CT angiography will show whether it is serving its purpose.
- Examine the pulmonary arteries in the lungs to rule out pulmonary embolism, a serious but treatable condition [14].

(3-3)How CT scans are performed:

Before having a computerized tomography (CT) scan, you'll be asked about any existing health conditions, whether you are taking any medication, and if you have any allergies. This is to make sure that there's no risk of an adverse reaction during the scan. Women of childbearing age will also be asked if they're pregnant. CT scans aren't recommended for pregnant women unless there's an urgent medical reason, as there's a small chance that the x- rays could harm the unborn child. If you feel anxious or claustrophobic about having a CT scan the radiographer will help you; because he is a healthcare professional trained to carry out X-rays and other types of scans. They'll be able to give you advice to help you feel calm and, if necessary, arrange for you to have a sedative (medication to help you relax) [15].

(3-4)The scan:

Before the scan, you may be asked to remove your clothing and put on a gown. You'll also be asked to remove any jewellery, as metal interferes with the scanning equipment. If you're having a head scan, you may also be asked to remove dentures, hair clips and hearing aids.

The CT scanner is a large circular machine. You will be asked to lie on your back on a motorized bed that can be moved in and out of the scanner. The radiographer will position the bed so that the part of your body being investigated is lined up with the scanner. The radiographer will operate the scanner from an adjoining room. While the scan is taking place, you'll be able to hear and speak to them through an intercom. While each scan is being taken, you'll need to lie very still and breathe normally. This ensures that the scan images aren't blurred. You may be asked to breathe in, breathe out, or hold your breath at certain points.

The X-ray unit inside the ring will rotate around you. Each time it goes round it creates a new X-ray scan. The bed will move forward slightly after each scan is completed. Depending on the area of your body being investigated, a CT scan may last up to 10 minutes. You should be able to go home soon after the scan has been completed. [16]

(3-5)Contrast medium:

Some CT scans, such as those investigating the brain or abdomen, you may be given contrast medium beforehand. This liquid contains a dye that shows up clearly on the images of certain tissues or blood vessels. It helps distinguish blood vessels from other structures in your body. Contrast medium can be given in different ways, depending on the part of your body being scanned. It can be

swallowed in the form of a drink, given as an enema in your back passage, or can be injected into your bloodstream (intravenously).

If your kidney function is poor, contrast medium isn't usually given intravenously as it can depress kidney function further. In rare cases, contrast medium can cause an allergic reaction. You must tell the radiologist if you have had an allergic reaction to iodine or contrast medium in the past, or if you have any other allergies. Contrast medium is harmless and will pass out of your body in your urine^[17].

(3-6)Types of CT Scans:

(3-6-1)CT Scanning of the Abdomen:

CT imaging of the abdomen is an examination that uses x-rays to visualize several types of tissue with great clarity, including organs such as the liver, spleen, pancreas and kidneys. Using specialized equipment and expertise to create and interpret CT scans of the lower gastrointestinal (GI) tract, the colon and rectum, an experienced radiologist can accurately diagnose many causes of abdominal pain, such as an abscess in the abdomen, inflamed colon or colon cancer, diverticulitis and appendicitis. Often, no additional diagnostic work-up is necessary and treatment planning can begin immediately.

CT is often the preferred method for diagnosing many different cancers, including colon cancer, since the image allows a physician to confirm the presence of a tumor and to measure its size, precise location, and the extent of the tumor's involvement with other nearby tissue. CT examinations of the lower GI tract can be used to plan and properly administer radiation treatments for tumors, and to guide biopsies and other minimally invasive procedures. CT can also play a

significant role in the detection, diagnosis and treatment of vascular disorders that can lead to stroke, gangrene or kidney failure.

The technologist begins by positioning the patient on the CT table. The patient's body is generally supported by specially molded pillows to help the patient remain still and in the proper position during the scan. As the study proceeds, the table will move slowly into the CT scanner. The increments of movement may be so small that they are almost undetectable, or large enough that the patient feels the sensation of motion depending on the body part being examined.

A CT examination of the gastrointestinal tract requires the use of a contrast material to enhance the visibility of certain tissues. Before administering the contrast material, the radiologist or technologist will ask whether the patient has any allergies, especially to medications or iodine, and whether the patient has a history of diabetes, asthma, a heart condition, kidney problems or thyroid conditions. These conditions may indicate a higher risk of reaction to the contrast material or potential problems eliminating the material from the patient's system after the exam.

A CT examination usually takes from five minutes to half an hour. When the exam is over, the patient may be asked to wait until the images are examined to determine if more images are needed.

(3-6-2)CT Scanning of the Chest:

CT scanning of the chest uses special equipment to obtain multiple cross-sectional images of the organs and tissues of the chest. CT produces images that are far more detailed than a conventional chest x-ray. CT is especially useful because it can simultaneously show many different types of tissue including the lungs, heart, bones, soft tissues, muscle and blood vessels.

CT of the chest is used to take a closer look at findings detected on conventional chest x-rays or may be used to investigate and try to explain clinical signs or symptoms of disease of the chest. The CT examination may provide more specific information regarding the nature and extent of the findings or, in some cases, determine that the chest is normal.

CT may be used to detect and evaluate the extent of tumors that arise in the lung and mediastinum, or tumors that have spread there from other parts of the body. CT is routinely used to assess whether tumors are responding to treatment.

You may have heard that, in recent years, some people have chosen to have a chest CT scan to screen for lung cancer. This makes the most sense for those who are former or current cigarette smokers, as they are at much greater risk of cancer than are nonsmokers. The best hope of curing lung cancer is to find it as early as possible, making it easier to treat. CT is able to detect even very small abnormalities that could be early lung cancer, which would not be visible on a conventional chest x-ray. A special low-dose CT technique is used for lung cancer screening. CT of the chest is not able to detect every cancer.

Chest CT also can demonstrate other lung disorders such as old or new pneumonia, tuberculosis, emphysema, bronchiectasis, and diffuse interstitial lung disease. When the clinical findings and regular chest x-ray are inconclusive, CT may clarify the situation. Inflammation or other diseases of the pleura, the membrane covering the lungs, can be seen in CT images.

Accident victims and other people with chest injury often have a CT exam to assess damage to organs, bones (including the spinal column), and to large blood vessels.

An aneurysm, or ballooning out of the aorta, may be found totally unexpectedly

when chest CT is done for other reasons. Or a CT scan may be used to confirm suspicion of aneurysm on the basis of a plain chest x-ray. It is important to be aware of this condition so that it may be watched and, if necessary, treated before rupturing.

CT is used to detect blood clots that travel from the deep veins in the legs and lodge in the pulmonary arteries, blocking the normal blood flow to the lungs. This condition, called pulmonary embolism, is usually seen in patients who are immobile for long periods of time or who have cancer or clotting disorders. Pulmonary embolisms can be life threatening if not detected and treated. When pulmonary embolism is suspected, a special type of CT scan is performed called a CT Angiogram (CTA). This involves injecting the iodine into a vein a little faster and also more numerous and thinner slices are made through the chest in order to see the arteries in the lungs.

The first step is for the technologist to make certain that you are correctly positioned on the CT table. Pillows may be used to help maintain the correct position during the examination. For the initial scans, the table will move rapidly through the scanner to determine the correct starting position. The rest of the scans are made as the table moves more slowly through the cavity in the scanner. The best chest CT scans are obtained when you are able to hold your breath. If this is not possible, you will be asked to breathe quietly and regularly.

CT scanning is a pain-free procedure. If contrast material is injected you may feel a flush of heat or a metallic taste in your mouth, usually lasting no more than a minute or two. You also may notice mild itching. If this persists or hives develop, effective medication is available. Very rarely a patient becomes short of breath or has swelling in the throat or another part of the body, indicating a more serious

reaction to contrast material that must be promptly treated. If you experience any of these symptoms, inform the technologist immediately.

You will be alone during the scan, but the technologist can see and hear you and can speak to you at any time from the adjacent control room. The examination usually takes 15 to 30 minutes, including preparation time. The actual scan time is less than 30 seconds.

(3-6-3)CT Scanning of the Head:

CT scanning of the head is an examination that provides detailed information on head injuries, brain tumors, and other brain diseases. It also can show bone, soft tissues, and blood vessels in the same images.

CT of the head can assist in:

- Locating skull fractures and brain damage in patients with head injuries.
- Detecting a blood clot or bleeding within the brain shortly after a patient exhibits symptoms of a stroke.
- Determining the extent of bone and soft tissue damage in patients with facial trauma, and planning surgical reconstruction.
- Detecting and localizing bleeding in a patient with sudden severe headache who may have a ruptured or leaking aneurysm.
- Detecting some brain tumors.
- Diagnosing diseases of the temporal bone on the side of the skull, which may cause hearing problems.

- Illuminating enlarged brain cavities (ventricles) in patients with hydrocephalus.
- Determining whether inflammation or other changes are present in the paranasal sinuses.
- Planning radiation therapy for cancer of the brain or other tissues.
- Guiding the passage of a needle used to obtain a tissue sample (biopsy) from the brain.
- Non-invasively assessing for aneurysms or arteriovenous malformations through a technique called CT angiography.
- Detecting diseases or malformations of the skull.
- Three-dimensional imaging of the skull and brain structures.

CT scanning of the head may be performed in the hospital or at an outpatient radiology center, but in either case your doctor must give you a written referral with the reason why the study should be performed. You will lie on a table that is guided into the center of the scanner, and you will be asked to lie very still. As stated earlier, some patients will require an injection of a contrast material to enhance the visibility of certain tissues or blood vessels. A small needle connected to an intravenous line is placed in an arm or hand vein. The contrast material will be injected through this line.

Depending on the number of images needed a CT exam of the head and brain can take between two and 45 minutes. When it is completed you will be asked to wait until the technologist examines the images to determine if more are needed.

When you enter the scanner, special lights may be turned on to ensure correct positioning. Some exams (such as a scan of the sinuses) call for a special head

holder that uses soft straps to keep the head and neck in proper alignment. In some cases you will lie on your stomach; in others on your back. The patient and technologist can talk at any time via an intercom.

CT itself causes no pain, though there may be some discomfort from the need to remain still. If contrast material is injected you may have a warm, flushed sensation during the injection. You may also experience a metallic taste in your mouth that lasts for about two minutes. Occasionally a patient will develop itching and hives for up to a few hours after the injection; this can be relieved by medication. If you develop light-headedness or difficulty breathing, it may indicate a more severe allergic reaction a physician or nurse will be present to assist you.

(3-7)CT Scanning of the Spine:

CT scanning of the spine is a type of x-ray examination that uses a scanner to obtain multiple images of the spinal column, as well as three-dimensional images if needed. CT images are far more detailed than those obtained by a conventional x-ray unit. In addition, CT is a very useful diagnostic method because it can display and distinguish many different types of tissue in the same region, including bone, muscle, soft tissue and blood vessels. The bony structure of the spinal vertebrae is clearly and accurately shown by CT scanning, as are the intervertebral disks and, to some degree, the spinal cord.

(3-8)Risks:

- CT does involve exposure to radiation in the form of x-ray, but the benefit of an accurate diagnosis far outweighs the risk.
- Special care is taken during x-ray examinations to ensure maximum safety for the patient by shielding the abdomen and pelvis with a lead apron, with

the exception of those examinations in which the abdomen and pelvis are being imaged. Women should always inform their doctor or x-ray technologist if there is any possibility that they are pregnant.

- Nursing mothers should wait for 24 hours after contrast material injection before resuming breast feeding.
- There is a risk of an allergic reaction which may be serious whenever contrast material containing iodine is injected. If you have a history of allergy to x-ray dye, your radiologist may advise that you take special medication for 24 hours before the exam to lessen the risk of allergic reaction. Another option is to undergo a different exam that does not call for contrast injection.
- Contrast injection should be avoided in patients with kidney disease or severe diabetes because x-ray contrast material can further harm kidney function.
- If a large amount of x-ray contrast leaks out under the skin where the IV is placed, skin damage can result. If you feel any pain in this area during contrast injection, you should immediately inform the technologist[18].

(3-9)Definition of quantities assessing dose in CT:

(3-9-1) Computed Tomography Dose Index (CTDI):

The CTDI is the primary dose measurement concept in CT

$$CTDI = \frac{1}{NT} \int_{-\infty}^{\infty} D(Z) dz$$

Where:

D (z) = the radiation dose profile along the z-axis,

N =the number of topographic sections imaged in a single axial scan. This is equal to the number of data channels used in a particular scan. The value of N may be less than or equal to the maximum number of data channels available on the system, and

T = the width of the homographic section along the z-axis imaged by one data channel. In multiple-detector-row (multi slice) CT scanners, several detector elements maybe grouped together to form one data channel. In single-detector-row (single-slice) CT, the z-axis collimation (T) is the nominal scan width.

CTDI represents the average absorbed dose, along the z-axis, from a series of contiguous irradiations. It is measured from one axial CT scan (one rotation of the x-ray tube) 21–24, and is calculated by dividing the integrated absorbed dose by the nominal total beam collimation. The CTDI is always measured in the axial scan mode for a single rotation of the x-ray source, and theoretically estimates the average dose within the central region of a scan volume consisting of multiple, contiguous CT scans [Multiple Scan Average Dose (MSAD)] for the case where

the scan length is sufficient for the central dose to approach its asymptotic upper limit^{22, 23, 25}. The MSAD represents the average dose over a small interval ($-I/2$, $I/2$) about the center of the scan length ($z = 0$) for a scan interval I , but requires multiple exposures for its direct measurement. The CTDI offered a more convenient yet nominally equivalent method of estimating this value, and required only a single-scan acquisition, which in the early days of CT, saved a considerable amount of time.

(3-9-2) CTDIvol:

The CTDIvol provides a single CT dose parameter, based on a directly and easily measured quantity, which represents the average dose within the scan volume for a standardized (CTDI) phantom. The SI units are milligray (mGy). CTDIvol is a useful indicator of the dose to a standardized phantom for a specific exam protocol, because it takes into account protocol-specific information such as pitch. Its value may be display prospectively on the console of newer CT Scanners. While CTDIvol estimates the average radiation dose within the irradiated volume for an object of similar attenuation to the CTDI phantom, it does not represent the average dose for objects of substantially different size, shape, or attenuation or when the 100-mm integration limits omit a considerable fraction of the scatter tails. Further, it does not indicate the total energy deposited into the scan volume because it is independent of the length of the scan. That is, its value remains unchanged whether the scan coverage is 10 or 100 cm. It estimates the dose for a 100-mm scan length only, even though the actual volume-averaged dose will increase with scan length up to the limiting equilibrium dose value.

(3-9-3)Dose-Length Product (DLP):

To better represent the overall energy delivered by a given scan protocol, the absorbed dose can be integrated along the scan length to compute the Dose-Length Product (DLP), where:

$$\text{DLP (mGy-cm)} = \text{CTDIvol (mGy)} \times \text{scan length (cm)}.$$

The DLP reflects the total energy absorbed (and thus the potential biological effect) attributable to the complete scan acquisition. Thus, an abdomen-only CT exam might have the same CTDIvol as an abdomen/pelvis CT exam, but the latter exam would have a greater DLP, proportional to the greater z-extent of the scan volume.

In helical CT, data interpolation between two points must be performed for all projection angles. Thus, the images at the very beginning and end of a helical scan require data from z-axis projections beyond the defined “scan” boundaries (i.e., the beginning and end of the anatomic range over which images are desired). This increase in DLP due to the additional rotation(s) required for the helical interpolation algorithm is often referred to as “over ranging.” For MDCT scanners, the number of additional rotations is strongly pitching dependent, with a typical increase in irradiation length of 1.5 times the total nominal beam width.

The implications of over ranging with regard to the DLP depend on the length of the imaged body region. For helical scans that are short relative to the total beam width, the dose efficiency (with regard to over ranging) will decrease. For the same anatomic coverage, it is generally more dose efficient to use a single helical scan than multiple helical scans [19] .

CHAPTER FOUR

Results and Discussion

(4-1)Results:

Type of examination	Voltage/kv	Current/mA	Time/Sec
Hand AP	42-48	100	0.04
Shoulder	62-64	200	0.06
Foot	42-46	100	0.04
Ankle	46-48	100	0.04
Knee	50-54	100	0.04
Chest	58-66	200	0.05
Abdomen suspire	80	200	0.12
Abdomen erect	85	200	0.12
Skull AP	66-74	100	0.1
Skull lat	64-68	100	0.1
C/S AP	72-78	100	0.1
C/S lat	64-68	100	0.1
D/S AP	72-78	100	0.1
D/S lat	78-86	100	0.12
L/S AP	80-90	100	0.12
L/S lat	88-96	100	0.16



Picture (4-1): Acidification room



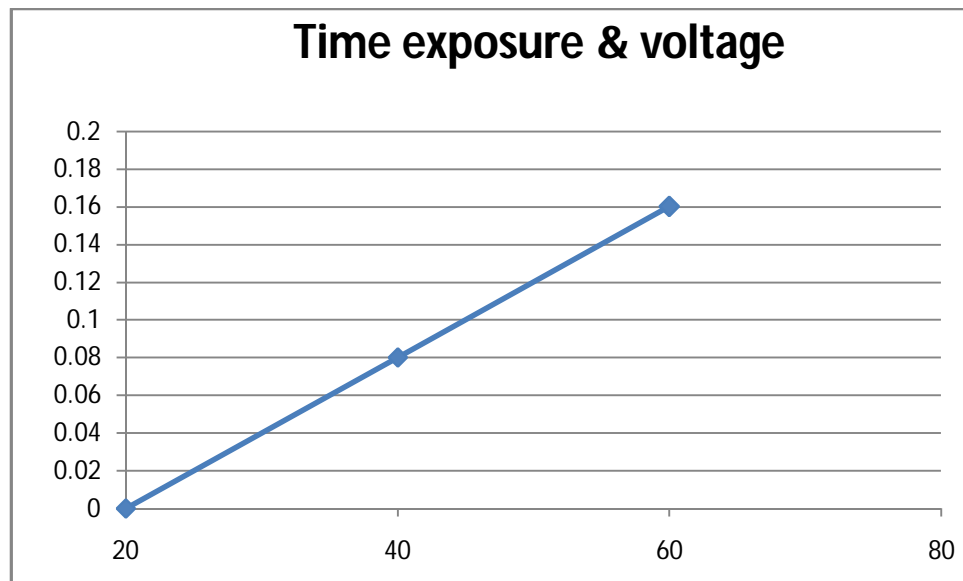
picture (4-2): power source



Picture (4-3): film



picture(4-4):exam table



(4-2)Discussion:

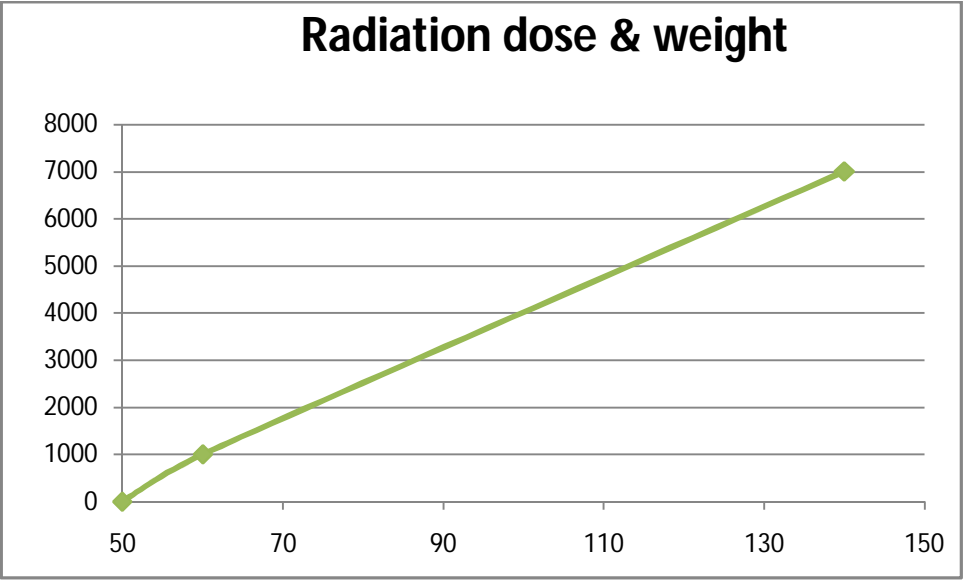
The table above represents the radiation dose for patients in Health care hospital by X-ray device for many parts of the body; hand AP, shoulder , foot ,ankle, knee, chest , abdomen(suspire –erect), skull(AP - lat), C/S(AP-lat),DS(AP-lat) ,LS(AP-lat).The table illustrates the analogy of voltage ,radiation dose and time.

You will be asked to lie on an exam table or stand next to the X-ray machine. The room may be cool in order to keep the equipment from overheating. The technologist, or person performing the exam, may use pillows or sandbags to help you hold the proper position. You will be asked to hold very still, without breathing for a few seconds. The technologist will step behind a radiation barrier and activate the X-ray machine. Often multiple images or views are taken from different angles, so the technologist will reposition you for another view and the process will be repeated. You will not feel the radiation.

X-rays are recorded on film or recorded digitally, but here it recorded on film. A radiologist, who is a physician with specialized training in X-ray and other imaging tests, will analyze and interpret the results of your X-ray and then send a report to your personal physician. For non-emergency situations, it usually takes a day or so to interpret, report, and deliver the results. If you need information of the results of your exam contact the physician.

(4-3) Results:

Type of examination	Age	weight	Kv	mAs	CTDI vol	DLP
brain	80	80	120	1952	30.70	524.60
KUB	32	100	120	4452	15.60	586.60
KUB	40	120	120	6533	20.70	879.40
Abdomen	30	90	120	3192	56.80	2288.80
PNS	44	85	120	2080	32.30	394.40
Chest	65	130	120	6890	31.20	938.50
CTU	65	110	120	5906	20.70	792.10
HR Chest	45	95	120	3710	15.60	491.10
RT Elbow	80	140	120	7164	28.80	409.50
PNS	40	70	120	1951	32.30	368.20



(4-4)Discussion:

The table bellow represents the radiation dose for patients in AlFaisal Hospital by CT device for many parts of the body.

The Volume CTDI (CTDIvol) measured in mGy, and the dose-length product (DLP) measured in mGy-cm. CTDIvol is a measure of the average dose within the scan volume to a standardized phantom. The total amount of radiation delivered to a standardized phantom is represented by the DLP, which is the product of CTDIvol and the scan length.

The operator of the scanner can vary these parameters on a patient- by -patient basis, usually through modification of the tube current or rotation time in order to change the mAs (tube current – time product). For example, a large patient will need a higher than average mAs to counteract the effect of increased attenuation and the resultant increase in image noise. Similarly, CT scans of a small adult, or child, will demonstrate adequate image quality at a lower mAs than that required for a large patient; but the age is not necessary comparing by weight; because there are adults have small size. It is illustrate on the above graph.

CHAPTER FIVE

RECOMMENDATIONS AND REFERENCES

(5-1)Recommendations and Future Work:

- All the types of medical imaging must be known
- Help the doctors to choose the best device for each case alone.
- The operator is responsible to use these systems correctly, and this requires education about the capabilities of particular AEC systems and the methods for controlling their operation.
- Ask why the test is necessary; to protect patient from radiation without reason.
- Avoid unnecessary repeat scans.
- Ask for the lowest effective dose.
- Get the right dose depending of patient size.

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