Sudan University of Sciences & Technology

College of Graduate Study

Evaluation of Radiation Dose for CT Abdomen With Respect To AP Diameter and Field Of View

(تقويم الجرعة الإشعاعية للاشعة المقطعية للبطن اعتمادا علي القطر المستعرض ومساحة التعرض)

A thesis submitted for partial fulfillment of M.Sc. Academic Degree in Diagnostic Radiologic Technology

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الآيه

(قل لوكان البحر مدادا لكلمات ربي لنفذ البحر قبل ان تنفذ كلمات ربي ولو جئنا بمثله مددا(*)قل انما انا بشر يوحى إلي انما الهكم اله واحد فمن كان يرجوا لقاء ربه فليعمل عملا صالحا ولا يشرك بعبادة ربه أحدا)

صدق الله العظيم

الايات(109-110)

سورة الكهف

Dedication

This thesis is dedicated to:

The sake of Allah, my Creator and my Master, My great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life, My great parents, who never stop giving of themselves in countless ways, My beloved brothers and sisters; I also would like to express my whole hearted thanks to my family for their generous support they provided me throughout my entire life and particularly through the process of pursuing the master degree. Because of their unconditional love and prayers, I have the chance to complete this thesis, my friends who encourage and support me, All the people in my life who touch my heart, I dedicate this research.

Acknowledgment

First and foremost, I must acknowledge my limitless thanks to Allah, the Ever-Magnificent; the Ever-Thankful, for His help and bless. I am totally sure that this work would have never become truth, without His guidance. I owe a deep debt of gratitude to our **SUDAN UNIVERSITY** for giving us an opportunity to complete this work.

I am grateful to some people, who worked hard with me from the beginning till the completion of the present research particularly my supervisor **Dr. IKHLAS ABDELAZIZ**; she has been always generous during all phases of the research.

I am very appreciative to my colleagues in the ALAML HOSPITAL Last but not least; deepest thanks go to all people who took part in making this thesis real.

Abstract

This study, carried out during the period from September 2015 to February2016 .the aim of this study was to evaluate the Radiation Dose of CT Abdomen With respect To AP Diameter and Field Of View. The 100 random cases, there ages ranged from 19 to up to 60 years. Came to the CT department with request for CT abdomen. All patients scanned by CT 44 (44.0%) were male and 56 (56.0%) female. CT machine used in this study was: used Multi-slice CT scanner (Toshiba) 64slice scanner in ALamal diagnostic center ‘Alamal National Hospital

From this study the result show that the AP diameter had significant role in reduction of patient dose in the CT abdomen exams and had correlation with the FOV

The study concluded that AP diameter had significant role in optimizing of patient dose in the CT abdomen exams and had correlation with the FOV.

الملخص

اجريت هذه الدراسة ، خلال الفترة من سبتمبر 2015 إلى فبراير 2016 . و هدفت هذه الدراسة إلى تقويم الجرعة الإشعاعية للاشعه المقطعية للبطن فيما يتعلق بالقطر الامامي الخلفي و مساحة التعرض . وجاءت الحالات عشوائية من 100 مريض إلى قسم الاشعه المقطعيه مع طلب اشعه مقطعيه للبطن جهاز الاشعه المقطعيه استخدم في هذه الدراسه متعدد شريحة الماسح الضوئي (توشيبا) 64 شريحه مركز الامل التشخيصي بمستشفي الامل الوطني .

من هذه الدراسة تؤثر القطر الامامي الخلفي للمريض كبير في تحسين الجرعة للمريض في فحوصات البطن التصوير المقطعي و معامل ارتباط مع مساحة التعرض . وكان جميع المرضى الذين تم اجراء الدراسه عليهم 44(44.0 ٪) ذكور و 56 (56.0 ٪) من الإناث.

تراوح أعمارهم بين19 الي 60 عاما.

وخلصت الدراسة إلى ان زيادة القطر الامامي الخلفي تؤثر بدرجه كبيرة في حساب الجرعة للمريض في فحوصات البطن بالاشعه المقطعية و كان لها ارتباط مع المساحه المتعرضه .

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List of abbreviations

CT	Computer tomography
FOV	Field of view
MDCT	Multidetector computed tomographic.
CTDI	CT Dose Index
DLP	Dose length product
REM	Roentgen Equivalent Man
AP-D	Anterior Posterior diameter
Rt-Lt	Right to left diameter
AAPM	American Association of Physicists In Medicine
KV	Kilo volte
mAs	Miliamper second

Chapter one

1.1 Introduction:

Ionizing Radiation is the name given to a band of energy on the electromagnetic spectrum. X-rays and radioactive substances are examples of ionizing radiation, in order to understand the difference between ionizing and non-ionizing radiation it is necessary to review the structure of an atom. (William R., E. Russell, 2002).

All matter is made up of atoms. Molecules are collections of atoms hooked together in various combinations and shapes, an atom is the smallest unit of an element (like helium, oxygen or carbon) that still has all the properties of that element. Atoms are so small they cannot be seen with even the most powerful microscope, all atoms are made up of three major subatomic particles: protons, neutrons, and electrons. Protons and neutrons make up the nucleus or center of the atom, protons have a positive electric charge but neutrons have no electric charge, electrons circle the nucleus and have a negative charge. In the neutral atom the negative charges of the electrons exactly balance the positive charges of the protons in the nucleus. If an atom has too many or too few electrons in orbit to balance the charge of the protons, the atom is called an ion, the number of protons in the nucleus of an atom determines which element it is, isotopes of the same element have the same number of protons but varying numbers of neutrons. (William R., E. Russell, 2002).

The helium atom (4He2) has two protons and two neutrons in the nucleus. An unstable isotope of carbon is carbon-14 ($^{14}C_{6}$). The superscript indicates the atomic weight while the subscript number indicates the number of protons. If the atom has too many or too few neutrons for the number of protons, the atom may be unstable. If unstable the nucleus will give off bursts of energy (radiation) in an attempt to become stable. (Goldman 2007).

These bursts of energy or disintegrations may be in the form of alpha particles (two protons and two neutrons - positively charged), beta particles (a negatively-charged electron), x-rays, or gamma rays (types of high energy electromagnetic waves). If these charged particles or waves interact with another atom, they have enough energy to knock an electron out of its orbit, creating an ion. That is why this type of radiation is called ionizing radiation.

Other forms of energy, like visible light, radio waves, and infrared light, do not have enough power to knock electrons out of their orbits so they are called non-ionizing radiation.

Amounts of ionizing radiation can be expressed in several different units. A **roentgen** (R) is an amount of x-rays or gamma radiation that causes a specified amount of ionization among the atoms and molecules in a cubic centimeter of air. Another unit is the **rad**, which applies to all ionizing radiation. It is a measure of the amount of energy absorbed from radiation in a specific volume of material.

A third unit, which is more useful and used more commonly, is the **REM** (Roentgen Equivalent Man). Measuring radiation in reams or millirems (one thousandth of a rem) allows direct comparison of the biological effects of different types of radiation. Alpha particles, beta particles, and x-rays or gamma radiation, differ in their ability to cause damage in tissues due to their differences in ionizing and penetrating ability. (Jerrold T, J.antony, Edwin, Boone, 2002).

Alpha particles are 20 times more damaging in tissue then the same amount of x-rays. Measuring radiation in rems takes this difference into account so that one rem of alpha radiation in tissues has the same effect as one rem of beta radiation or one rem of x-rays. A rem is a relatively large quantity of radiation so most human exposures are measured in millirems. An easy way to remember the difference between these units is that a roentgen is a measure of how much you are exposed to, the rad is how much you absorb, and the rem is how much damage it does.

All people receive ionizing radiation from naturally occurring sources. Depending on where you live, most people receive an exposure in the range of 100 millirems per year from cosmic radiation from outer space and from naturally occurring isotopes (excluding radon) in the ground, air, food, and water. Radon is estimated to add another 200 millirems per year to our background. Medical and dental uses of x-rays can also contribute to a person's yearly radiation exposure. A typical well-conducted chest x-ray involves an exposure of 30 milliroentgens.

1.1.1 Types of radiation:

Radiation has a wide range of energies that form the electromagnetic spectrum (illustrated below). The spectrum has two major divisions: Non-ionizing radiation ,Ionizing radiation.

Radiation that has enough energy to move around atoms in a molecule or cause them to vibrate, but not enough to remove electrons, is referred to as "non-ionizing radiation." Examples of this kind of radiation include visible light and microwaves.

Radiation that falls within the "ionizing radiation" range has enough energy to remove tightly bound electrons from atoms, thus creating ions. This is the type of radiation that people usually think of as 'radiation.' We take advantage of its properties to generate electric power, to kill cancer cells, and in many manufacturing processes. (Anne et al. 2001).

The energy of the radiation shown on the spectrum below increases from left to right as the frequency rises, non-ionizing Radiation We take advantage of the properties of non-ionizing radiation for common tasks:

Microwave radiation telecommunications and heating food.

Infrared radiation infrared lamps to keep food warm in restaurants.

Radio waves broadcasting.

Non-ionizing radiation ranges from extremely low frequency radiation, shown on the far left through the audible, microwave, and visible portions of the spectrum into the ultraviolet range.

Extremely low-frequency radiation has very long wave lengths (on the order of a million meters or more) and frequencies in the range of 100 Hertz (cycles per second) or less. Radio frequencies have wave lengths of between one and 100 meters and frequencies in the range of one million to 100 million Hertz. Microwaves that we use to heat food have wavelengths that are about one hundredth of a meter and have frequencies of about 2.5 billion Hertz. (Anne et al. 2001).

Ionizing radiation is categorized by the nature of the particles or electromagnetic waves that create the ionizing effect. These have different ionization mechanisms, and may be grouped as directly or indirectly ionizing, higher frequency ultraviolet radiation begins to have enough energy to break chemical bonds. X-ray and gamma ray radiation, which are at the upper end of magnetic radiation, have very high frequencies (in the range of 100 billion billion Hertz) and very short wavelengths of about 1 picometer (1 trillionth of a meter). Radiation in this range has extremely high energy. It has enough energy to strip off electrons or, in the case of very high-energy radiation, break up the nucleus of atoms,ionization is the process in which a charged portion of a molecule (usually an electron) is given enough energy to break away from the atom. This process results in the formation of two charged particles or ions: the molecule with a net positive charge and the free electron with a negative charge. (Anne et al. 2001).

Each ionization releases approximately 33 electron volts (eV) of energy. Material surrounding the atom absorbs the energy. Compared to other types of radiation that may be absorbed, ionizing radiation deposits a large amount of energy into a small area. In fact, the 33 eV from one ionization is more than enough energy to disrupt the chemical bond between two carbon atoms. All ionizing radiation is capable, directly or indirectly, of removing electrons from most molecules**,**there are three main kinds of ionizing radiation(Alpha particles, which include two protons and two neutrons, Beta particles, which are essentially high-speed electrons, Gamma rays and x-rays, which are pure energy (photons). (Rounds et al.2003)

Use of radiation in medicine is used in medicine in 3 ways Diagnostic radiology, which uses x-ray machines to obtain images of the inside of the patient's bodyNuclear medicine, which uses radioactive substances introduced into the patient for diagnosis or treatmentRadiotherapy, which uses many types and sources of ionizing radiation to cure or relieve symptoms of cancer and other disease.

Diagnostic radiology is concerned with the use of various imaging modalities to aid in the diagnosis of disease. Diagnostic radiology can be further divided into multiple sub-specialty areas. Interventional radiology, one of these sub-specialty areas, uses the imaging modalities of diagnostic radiology to guide minimally invasive surgical procedures.

Risk of radiation radioactive materials that decay spontaneously produce ionizing radiation, which has sufficient energy to strip away electrons from atoms (creating two charged ions) or to break some chemical bonds. Any living tissue in the human body can be damaged by ionizing radiation in a unique manner. The body attempts to repair the damage, but sometimes the damage is of a nature that cannot be repaired or it is too severe or widespread to be repaired. Also mistakes made in the natural repair process can lead to cancerous cells. The most common forms of ionizing radiation are alpha and beta particles, or gamma and X-rays. (Hunold et al. 2003).

In general, the amount and duration of radiation exposure affects the severity or type of health effect. There are two broad categories of health effects: stochastic and non-stochastic. (Hunold et al. 2003).

1.2 importance of study:

This study is to investigate the relationship among cross-sectional diameters, field of view (FOV) and the computed tomography (CT)dose descriptors (CTDI and DLP) to identify which is best used as measure for the establishment of DRLs in CT.

The importance of using AP diameter are that it can easily be measured prior to scanning or retrospectively from previous CT images, also the AP diameter has a greater correlation with radiation dose than body weight and thus be its substituted in dose-reduction strategies and establishment of DRLs.

1.3 The statement of the problem:

Increasing of CT examinations for abdomen in Sudan and the area of scanning have sensitive anatomical organs (breast, pelvic organs).

The FOV of the patients and CT changing or applying same protocol to any patient without look for the diameter.

1.4 Objectives of the Study:

1.4.1 General objective:

To evaluate radiation dose for the CT abdomen with respect AP diameter and FOV.

1.4.2 Specific Objectives:

- To assess radiation dose for CT abdomen protocol.
- To optimize radiation dose.
- To correlate between AP diameter, FOV, RT-LT diameter and radiation dose.

1.5 Over view of the study:

Chapter one…. Introduction.

Chapter two…. Literature Review.

Chapter three ……..Materials and Methods.

Chapter four….Results.

Chapter five…... Discussion, Conclusion and Recommendation.

Chapter two

Literature Review

2.1 Theoretical Background:

2.1.1 Structures:

The abdomen contains most of the tube-like organs of the digestive tract, as well as several solid organs. Hollow abdominal organs include the stomach, the small intestine, and the colon with its attached appendix. Organs such as the liver, its attached gallbladder, and the pancreas function in close association with the digestive tract and communicate with it via ducts. The spleen, kidneys, and adrenal glands also lie within the abdomen, along with many blood vessels including the aorta and inferior vena cava. Anatomists may consider the urinary bladder, uterus, fallopian tubes, and ovaries as either abdominal organs or as pelvic organs. Finally, the abdomen contains an extensive membrane called the peritoneum. A fold of peritoneum may completely cover certain organs, whereas it may cover only one side of organs that usually lie closer to the abdominal wall. Anatomists call the latter type of organs retroperitoneal.

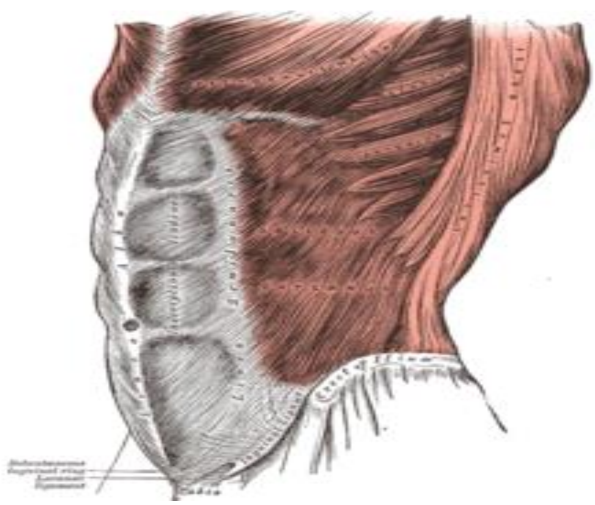

Fig (2-1): shows Describes Abdominal Muscles

There are three layers of the abdominal wall. They are, from the outside to the inside: external oblique, internal oblique, and transverse abdominus. The first three layers extend between the vertebral column, the lower ribs, the iliac crest and pubis of the hip. All of their fibers merge towards the midline and surround the rectus abdominus in a sheath before joining up on the opposite side at the linea alba.

Strength is gained by the crisscrossing of fibers, such that the external oblique are downward and forward, the internal oblique upward and forward, and the transverse abdominus horizontally forward, the transversus abdominis muscle is flat and triangular, with its fibers running horizontally. It lies between the inner oblique and the underlying transversalis fascia. It originates from Poupart's ligament, the inner lip of the ilium, the lumbar fascia and the inner surface of the cartilages of the six lower ribs. It inserts into the linea Alba behind the rectus abdominis, the rectus abdominis muscles are long and flat. The muscle is crossed by three tendinous intersections called the linae transversae. The rectus abdominis is enclosed in a thick sheath formed, as described above, by fibers from each of the three muscles of the lateral abdominal wall. They originate at the pubis bone, run up the abdomen on either side of the linea alba, and insert into the cartilages of the fifth, sixth, and seventh ribs. In the region of the groin, the inguinal canal, a passage through the layers. This gap is where the testes can drop through the wall and where the fibrous cord from the uterus in the female runs. This is also where weakness can form, and inguinal hernias, The pyramidalis muscle is small and triangular. It is located in the lower abdomen in front of the rectus abdominis. It originates at the pubic bone and is inserted into the linea Alba halfway up to the umbilicus.

2.1.2 Historical background:

The CT system was invented by Godfrey Newbold Hounsfield in Hayes, England at THORN EMI Central Research Laboratories

using X-rays. Hounsfield conceived the idea in 1967, and it was publicly announced in 1972. Allan McLeod Cormack of Tufts University independently invented the same process and they shared a Nobel Prize in medicine in 1979. The original 1971 prototype took 160 parallel readings through 180 angles, each 1° apart, with each scan taking a little over five minutes. The images from these scans took 2.5 hours to be processed by algebraic reconstruction techniques on a large computer,the first commercial CT machine using X-rays (called the EMI-Scanner) was limited to making tomographic sections of the brain, but acquired the image data in about 4 minutes (scanning two adjacent slices) and the computation time (using a Data General Nova minicomputer) was about 7 minutes per picture. This scanner required the use of a water-filled Perspex tank with a pre-shaped rubber "head-cap" at the front, which enclosed the patient's head. The water-tank was used to reduce the dynamic range of the radiation reaching the detectors (between scanning outside the head compared with scanning through the bone of the skull). The images were relatively low resolution, being composed of a matrix of only 80 x 80 pixels. The first EMI-Scanner was installed in Atkinson Morley's Hospital in Wimbledon, England, and the first patient brain-scan was made with it in 1972. In the US, the machine sold for about $390,000, with the first installations being at the Mayo Clinic ,Massachusetts General Hospital, and George Washington University in 1973. (Hunold et al. 2003).

There are several advantages that CT has over traditional 2D medical radiography. First, CT completely eliminates the superimposition of images of structures outside the area of interest. Second, because of the inherent high-contrast resolution of CT, differences between tissues that differ in physical density by less than 1% can be distinguished. Finally, data from a single CT imaging procedure consisting of either multiple contiguous or one helical scan can be viewed as images in the axial, coronal, or sagittal planes, depending on the diagnostic task. This is referred to as multiplanar reformatted imaging,CT is regarded as a moderate- to high-radiation diagnostic technique. The improved resolution of CT has permitted the development of new investigations, which may have advantages; compared to conventional radiography, for example, CT angiography avoids the invasive insertion of a catheter. CT colonography (also known as virtual colonoscopy or VC for short) may be as useful as a barium enema for detection of tumors, but may use a lower radiation dose. CT VC is increasingly being used in the UK as a diagnostic test for bowel cancer and can negate the need for a colonoscopy.The radiation dose for a particular study depends on multiple factors: volume scanned, patient build, number and type of scan sequences, and desired resolution and image quality. In addition, two helical CT scanning parameters that can be adjusted easily and that have a profound effect on radiation dose are tube current and pitch. Computed tomography (CT) scan has been shown to be more accurate than radiographs in evaluating anterior interbody fusion but May still over-read the extent of fusion. . (Hunold et al. 2003).

2.1.3Generation of CT:

First generation:

These CT scanners used a pencil-thin beam of radiation directed at one or two detectors. The images were acquired by a "translate-rotate" method in which the x-ray source and the detector in a fixed relative position move across the patient followed by a rotation of the x-ray source/detector combination (gantry) by one degree. In the EMI-Scanner, a pair of images was acquired in about 4 minutes with the gantry rotating a total of 180 degrees. Three detectors were used (one of these being an X-ray source reference), each detector comprising a sodium iodide scintillator and a photomultiplier tube. (Mahesh, 2002)

Second generation:

This design increased the number of detectors and changed the shape of the radiation beam. The x-ray source changed from the pencil-thin beam to a fan shaped beam. The "translate-rotate" method was still used but there was a significant decrease in scanning time. Rotation was increased from one degree to thirty degrees (Mahesh, 2002).

Third generation:

CT scanners made a dramatic change in the speed at which images could be obtained. In the third generation a fan shaped beam of x-rays is directed to an array of detectors that are fixed in position relative to the x-ray source. This eliminated the time consuming translation stage allowing scan time to be reduced, initially, to 10 seconds per slice. This advance dramatically improved the practicality of CT. Scan times became short enough to image the lungs or the abdomen; previous generations had been limited to the head, or to limbs. (Mahesh, 2002)

Fourth generation:

This design was introduced, roughly simultaneously with 3rd generation, and gave approximately equal performance. Instead of a row of detectors which moved with the X-ray source, 4th generation scanners used a stationary 360 degree ring of detectors. The fan shaped x-ray beam rotated around the patient directed at detectors in a non-fixed relationship. (Mahesh, 2002)

Multidetector CT scanner:

(MDCT) A form of computed tomography (CT) technology for diagnostic imaging. In MDCT, a two-dimensional array of detector elements replaces the linear array of detector elements used in typical conventional and helical CT scanners. The two-dimensional detector array permits CT scanners to acquire multiple slices or sections simultaneously and greatly increase the speed of CT image acquisition. Image reconstruction in MDCT is more complicated than that in single section CT. Nonetheless, the development of MDCT has resulted in the development of high resolution CT applications such as CT angiography and CT colonoscopy. multidetector computed tomography is also known by a confusing array of other terms such as multidetector CT, multidetector-row computed tomography, multidetector-row CT, multi-section CT, multi-slice computed tomography, and multi-slice CT. . (Mahesh, 2002)

2-1-4 CT dosimeter:

The radiation dose in computed tomography (CT) has come under recent scrutiny, due to the dramatically increased utilization of CT in diagnostic medicine. While CT scanner technology has advanced greatly in the past decade, the most widely used radiation dosimetry methods were developed 30 years ago. The International Commission on Radiological Units and Measurements (ICRU) report committee on CT image quality and radiation dose will propose new CT dosimetry methods, and these will be discussed in this presentation. These methods are largely consistent with measurement protocols defined in the American Association of Physicists in Medicine document TG-111. The proposed methods also allow the characterization of CT scanners which allow very wide z-axis collimation.

CTDI-based methods for CT dosimetry were originally designed as dose metrics, however widely used extensions of CTDI (including $CTDI_w$ and $CTDI_{vol}$) represent simple efforts to estimate patient dose. Unfortunately the 160 mm and 320 mm polymethyl methacrylate (PMMA) phantoms used for $CTDI_{100}$ measurement are not representative of most patients and their use (without correction factors) reduces the accuracy of dose estimation. (Perry Sprawls.org, Online).

The principal advances of the proposed ICRU CT dosimetry methods are that they include patient diameter, as well as beam energy and the scan length used. It is recognized that Monte Carlo derived dose coefficients are likely to be the most accurate dosimetry method, while physical measurements are performed principally to calibrate and validate Monte Carlo derived CT dosimetric values. Further, the ICRU CT committee is developing dose values for a range of patient sizes, from pediatric to obese adults that will likely serve the needs of most patient dose estimates. Correction for scan length is straightforward. (Perry Sprawls.org, Online).

In addition to patient dosimetry, recommendations will be made in regard to acceptance testing procedure and periodic quality assurance measurements on CT scanners. Specifically, a polyethylene phantom has been developed which is both a dosimetry phantom as well as an image quality phantom. The phantom would be scanned and the center dose determined, and then the user can adjust the CT technique factors to achieve a standard dose level to the phantom. This second adjusted scan can be used to determine the image noise using the Noise Power Spectrum. This will allow comparisons of the dose efficiency between CT scanners which differ by vendor and model number. (Perry Sprawls.org, Online).

2.1.5CT abdomen technical aspects:

In general a CT examination of the abdomen includes transaxial images from just above the dome of the diaphragm to the upper margin of the sacroiliac joints with 5 mm or less slice thickness. A CT of the pelvis extends from the iliac crest through just below the ischial tuberosities with 5 mm or less slice thickness (see section VI). Often, depending on the clinical indication for the study, both the abdomen and pelvis may be examined concurrently. In certain cases, it may be appropriate to limit the area exposed and focus only on the area or organs of concern in order to limit the radiation dose. This is especially advised in patients with multiple CT studies and follow-up examinations. An adequate study may be performed with single detector helical technique, but multidetector (including wide detector) scanners are now preferred. Beam pitch should not routinely exceed 2:1 for helical scanners.

B. In addition to axial images, images in coronal, sagittal, or other more complex oblique planes may be constructed from the source-image data to answer specific clinical questions, to aid in disease visualization, or to assist in planning for interventional or surgical procedures.

Additionally, the imaging information may be displayed to demonstrate specific structures such as in CT angiography, CT urography, CT cystography, CT colonography, CT enterography, CT cholangiography, and/or other applications deemed necessary. Such applications are best performed based on data acquired with multidetector CT.

Some abdominal and/or pelvic CT examinations may be performed with multiple acquisitions. All acquisitions are best obtained in the same suspended state of respiration if possible. In general, the fewest number of acquisitions needed to answer the clinical question should be obtained. This is particularly important when imaging children and adolescents. The vast majority of clinical questions for abdominal and/or pelvic CT in children can be appropriately answered with a single-phase study. For radiation treatment planning, examinations should be obtained during normal respiration. Scans should be obtained through the entire area of interest. The scan field of view should be optimized for each patient. Exposure parameters should be optimized for each acquisition to minimize radiation dose while providing the necessary information. Scanner specific dose modulation programs may be helpful for this purpose. Radiation dose reduction is particularly important in the pediatric population and young adults. An intraluminal gastrointestinal contrast agent may be administered orally, rectally, or by nasogastric or other tube to provide adequate visualization of the gastrointestinal tract unless medically contraindicated or unnecessary for the clinical indication. This may be a positive contrast agent such as dilute barium or a water-soluble iodinated solution, a neutral contrast agent such as water or a nonabsorbable agent, or a negative agent such as air or carbon dioxide.

Abdominal and/or pelvic CT examinations may be performed during and/or after administering intravenous (IV) contrast medium, using appropriate injection techniques .For specific indications, it may be necessary to perform a non-IV contrast enhanced study first. Abnormal findings on an unenhanced examination. May require further evaluation with contrast enhancement or an alternative imaging study if contrast medium is contraindicated

Appropriate window width and level settings should be used to view the visceral organs, the intra-abdominal fat and muscles, the pulmonary parenchyma at the lung bases, and the osseous structures.

Although many of the operations of a CT scanner are automated, a number of technical parameters remain operator-dependent. Because these parameters can significantly affect the diagnostic quality of a CT examination, the supervising.

Physician must become familiar with the following:

Radiation exposure factors.

Collimation.

Table increment or pitch.

Field of view.

Window settings.

Reconstruction algorithm.

Image reconstruction interval.

Detector configuration for multidetector systems.

Display slice width for multidetector systems.

Tube current dose modulation setting.

Radiation dose report.

Optimizing CT examination technique requires the supervising physician to develop an appropriate CT protocol based on careful review of the patient history (to include risk factors that might increase the likelihood of adverse reactions to contrast media) and clinical indications, as well as all relevant imaging studies when available. This optimization process may include determining if CT examination of the abdomen, pelvis, or both is necessary.

Protocols may be prepared by region of interest and medical indication. Techniques should be selected that provide image quality consistent with the diagnostic needs of the examination at acceptable radiation dose levels. For each area of interest or indication, the protocol should indicate the following:

The volume and type of gastrointestinal contrast media to be administered, the route of administration (oral, rectal, or via nasogastric or other tube), and the time intervals during which it should be delivered.

If intravenous contrast material is used, the type, volume, rate of administration, and time delay between administration and scan initiation. Bolus tracking should be used whenever indicated to optimize results.

Detector configuration.

Table increment and pitch.

Slice thickness.

Reconstruction interval.

Reconstruction kernel (algorithm).

KVp and mAs per slice or range (minimum and maximum mAs for multidetector CT) as appropriate for adult or pediatric patients.

Noise index (for multidetector CT).

Superior and inferior extent of the region of interest to be imaged.

Protocols for sending images to PACS (Picture Archiving and Communication System) (e.g., scans in original slice thickness and/or reformations in axial plane at larger slice thickness in the coronal, sagittal, and other oblique planes), and MIPS (Medical Image Processing System) as needed.

3D reconstructions where needed.

For every CT examination, the information in the radiation dose report (CTDI and Dose Length Product) should be retained in the radiological record (sent to PACS) for future reference. These protocols should be reviewed and updated periodically and dated copies should be available to appropriate physician, technical and administrative personnel at the facility

Indications for CT abdominal examinations include, but are not limited to:

Evaluation of abdominal, flank, or pelvic pain, including evaluation of suspected or known urinary calculi and appendicitis, and to evaluation of renal and adrenal masses and of urinary tract abnormalities with CT urography,evaluation of known or suspected abdominal or pelvic masses or fluid collections, including gynecological masses,to assessment primary or metastatic malignancies, including lesion characterization, e.g., focal liver lesion, evaluation of diffuse liver disease (e.g., steatosis, iron deposition disease, cirrhosis and biliary system, including CT cholangiography , to assessment for recurrence of tumors following surgical resection,Detection of complications following abdominal and pelvic surgery, e.g., abscess, lymphocele, radiation change, and fistula/sinus tract formation, to evaluation of abdominal or pelvic inflammatory processes**,** including inflammatory bowel disease, infectious bowel disease and its complications, without or with CT enterography.

Assessment of abnormalities of abdominal or pelvic vascular structures.

Evaluation of abdominal or pelvic trauma, clarification of findings from other imaging studies or laboratory abnormalities, evaluation of known or suspected congenital abnormalities of abdominal or pelvic organs, Evaluation for small bowel or large bowel obstruction, and to Screening for colonic polyps and cancers with CT colonography, guidance for interventional or therapeutic procedures within the abdomen or pelvis, to treatment planning for radiation and chemotherapy and evaluation of tumor response to treatment, including perfusion studies.

2.2 Previous study:-

A study in Khartoum done by Islam Altag (2013) titled “effect of AP diameter in patient dose during CT abdomen and chest” .in this study conclude that the AP diameter has significant rule in optimaizating of patient dose during CT abdomen and chest and it has significant correlation with dose rather than patient weight.

A study in California done by Philip M. cheng, (2011) titled “ Automated Estimation of Abdominal Effective Diameter for Body Size Normalization of CT Dose” concluded that the normalization by effective patient diameter is that dose instances that previously appeared elevated in large patients are slightly dampened, while dose instances that previously appeared low for small patients become more conspicuous. We believe that these changes will improve our ability to evaluate the adequacy of protocols in adjusting technique appropriately for body habits. Automated measurement of effective diameter on CT abdominal image is accurate and may be helpful for normalization of CT dose data for body size.

Another study done by Xiang Li Ehsan Sami in (2010) titled ”patient –specific radiation dose and cancer risk for pediatric chest CT “cocluded that the organ dose normalized by tube current time product or CTDI decreased exponentially with increasing average chest diameter. Effective dose normalized by tube current time product DLP decreased exponentially with increased chest diameter. Chest diameter was stronger predictor of dose than the weight total scan length. Risk index normalized by tube current time or DLP decreased exponentially with both chest diameter and age. When normalized by DLP, effective dose and risk index were independent of collimation, pitch and tube potential (lower than 10 % variation). The corrections of dose and risk with patient size and age can be used to estimate patient specific dose and risk they can further guide the design and optimization of pediatric CT protocols.

In 2011, the American Association of Physicists in Medicine (AAPM) task group 206 describe a method for adjusting CTDI values based on the effective diameter of the patient, where effective diameter is defined as the diameter of circle whose area is same as the patient cross section. This can be calculated manually as the geometric mean of the lateral and anterior-posterior dimensions of the patient, assuming and elliptical patient cross-section. However, manual measurement of these dimensions for each patient is laborious and not practically feasible for large dose database.

Chapter Three

Materials and Methods

3.1Materials

3.1.1 Machine used:

Multi-slice CT scanner (Toshiba) 64slice scanner installed in2010, all quality control test were performed to the machine prior any data collection so all the data within acceptable range. The study was conducted in AL-Amal National Hospital it started from September 2015 until March 2016sssn and classified in to material and method.CT scanner system model with tube current modulation.64-slice CT scanner with 64-detector channels, 3-D cone been algorithms. A calibrated DLP embedded in CT machine will be used to measure patient doses during CT examination. 64- Slice is ushering in a new era in CT imaging by giving physicians the ability to see more anatomical details in only a fraction of the time.

Table (3-1) demonstrates CT machine:

Hospital	Manufacture	Model	Year of installation	Detectors No
AL-Amal	Toshiba	Aquilion	2010	64 Rows

Fig (3:1) Represents CT Toshiba Aquilion 64

3.1.2 Patients:

A total of 100 patients both male and female refer to AL-Amal National Hospital in the prior of study for CT abdomen, data were collected to study CT dose by use parameter (age , sex , AP diameter , RT –LT diameter & FOV)

3.2 Methods

A 100 adult's patients both male and female under went 64-MDCT of the abdomen without automatic tube current modulation an AP scout images, maximal body diameters were measured in the transvers from Rt to Lt at the level of L4 in the anterior border and antroposterior (AP) planes which perpendicular with Rt to Lt measuring line.

3.2.1Techniqu used:

Patient lay at supine position feet first arms placed behind the head if passible then the center above the exaiphoid prosses .to the pubic. The protocol use the abdomen multi (plain abdomen) or **KUB** protocol. Usually used to detected renal calculi.

3.2.2 Data collection:

The data were collected using a sheet of all the patients in order to maintain consistency of information from display (appendix).

A data collection sheet was designed to evaluate the patient doses and the radiation related factors. The collected data included sex, FOV, age. Tube voltage and tube current-time , we also recorded all scanning parameters , as well as the CT dose descriptor CT dose index volume in (milligrays) and dose length product (In milligray-centimeters). All these factors that have a direct influence on radiation dose, AL-Amal National hospital was passed successfully the extensive quality control tests performed by Sudan Atomic Energy Commission and met the criteria of this study.

3.2.3 Method of measurement diameters:

We measured the antroposterior and the right to left diameters   in axial cute at level of unplaits from skin to skin the AP line crossed in vertebral foramina.

Fig (3-2) represents the AP and RT to left diameter measurement procedure

3.2.4 Analysis of data

All dose parameters were registered down and from the display monitor in 64 slice CT scan and they use in calculation for the evaluate dose using conversion factor to abdomen, then used as input to the statistical software (SPSS) and Microsoft excel for analysis.

Chapter Four

Results

The results were shown by the following tables and figers:-

Table (4.1) presents the frequencies and percent of the type which include in the study

Type	Frequency	Percent
Male	44	44.0%
Female	56	56.0%
Total	100	100.0%

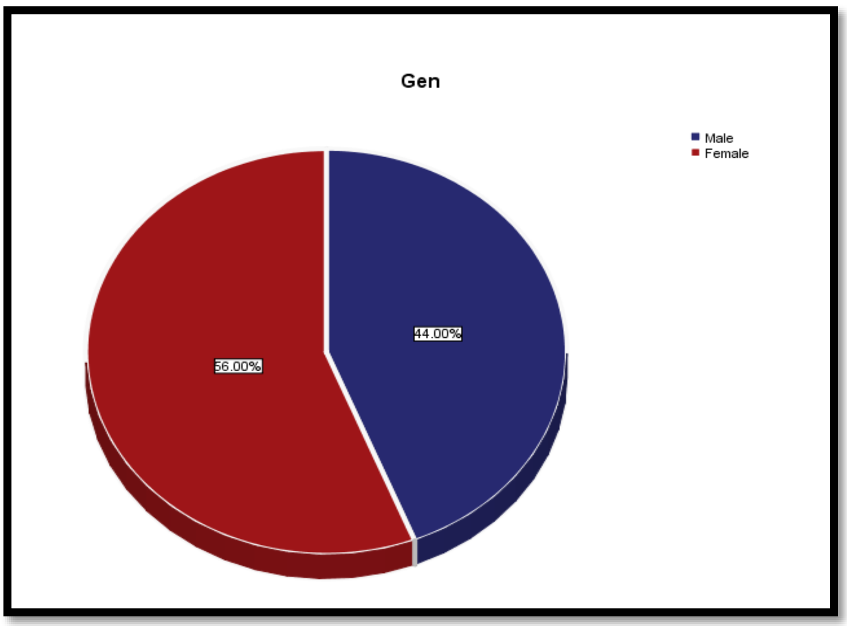

Fig (4.1) pie graph represents the frequencies and percent of the genders

Table (4.2) presents the frequencies and percent of the age groups which

Age	Frequency	Percent
0-19	4	4.0
20-39	30	30.0
40-59	38	38.0
>=60	28	28.0
Total	100	100.0

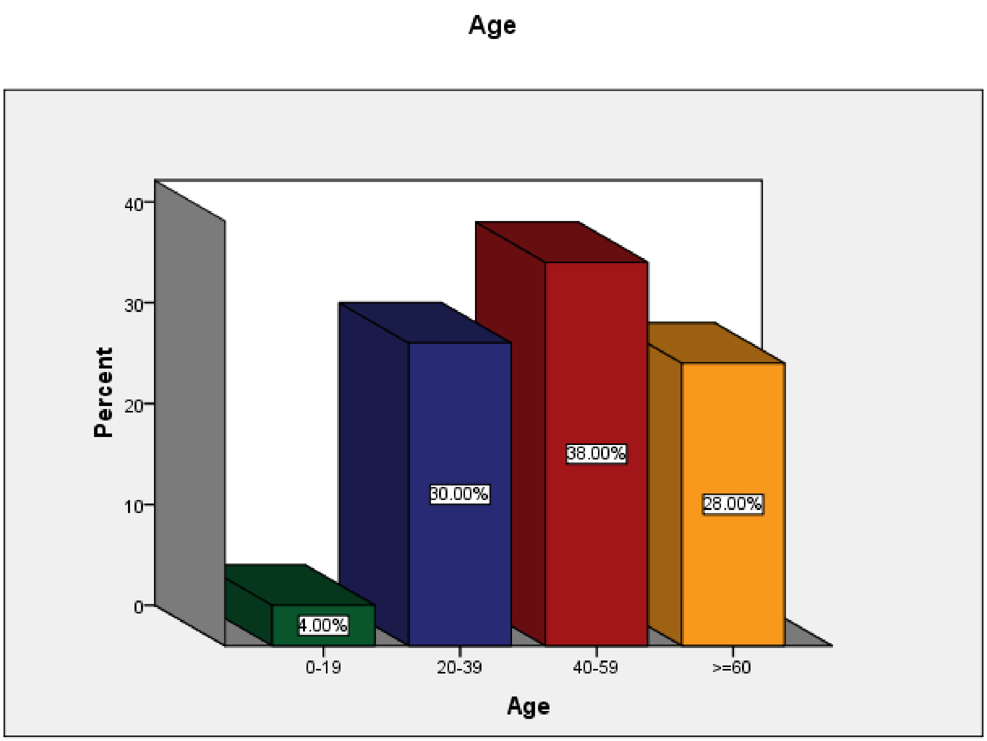

Fig (4.2): represents the frequencies and percent of the age groups which

Table (4.3) represent Chi-Square Tests a Cross tabulation between FOV & DLP

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.000E2[a]	108	.000
Likelihood Ratio	326.020	108	.000
Linear-by-Linear Association	84.268	1	.000
N of Valid Cases	100		

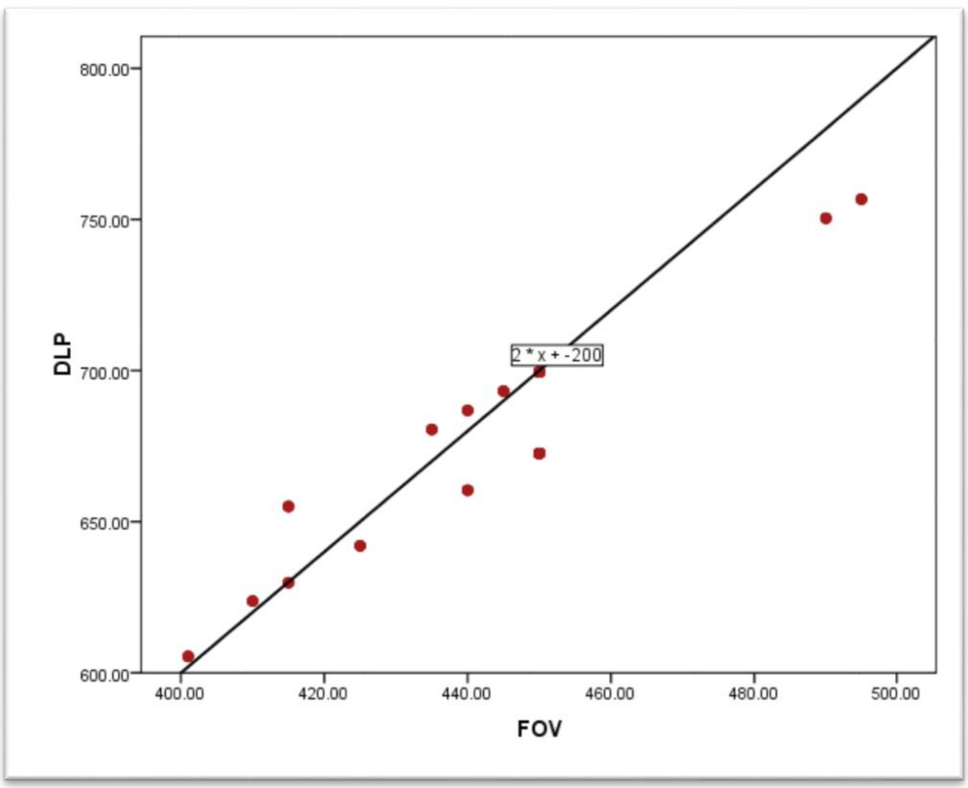

Fig (4.3) scatter plot with represent the relation between the FOV and the DLP

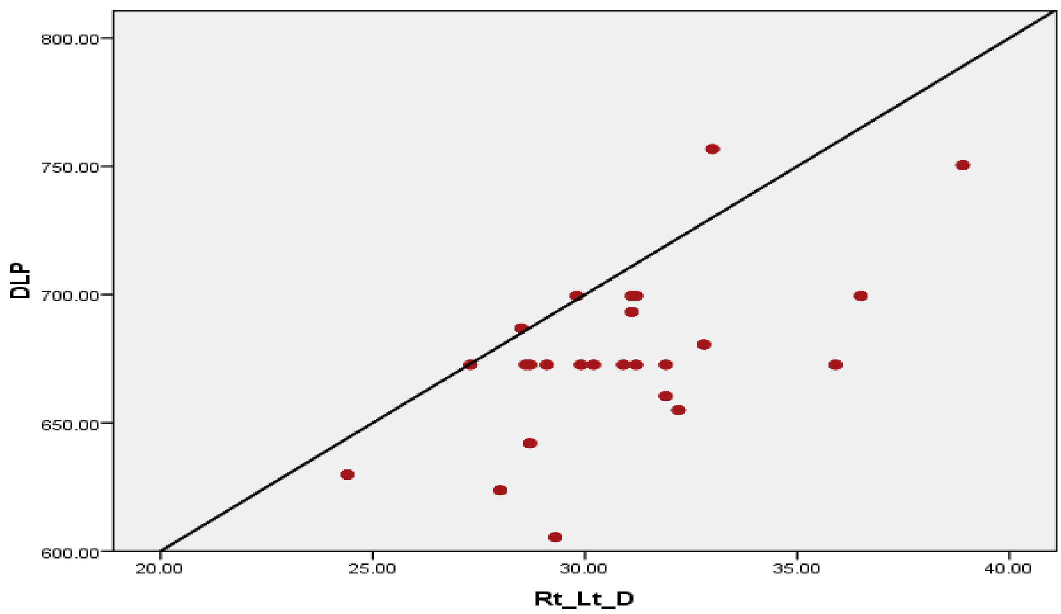

Fig (4.4) scatter plot with represent the relation between the RT to LT diameter and the DLP value

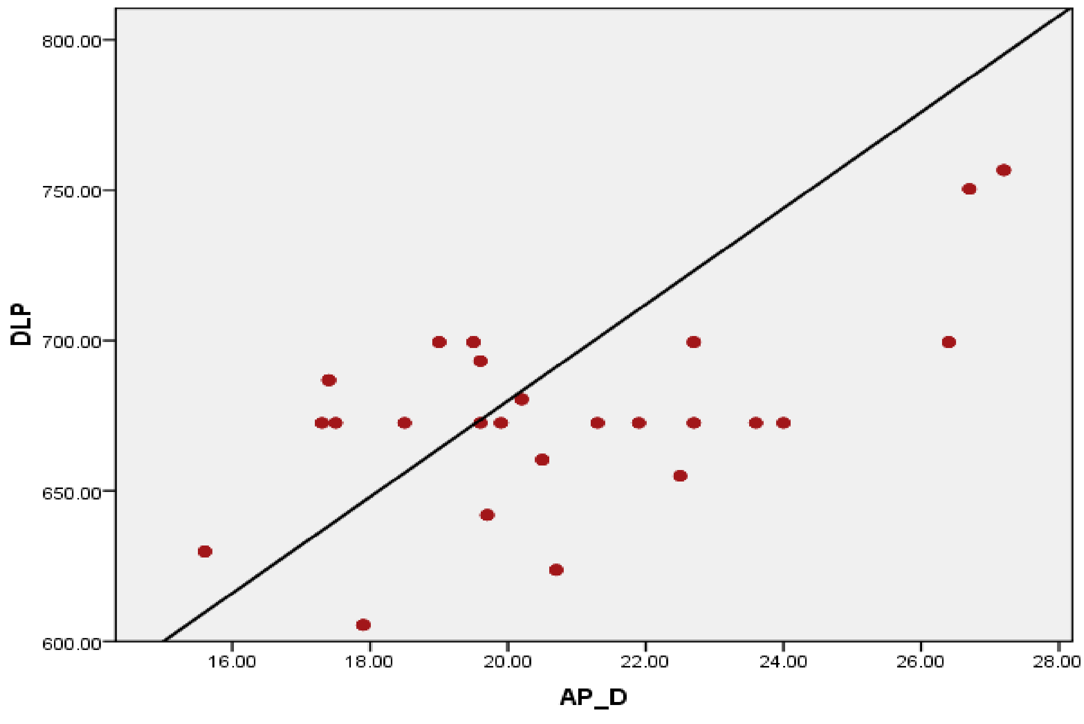

Fig (4.5) scatter plot with represent the relation between the AP diameter and the DLP value

Chapter Five

Discussion, Conclusion and Recommendation

5.1Discussion:

The researcher used two data sheets to collect the information from either patients and technologist , the data that collected from the patients is age and gender , the data which collected from machine is AP diameter, FOV , Kvp ,mAs , CTDIv and DLP this information is gather to measure AP diameter and it is effect in patients doses.

This measurement was done and then statistical was done to produce the previous study CT scanning has been recognized as high radiation dose modality, when compared to other diagnostic X-ray techniques, since its launch into clinical practical more than 30 years ago over that time as scanner technology has develop and its use has become more widespread, concerns over patient.

In this study total of **100** adults and child patients come to AL-Amal diagnostic center in the period of study and we measured the diameter the results of study show wide variation in patient dose for abdomen examination the CTDIv and DLP shown in Table (4.3). When the patient AP diameter is **11.8** cm (smaller diameter in the study) and FOV is **25** cm the DLP is **261.90** and the CTDI is **9.10**. In other wise when patient AP diameter is 28.6 cm and FOV **40.0** cm the DLP increased to **629.60** and CTDI **12.70.**

This results is simetrical to the previous study presented by Islam Altag in (2013) show the AP diameter has relationship with radiation dose, when the AP diameter increase the dose recpted by patient is increase.

5.2 Conclusions:

Radiation dose from CT procedures various from patient to patient. A particular radiation dose will depend on the size of body part examined the type of procedure, and the type of machine and it is operation. Typical values cited for radiation dose should be considered as measure and estimates that cannot be precisely with any individual patient, examination or type of CT system.

The main contributor for this high dose the use for different techniques, which justify the important of use the radiation dose optimization technique and the technologists training. Dual slice scanner delivered the least radiation dose while 16 and 64 slice scanner delivered highest radiation dose. CT dose optimization protocol is not implemented in all departments.

By the end of this study we conclude that the AP diameter had significant rule in optimizing of patient dose in the CT abdomen exams and had correlation with the FOV.

5.3 Recommendations:

- Clear justification of examinations is highly recommended.
- Avoid repeating of examination is important.
- Use of current modulation is important.
- In case CT modification, modification of exposure parameters should be done.
- Limitation of scan length.
- Requests for CT most be generated only by qualified medical practitioners and justified by both the referring doctors and radiologists.
- Continues education is highly recommend specially for new modality.
- Limitation of scan length.

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Appendix:

Data collection sheet:

PT	AGE	GEN	APD	RT-LTD	KV	MAS	CT DI	DLP	FOV
1.									
2.									

3.									
4.									
5.									
6.									
7.									
8.									
9.									
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18.									