بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Estimation of Effective Dose of Gonads During Abdominal Scan using Computed Tomography

تقدير الجرعة الفعالة للأعضاء التناسلية أثناء التصوير بالأشعة المقطعية المحوسبة للبطن

A thesis Submitted for Partial Fulfillment for the Requirements of M.Sc. Degree in Diagnostical Technology

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الآية

بسم الله الرحمن الرحيم

قال تعالى: ﴿وَمَا تَوْفِيقِي إِلاَّ بِاللّهِ عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ﴾

صدق الله العظيم

سورة هود الآية (88)

Dedication

To my lovely parents who have never failed to give me support for giving all my need during the time I developed my stem

To my big family

To my friends for their help and support

Acknowledgment

I would like to thank Allah first for making such work possible.

We also I would like to thank my supervisor for **Mr. Eltayeb Wagiallh**

His precious guidance, support and advices which helped me make this work possible along with Mr. **Mojtaba Gazali**. And **Mr. Omer Osman.**

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Abstract

This descriptive, cross sectional study aimed to estimate the effective dose of gonads in abdominal multi-detector helical computed tomography examinations. The problem of the study was that there is no recent local study that estimates effective dose for 3gonads; the most recent one was before four years ago. The study was done in 140 patients (72 males and 68 females) in range of age between 16 to 90 years old, who came for enhanced abdominal multi-detector computed tomography (one to five runs), during the period from April2022 to august 2022, in hospitals and diagnostic centers in Khartoum state include (Omer.Sawi.Medical Hospital, Alfisa.hospital, Doctors hospital, AL Nileien.medical Diagnostic Center and AL Zytoona specialized hospital). The data was collected and analyzed by statistical package for social sciences.The study shows the highest effective dose was in 64 slices scanner (278.0077msv), that because of using inappropriate protocol for abdomen exams. On other hand lower dose (84.2730 msv) in 128 slices scanner.

The statistical table showed different manufacture with same number of slice (16 slices) Toshiba was higher dose(248.0443msv) than Canon (138.0829msv) according to independent t test (p=0.00) which indicate significant difference between manufacture.

Comparing with previous studies we found that CTDI volume of our study (43 mGy) was higher than local and international previous studies (5.4 mGy and 35.6 mGy) respectively.

Comparing the present study with the national and international organization and diagnostic reference level worldwide; our present study found the DLP(2105.9mGy.cm) was higher than the international studies(1200 mGy.cm) in Germany and Australia and also higher than the study conducted in Sudan (459 mGy.cm)(2010) On the other hand the

effective dose of the present study was higher than all national and international studies.

The study recommends that appropriate selection of technical parameters that reduce radiation dose without affecting image quality must be take in place.

مستخلص الدراسة

هدفت هذه الدراسة الوصفية التقاطعية لتقدير الجرعة الإشعاعية المؤثرة للاعضاء التناسلية لفحوصات الأشعة المقطعية ذات الكواشف المتعددة للبطن وكانت مشكلة هذه الدراسة أنة لا يوجد دراسة حديثة محلية تقدّر الجرعة الإشعاعية المؤثرة للاعضاء التناسلية. أحدث دراسة أجريت قبل ستة سنوات. أجريت هذه الدراسة على 140 مريض(72ذكر و 68 أنثى) في المدى العمري ما بين 16 إلى 90 سنة، للمرضى الذين أتوا للفحص الروتيني للبطن عن طريق الأشعة المقطعية ذات الكواشف المتعددة (من تدفق واحد إلى خمسة تدفقات)، خلال الفترة الزمنية ما بين ابريل 2022 إلى اغسطس 2022.في ولاية الخرطوم في المستشفيات والمراكز التشخيصية التالية: مدينة المعلم الطبية، مستشفى فضيل، مستشفى الأمل الوطني ومركز النيلين التشخيصي ومستشفى الزيتونة. وتم جمع وتحليل هذه البيانات بواسطة برنامج الحزمة الإحصائية للعلوم الاجتماعية. أظهرت هذه الدراسة أن أعلى جرعة إشعاعية للاعضاء التناسلية توجد في جهاز 64 مقطع وتساوي (278.0077 مللي سيفريت) وذلك لاستخدام برتكول غير مناسب لفحوصات البطن الروتينية. من جهة أخرى أقل جرعة (82.4703 مللي سيفريت) كانت في جهاز 128 مقطع.

أظهر الجدول الإحصائي تصنيعًا مختلفًا بنفس العدد من الشرائح (16 شريحة) كانت توشيبا أعلى بجرعة (248.0443 مللي ثانية) من كانون (138.0829 مللي ثانية) وفقًا لاختبار t المستقل (ع = 0.00) مما يشير إلى فرق كبير بين التصنيع.

مقارنة مع Canon (138.0829msv) وجدنا في الدراسات السابقة أن حجم CTDI لدراستنا (43 مللي غراي) كان أعلى من الدراسات السابقة المحلية والدولية (5.4 مللي غراي و 35.6 مللي غراي) على التوالي.

مقارنة الدراسة الحالية مع المنظمات الوطنية والدولية والمستوى المرجعي للتشخيص في جميع أنحاء العالم ؛ وجدت دراستنا الحالية أن DLP (mGy.cm2105.9) كان أعلى من الدراسات الدولية (mGy.cm 1200) في

ألمانيا وأستراليا وأيضًا أعلى من الدراسة التي أجريت في السودان (459 2010) (mGy.cm) من ناحية أخرى كانت الجرعة الفعالة للدراسة الحالية أعلى من جميع الدراسات الوطنية والدولية.

توصي الدراسة باستخدام العوامل التقنية التي تقلل الجرعة الإشعاعية من غير التأثير على جودة الصورة.

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AEC	Automatic Exposure Control
CT	Computed Tomography
CTDI	Computed Tomography Dose Index
CDRH	Center For Devices And Radiological Health
DLP	Dose Length Product
DRLs	Diagnostic Reference Levels
ED	Effective Dose
Eq	Dose Equivalent
FDA	Food And Drugs Administration
H	Food And Drugs Administration
ICRP	International Commission On Radiation Protection
IAEA	International atomic energy agency.
K	Kerma
LDRLs	Local Diagnostic Reference Levels
MDCT	Multi-Detector Computed Tomography
MSAD	Multiple Scan Average Dose
NDRLs	National Diagnostic Reference Levels
Q	Quality Factor
Wr	Radiation Weighting Factor
Wt	Tissue Weighting Factor

Chapter One

Introduction

Chapter One

Introduction

1.1 Introduction:

Computed tomography (CT) is an image modality that has played significant role in detection of human disease and perform an image guided intervention. radiation dose in CT is so high and differ from that in conventional x-ray, so when the patient regularly exposed to high radiation during CT examination or for long time this may result in development of serious health effect for examples : cancer, hereditary effect, epilation and pericarditis...etc(Lois. 2011)

Computed tomography (CT) dosimetry concept is an important principle for dose measurement and participate effectively in informing both the public and other hospitals personnel about dose in CT. And compare their hospital CT dose with the national average dose to find out whether their radiation protection effort.(Euclid 2013)

The gonads are highly sensitive to the effects of irradiation with resultant temporary or permanent effects on fertility depending on the dose of irradiation received. In addition to the effect on the germ cells, sex steroid production may be impaired. (Amandal2015)

There is no recent national study that effective dose for gonad from CT abdomen examination.

due to use CT scanning gonads are exposed to unnecessary doses which may result in unintended health effects**,** The aim of this study firstly is estimate effective dose for gonads secondly, to, asses, for, abdominal CT protocol that reduces effective does of gonads among the Sudanese from CT abdomen examination and to statistically compare them with the data available worldwide.

1.2 Problem:

There is no recent national study that estimate effective dose for gonads.

1.3 justifications:

When using CT scanning for abdominal examination gonads receiving unknown dose limits need to estimate the effective dose among Sudanese population.

1.4 Objectives:

1.4.1 General objective:

To estimation effective dose of gonads in abdominal multi detector computed tomography in Khartoum state**.**

1.4.2 Specific objectives:

- To measurement effective dose of gonads during abdomen CT scanning examination.
- To correlate between different variables under study.
- To compare the local effective dose of gonads study of abdominal computed tomography with international DRLs.
- To compare the dose measurement variations according to scanner variations.

Chapter Two

Literature review and background

Chapter Two

Literature review and background studies

2.1: Principle of multi detector computerized tomography:

When multiple detector arrays are used the collimator spacing is wider and therefore, more of the X-ray that are produced by the X-ray tube are used in producing image data, with conventional, single detector array scanners, opening up thickness, which is good for improving the utilization of the X-ray beam but reduces spatial resolution in the slice thickness dimension. With the introduction of multiple detector arrays, the slice thickness is determined by the detector size and not by the collimator. This represents a major shift in CT technology. (Lois. 2011. p.165-171)

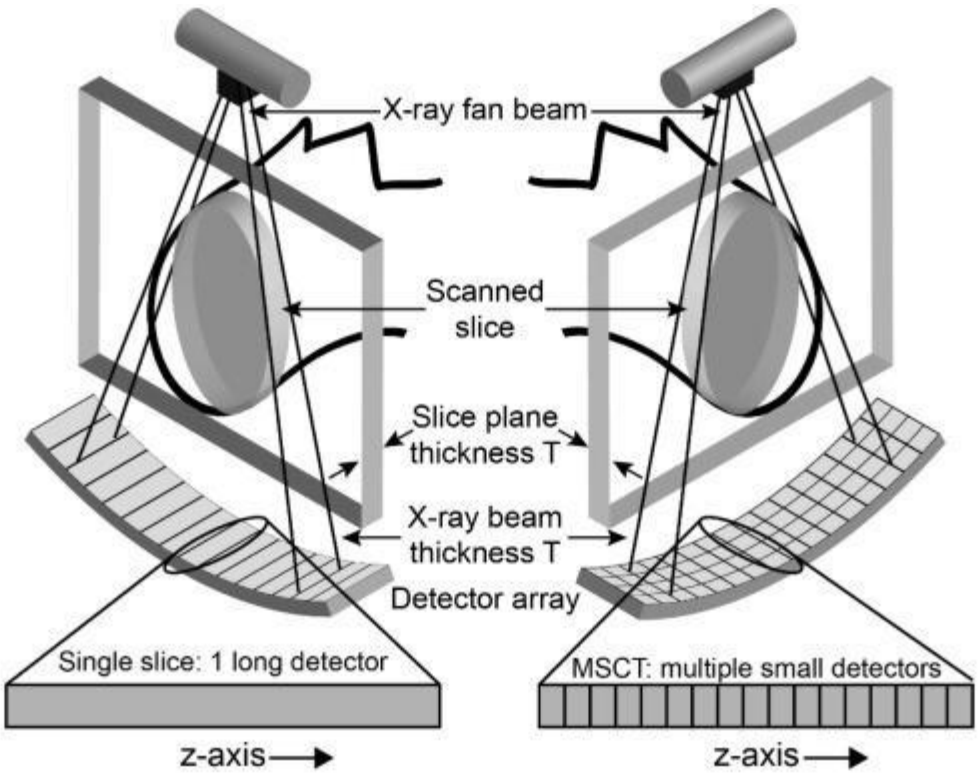

Figure (2.1): Shows multi detector CT scanner.[9]

2.2: CT Dosimeter:

2.2.1: Exposure:

Refers to a measure of radiation needs to ionize air as a medium. It measured in Roentgens (R) and defined as the quantity of X rays that produced 2.580 x10-4 C of charge collected per unit mass (kilogram) of air at standard temperature and pressure (STP) Equation for exposure (X). (Lois. 2011)

$$X=dQ/dm$$

Where dQ is the absolute value of total charge of ions of the one sign produced in air when all of the electrons liberated by photons in a volume element of air having a mass dm are completely stopped in air.((Lois. 2011)

2.2.2: Absorbed dose:

Describes the amount of energy absorbed by unit mass (Patient). The traditional unit of measurement is called radiation absorbed dose (rad) and the SI or(international unit is called the Gray Gy). (Lois. 2011.)

2.2.3: Quality factor (Q):

It accounts for the different biological effects produced by the different types of ionizing radiation such as the diagnostic x ray used in CT where it equals . (Lois. 2011)

2.2.4: Dose equivalent (Eq):

The dose equivalent equals the multiplication of the absorbed dose and the quality factor and measured in the roentgen equivalent man (rem) which is the traditional unit, or in the Sievert (Sv) which is the SI or international unit. (Lois. 2011)

1sv=100 rem

2.2.5: Equivalent Dose (H):

It's a similar dose to the dose equivalent but a newer one and it equals the product of the absorbed dose and the radiation weighting factor (WR), it's also measured in the same units of rem and Sv. (Lois. 2011)

Another definition is: the attempts to account the particular effects to the patient's tissues that have absorbed the radiation dose. (Lois. 2011)

2.2.6: Effective dose:

Effective dose is a biological dose, determines how dangerous an individual exposure to radiation can be and it is used commonly in radiation protection, It can be estimated by following equation. (Lois. 2016)

$E = DLP \times WT$

OR

$E = DLP \times K.$

E = Effective dose.

DLP = Dose length product.

WT = Tissue Weighting Factor

K factor is called kerma which stands for kinetic energy released to matter and it is a measurement of the amount of energy transferred from photons to electrons per unit mass (matter) at a certain position. Measured by the SI unit gray. The amount of the K factor for abdomen and pelvis equals 0.015. (Lois. 2011)

2.2.7: Radiation weighting factor (WR):

It extrapolates the risk of partial body exposure to patients, and it differs according to the type of radiation because it varies in its degree ionizing and biological effects. (Lois. 2011)

Table 2.1: Demonstrate the radiation weighting factors for different types of ionizing radiation. (Lois. 2016)

Radiation type and Energy	Radiation weighting factor WR
Photons (All energies)	1
Electrons (All energies)	1
Neutrons	0
<10 KeV	5
10 Kev to 100 KeV	10
>100 keV to 2 MeV	20
>2 MeV to 20 MeV	10
>20 MeV	5
Protons > 2 MeV	5
Alpha particle, Fission fragment and heavy nuclei	20

2.3: CT descriptors:

The earlier dose studies reported CT dose by using various term to describe the absorbed dose in CT examination, these include single and multiple scan peak dose.

CDRH recommended the use of CTDI, MSAD and DLP in federal performance standard as the dose descriptors specific to CT.

2.3.1: Multiple scan average doses (MSAD):

For a series of multiple scans with constant separation, the multiple scan average dose (MSAD) is an indication of the magnitude of the dose along the length of the scanned volume ata particular radial depthitis usually calculated from multiple scans. Measurements are made from the central slice; which has the total radiation dose, plus several points in the peripheral slices (scatter over laportails). It will increase if the slices overlapped and will decrease if there were agap between the slices. .(Euclid 2013)

2.3.2: Computed tomography dose index (CTDI):

Another measurement for radiation dose in CT is the Computed tomographic dose index (CTDI) which is what manufacturers now report to FDA and prospective customers regarding the dose delivered by their machines. .(Euclid 2013)

The CTDI can only be calculated if slices are contiguous, that is, there are no overlapping or gapped slices. If there is slice overlap or gaps, the CTDI is multiplied by the ratio of slice thickness to slice increment. This would technically be the MSAD, because the CTDI conditions would no longer exist. .(Euclid 2013)

2.3.3: CTDI volume:

Provides measurements of the exposure per slice of tissue for z axis, under the condition of no gaps or overlapping in the scan slices.(Euclid 20013)

CTDIvol affected by pitch as shown in table (2-2) there is a direct relation between CTDIvol and pitch. .(Euclid 2013)

2.3.4: CTDI weighted:

Provides Measurement of the dose in the x-y axis of the patient instead of z axis, the dose at the periphery of the slice higher than the central dose. [2]

The CTDIw adjusts for this by providing a weighted average of measurements at center and the peripheral slice locations. .(Euclid 2013)

CTDI vol= CTD Iw/Pitch

Table 2.2: Demonstrate the effect of the pitch over the CTD Ivol. All other factors were held constant at 120kVp; 300mA, 1s and 10mm. results are from a single-detector row CT scanner. .(Euclid 2013)

Pitch	**CTDI vol inheadphantom (mGy)**	**CTDI vol inbodyphantom (mGy)**
0.5	80	36
0.75	53	24
1.0	40	18
1.5	27	12
2.0	20	9

2.3.5: Dose length product (DLP):

Dose length product (DLP) is a measure of CT radiation exposure. It is related to CTDIvol, but CTDIvol represents the dose through a slice of an appropriate scan. DLP accounts for the length of radiation output along the long axis of the patient. It provides a measurement of the total amount of exposure for series of scans. .(Euclid 2013).

It can be calculated if the length of the irradiated volume (Scan length) and CTDIvol are known by using the following equation:

$$\mathbf{DLP = CTDIvol \times Scanlength}$$

That equation concluded that if the scan length is increased, this will also increase the DLP.

Although the DLP more closely reflects the radiation dose for a specific CT examination, its value is affected by variances in patient anatomy. Therefore, the CTDIvol is more useful tool for comparing radiation doses among different protocols. .(Euclid 2013)

2.4: Factors influence the amount of radiation dose

Although the scanner design is of some importance, surveys on CT practice have regularly shown that the way how the scanner is used has the largest impact on the doses applied in act examination.(Hans2017).

2.4.1: Beam filtration:

Which is well known to reduce the portions of radiation spectrum with no or less contribution in the image formation, The size of the filter differs according to the scanner type and the dose values and may range from 18mm Al equivalent (in old scanners) to 5-6mm Al equivalent in newer ones and may be more or less due to manufacturers differences. The use of additional filtration impairs primary contrast and increase noise due to the reduction of beam's intensity which effects the detectably of small or low-contrast details and is compensated by for example increasing tube current-time production. .(Hans2017).

Other studies says that in order to maintain the contrast to noise ratio for constant image quality the standard beam filtration must be increased, while new surveys on CT revealed that scanners with comparable age with largely Differing beam filtration operate at almost similar dose level. .(Hans2017).

2.4.2: Beam collimator:

Beam collimator used for defining the thickness of the slice to be imaged and they are two of them, primary collimation which is close to the x-ray tube and it affects the dose profile along with its distance from the focal spot, and the size and shape of the focal spot. The penumbral effects are increased with the decreased width of the collimator that's why the collimator is wider than the activated detectors arrays. .(Hans2017).

The second type is post-patient collimator which is close to the detectors array and used to remove scattered radiation, and this collimator may be further narrowed in single and dual scanners to improve the shape of the slice profile. .(Hans2017).

Newer scanners are equipped with means that automatically adapt the MAS settings to the individual size and shape and they are called Automatic dose control. .(Hans2017).

2.4.3: Dose Display:

With the dose display (CTDI-DLP), dose is not saved per scan, but feedback is provided that may help to achieve this goal, e.g. by comparison of the displayed dose values with dose recommendations. In addition, changes in scan parameter settings and their implications for patient exposure are made immediately obvious. Thus, the dose display can be used for purposes of dose optimization. Finally, CTDIvol can be used as a fair estimate for the dose to organs that are entirely located in the scan range. .(Hans2017).

The interpretation of the dose values displayed at the scanner's console needs special attention in the following situations, first; Many dose recommendations are given in terms of weighted CTDI (CTDIw); in order to allow for comparisons, the pitch correction involved in CTDIvol must be reverted by multiplying CTDIvol with the pitch factor and secondly; Up to now, the dose values for examinations carried out in body scanning mode are always based on body-CTDI regardless of patient size. In pediatric CT examinations, the displayed figures should be multiplied by 2 for children and by 3 for infants in order to give a realistic estimate of patient dose. (Hans2017).

2.4.4: Tube current-time product:

Which is also known as MAs, and as in conventional radiology it has a linear relation with the dose. And it affects the noise of the image as well. (Hans2017).

Often the mAs is used as a surrogate for the patient dose which is misleading because there are other almost 6 factors that can affect it, only CTDIvol and DLP can be used for this purpose. .(Hans2017).

Even though, AEC should be used to reduce the tube current according to the patient's size, body part thickness and the dose requirements for each type of exam. .(Hans2017).

2.4.5: Slice thickness:

It's known to have an inverse relationship with the dose and image noise but a linear relation with spatial resolution and small details viewing. And the use of weather thick or thin slice thickness is determined according to the patient's condition and the part needs to be seen. .(Hans2017).

2.4.6: The pitch:

In MSCT scanners make use of spiral interpolation thus the slice profile stays the same with changes in the pitch unlike in SSCT scanners, instead image noise changes with the pitch unless the tube current is adopted using automatic adaptation of mAs. .(Hans2017).

2.4.7: Object diameter:

Although is not a parameter to be selected from the operating console but still needs to be considered in the context. .(Hans2017).

Considerable reduction in mAs settings are appropriate whenever thin or young patients are examined to avoid unnecessary over- exposure. The mAs are adopted by the operator unless AEC is available. .(Hans2017).

2.4.8: Scan Length (L):

The local dose, i.e .CTDI, is almost independent of the length of the scanned body section. The same does not hold, however, for the integral dose quantities, i.e. dose-length product and effective dose. Both increase in proportion to the length of the body section. Therefore, limiting the scan length according to the clinical needs is essential. So, it should be as short as possible especially in multi-phase scans and follow up and selected individually according to the scan to be done. .(Hans2017).

2.5: Scanner type:

Table (2-3): Demonstrate the manufacture differences between Siemens and Toshiba Aquilion.(David 2005).

Manufacturer	**Siemens**	**Toshiba Aquillion**
Couch top material	Carbon fiber	Carbon fiber
kV settings available	80,100,120,140	80,100,120,135
mA rang and step size	10-800(5mA steps)	10-50(5mA step)
Focal spot size(mm)	0.6*0.7	0.9*0.8
Total filtration (mmAl equivalent)	6.8(70kV,head) 9.5(70kV body)	1.5-10 (wedge dependent)
Anode heat capacity (MHU)	8	7.5
Maximum anode cooling rate (KHU/min)	2100	1386

2.6: Tissue weighting factors:

Same equivalent dose is provided to various parts of the body, make the response of different tissues is different.

Some tissues are more sensitive to radiation while some others are relatively less sensitive.

The same equivalent dose make the damage provided to different tissues is different.

In order to take into account for response of various tissues into the interacting radiation anew factor called tissue weighting factor (Wt.).:(Wazirmuhhammad2017).

Table 2.4: Demonstrate tissue weighting factor for different organs according to ICRP report number 103.(Jodie.2010).

Tissue or organ	ICRP103
Gonads	0.08
Red bone marrow	0.12
Colon	0.12
Stomach	O.12
Liver	0.04
Bladder	0.04
Skin	0.01

2.7: Biological effects of ionizing radiation:

These are the effects or may be diseases such as cancer or changes in the DNA structures that happens after the individual is exposed to high dose of radiation, these effects has two types which are late ones called stochastic effects and early ones and they are called deterministic effects. (Lois. 2016)

Deterministic effects occurs when the threshold of exposure dose is exceeded (the smallest amount of exposure that will cause a specific and measured effect) and its severity increases with dose increasing, examples such as skin erythema, cataract and fetal death ((Lois. 2016)

2.8: Gonads sensitivity:

Direct and indirect exposure to radiation may have profoundeffect on reproductive function.

Totaldose, number of fractions and duration are important determinant of the radiobiological effect on the tissue involved and varies among different tissue and organ.[(3)]

2.8.1: Radiation to Testis:

The testis is one of the most radiosensitive tissue with direct radiation dose as low as 0.15 Gy causing significant depression in the sperm count and temporary azoopermia occurring after dose 0.3 Gy .

Irradiation to testis may occur during therapeutic and diagnostic procedure as well as from occupational exposure.

Testis may receive scatter dose from nearby pelvic and abdominal irradiation.(Amandal2015).

2.8.2: Radiation to ovary:

Pelvic and abdomen CT scan delivers dose to ovaries ,which damage and influence the number of oocyte (normal range 2 million) in new born girl. (Amandal2015)

The susceptibility radiation induced ,cell death depends on the developmental stage of germ cell at the time of exposure.(Amandal2015).

2.8.3: Radiation Protection:

Radiation protection action includes the use of time, gonadal shielding and distance, which are intended to protect both patients and technologists in CT department.(eu

Optimization is a principle that is intended to ensure that dose delivered to patients are kept as low as reasonably achievable (ALARA), economic and social factors being taken into account. .(Euclid 20013)

Implementing ALARA, technologist should always apply all relevant technical radiation protection practice to insure that the dose is optimized and that image quality is not compromised. .(Euclid 20013)

Optimizing scan parameter will reduce patient dose such as exposure technique factor (constant and effective MAS and KVP), collimation, pitch, number of detectors and patient centering, To effectively reduce the dose and maintain the needed image quality, Users must have systematic, Approaches or strategies to CT dose optimization. .(Euclid 20013)

2.9: Dose reference level (DRL):

Diagnostic reference level means to establish a level of exposure to acceptable according to international standards without prejudice to reduce the presence of medical imaging and desired information from the tests.(RadiologyInfo.org,2016)

It should be set for representative examinations or procedures performed in local areas, countries or regions where they applied and the government has responsibilities for settling and updating DRLs which are general guidelines for clinical operations and don't apply directly to individual's patient and examination, and they are estimated by average of CTDIvol per sequence, DLP and ED for presented data of the selected exam. (RadiologyInfo.org,2016)

DRL has two types: national DRL (NDRLs) which are observed from national wide scale surveys, and local DRL (LDRLs) which are observed from a single large center or a group of health care facilities. (RadiologyInfo.org, 2016)

DRLs have already proved useful as a tool in promoting improvements in patient dose. (RadiologyInfo.org,2016)

2.10: Previous studies:

2.10.1. Done by: Ebthal Adam Sheikh Aldeen Adam in Sudan ,(2016) under the title of **Estimation of patient Dose I n Abdomen CT Examination in Some Sudanese Hospitals**. The aim of study was to estimate radiation dose in abdomen CT examinations of patients in two Sudanese hospitals. The mean parameter observed effective dose for patients in two hospitals reveals that the mean effective dose of patient in one hospital is 26.25 mSv. Which is quite high compared with other hospitals, which has the mean value of 2.8 mSv and also higher than the IAEA level for this investigation which is 7.6 mSv. (Ebthal, 2016).

2.10.2. Done by: Emmanuel Ngaile in Tanzania ,(2016) under the title of **Estimation of patient organ doses from CT examination in Tanzania** .the aims of this study were first ,to determine the magnitude of radiation doses received by selected radiosensitive organs of patients undergoing CT examination and compare them with other studies.

Secondly ,to assess how CT scanning protocols in practice affect patient organ doses .the mean parameter observed were as follow: organ dose for eye lens(head),thyroid (chest), breast for (chest) ,stomach (abdomen) and ovary(pelvic)were 63.9 mGy ,12.3mGy, 26.1mGy, 35.6 mGy and 24.0 mGy respectively. .(Emmanuel, 2016).

2.10.3 Done by: Mustafa Awad Elhaj Mohamed. in Sudan ,(2015) under the title of **Estimates of Effective Dose in Adult CT Examinations** The goal of this study was to estimate effective dose (E) in adult CT examinations tor Toshiba x64 slice using CT. Exp version 2.5 software in Sudan. Using of CT in medical diagnosis delivers radiation doses to patients that are higher than those from other radiological procedures. Lack of optimized protocols could be an additional source of increased dose in developing countries. In order to achieve these objectives, data ofCT-scanner has been collected from three hospitals (ANH, ZSH and MMH). Data collected included equipment information and scan parameters for individual patients, who were used to assess doses. 300 adult patients underwent head, chest, abdomen-pelvis and pelvis CT examinations. The,CT CTDIvoi, DLP, patient effective dose and organ doses were estimated, using CT exposure parameters and CT Exp ٠ software. A large variation of mean effective dose and organ doses among hospitals was observed for similar CT examinations. These variations largely originated from different CT scanning protocols used in different hospitals and scan length. The mean effective dose in this study in the Brain, PNS, Chest, Pulmonary, Abdomen-Pelvis, Pelvis, KUB and

CTL were: 3.2 mSv, 2.6 mSv, 18.9 mSv, 17.6 mSv, 27.1 mSv, 11.2 mSv, 9.6 mSv and 23.7 mSv respectively, and organ equivalent doses presented in this study for the eye lens (for head), lungs and thymus (for chest), liver, kidney and smal.1 intest (for abdomen-pelvis), bladder, uterus and gonads (for pelvis), were 62.9 mSv, 39.5 mSv, 34.1 mSv, 35.4 mSv, 53.9 mSv, 52.6 mSv, 58.1 mSv, 37 mSv, and 34.6 mSv, respectively. These values were mostly comparable to and slightly higher than the values of effective doses reported from similar studies the fjnited Kingdom, Tanzania, Australia, Canada and Sudan. It was concluded that patient effective dose and organ doses could be substantially minimized through carefill selection of scanning parameters based on clinical indications ofsfttdy, patient size, and body region being examined. Additional dose reduction to superficial organs would require the use of shielding materials (.Mustafa, 2016).

2.10.4..Done by: Abdelrahman Mohamed Elnour in Sudan, (2015) under the title of **Establishment of Diagnostic Reference Level for CT Scan in Sudan**. The aim of this study was to establish a level of exposure to acceptable according to international standards without prejudice to reduce the presence of medical imaging and desired information from the tests and that called DRL_S. In this study used statistical method to represent the results and data in order to calculate DRL_S of the total statistical data, the study showed follows: First in brain imaging the $DRL_S$are (1209 mGy /cm).Second, a CT scan of the chest, the DRL_S are (650mGy/cm). Thirdly, CT scan of the abdomen and pelvis the study showed that DRL_S are (978 mGy / cm).(Abdelrahman, 2015).

2.10.5..Done by: tayfour hassan saeed bakiett in Sudan ,(2017) under the title of **Estimation of Effective Dose for Abdominal Organs during Computed tomography** aim of this study to estimate the radiation dose received by the patients during abdomen CT examinations. A total of 60 adult patients undergoing abdominal CT scanning exams were estimated using CTDIvol, dose length product (DLP) and effective dose (E) and evaluate effective dose and organs dose by using CT expo version 2.5 software. Also this study revealed that the mean effective dose for abdomen in hospital (A), hospital (B) and hospital (C) was (7.6)mSv, (5.3) mSv and (6.3) mAs respectively. The mean of DLP for in hospital (A), hospital (B), and hospital (C) was (450) mGy*cm, (410.95) mGy*cm and (380) mGy*cm respectively. The mean CTDIvol for abdomen in hospital (A), hospital (B) and hospital (C) was (9.9) mGy, (8.8) mGy and (7.3) mGy respectively The result of this study revealed that the mean equivalent dose for abdomen organs, stomach was (12.23) mSv, spleen was (11.99) mSv, pancreas was (9.8) mSv and adrenal gland was (9.158) mSv. And the organ doses were estimated using measurements of CT dose indexes (CTDI), exposure-related parameters, and the ImPACT spreadsheet based on NRPB conversion factors. Light variation of organ doses among three hospitals was observed for similar CT examinations. These variations largely originated from different CTscanning protocols used in different three hospitals. The organ doses in this study.(: tayfour2016)

2.10.6 Done by: Sawsan Alameen Abdallah Alameen in Sudan, (2014) under title of **Techniques and radiation dose in CT examination of adult patient** .the aim of study was measure radiation dose in CT examination of adult in three Sudanese hospitals .the mean effective dose in this study for the head, chest and abdomen were 0.82 ,3.7 and 5.4 mGy respectively.(Sawsan, 2014)

Chapter three

Material and Methods

Chapter three

Material and Methods

3.1: Materials:

3.1.1: Type of study:

It was cross sectional study.

3.1.2: Area of study:

It was conducted in department of CT in Khartoum hospitals, Omer Sawi Medical Hospital, Alfisa hospital, Doctors hospital, AL Nileien medical Diagnostic Center and AL Zytoona specialized hospital)..

3.1.3: Equipment used in the study.

Computed Tomography scanners: Toshiba 16 slices, Siemens 16 slices, Toshiba 64 slices, Siemens 32 slices, Toshiba 160 slices.

3.1.4: Duration of the study:

The study conducted from (April2022 to august 2022).

3.1.5: Population of the study:

All patients with different age and sex whom came for CT abdomen scan in computed tomography department.

3.1.6: Sample size:

This study included (140) patients who came to CT abdomen scan.

3.1.7: Inclusion criteria:

Each patient presented for CT abdomen scan.

3.1.8: Exclusion criteria:

Each patient who had another CT examination with abdominal CT scan.

3.2: Methods:

3.2.1 Data collection:

Data sheet was designed especially for this study.

3.2.2: Study variables:

Age, gender, number of detectors, number of runs, mAs, pitch, collimation, slice thickness, CT Dose Index and Dose Length Product.

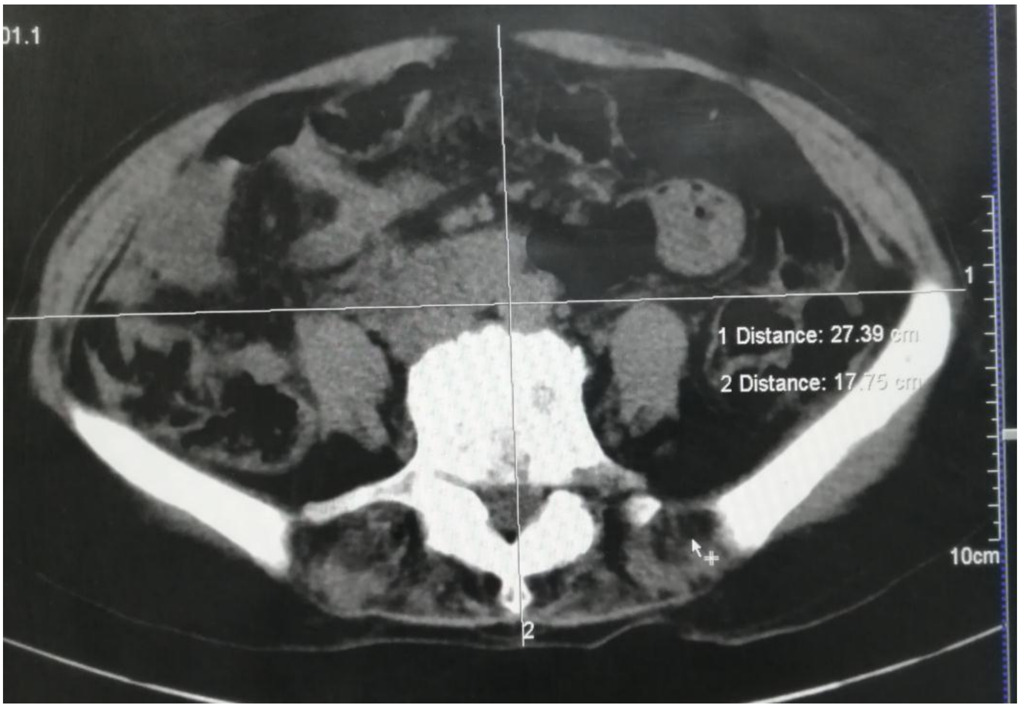

Fig (3.1): shows methods of measuring patient′s AP and latero-lateral diameters at level of umbilicus.

3:2:3: Abdomen computerized tomography technique:

Enhanced Abdominal CT technique, PT came fast for 4 hours prior to exam, patient supine feet first ,scout AP and lateral ,start the scan from xiziphoid process to symphysis pubic with IV and oral contrast 70 ml Intravenously and 30 ml orally scan delayed =8 minute.

3:2:4: Justification of technique used:

It's the most common technique used, and the study aim to estimate effective dose during enhanced abdominal technique.

3:2:5: Data Analysis:

Data was analyzed by using static package for social science (SPSS).

3:2:6: Data storage:

The data storage in mobile, flash and computer.

3:2:7: Data presentation:

The data presented in tables and graphs.

3:2:8: Ethical consideration:

During this study the patient's details would not be mentioned.

Chapter Four

Results

Chapter Four

Results

Table (4-1): Shows frequency distribution of gender.

	Frequency	Percent	Cumulative Percent
Female	68	48.6	48.6
Male	72	51.4	100.0
Total	140	100.0	

Table (4-2): Shows descriptive statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
Age	140	16	90	46.8	18.2
AP Diameter	140	12.2	36.0	21.9	4.86
Latero-lateral diameter	140	18.8	48.2	31.2	5.8
CTDI	140	3.8	109.5	43	24.5
DLP	140	153.0	5376.0	2105.9	1271.8
ED	140	12.24	430.08	168.47	101.75

Table (4-3): Shows Patients distribution in various CT scanners and numbers of runs.

	One run	Two runs	Three runs	Four runs	Five runs	Total
16 Slices	0	0	0	54	2	56
32 Slices	5	3	14	6	0	28
64 Slices	0	1	11	13	3	28
160 Slices	0	0	2	22	4	28

Table(4-4): shows the effective dose according to number of slices and manufacturer.

Number of slices	Manufacturer	ED			
		Minimum	Maximum	Mean	Std. Deviation
16	Toshiba	108.95	348.50	248.0443	83.91629
	Canon	69.76	257.28	138.0829	47.27135
32	Siemens	12.24	167.60	93.9600	43.05762
64	Neusoft	28.34	430.08	278.0077	89.82922
160	Siemens	51.36	214.88	84.2703	31.99760

Table(4-5): shows the effective dose according to number of runs

Number of runs	ED			
	Minimum	Maximum	Mean	Std. Deviation
1	12.24	48.72	32.3040	16.95296
2	164.48	169.01	167.1320	1.90319
3	15.68	269.68	147.6501	80.46719
4	28.34	374.17	177.4123	102.56447
5	64.24	430.08	212.8284	137.40608

Table (4-6) Shows Largest area in the scan per centimeter in different CT scanners and numbers of runs and statistical correlation with effective dose.

	One run				Two runs				Three runs				Four runs				Five runs			
Area cm	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
16 Slices	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	95.74	462.5	222.47	77.47	317.23	388.13	352.68	50.13
32 Slices	103.43	295.63	194.97	80.18	338.49	466.15	423.09	73.27	91.50	427.29	195.76	89.96	131.07	240.18	187.8	42.96	N/A	N/A	N/A	N/A
64 Slices	N/A	N/A	N/A	N/A	103.63	103.63	103.63	0	116.32	503.35	250.05	145.15	118.83	358.34	240.99	74.62	167.82	237.12	191.04	39.9
160 Slices	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	255.25	269.78	262.51	10.27	121.37	416.56	211.59	72.7	105.34	169.37	144.14	29.15
P = .001 r = .273																				

Table (4-7): Shows comparison between Toshiba and Siemens using independent sample T test:

	Manufacturer	N	Mean	Std. Deviation	Std. Error Mean
ED	Toshiba	28	248.0443	839.1629	158.5869
	Siemens	28	138.0829	472.7135	89.3344

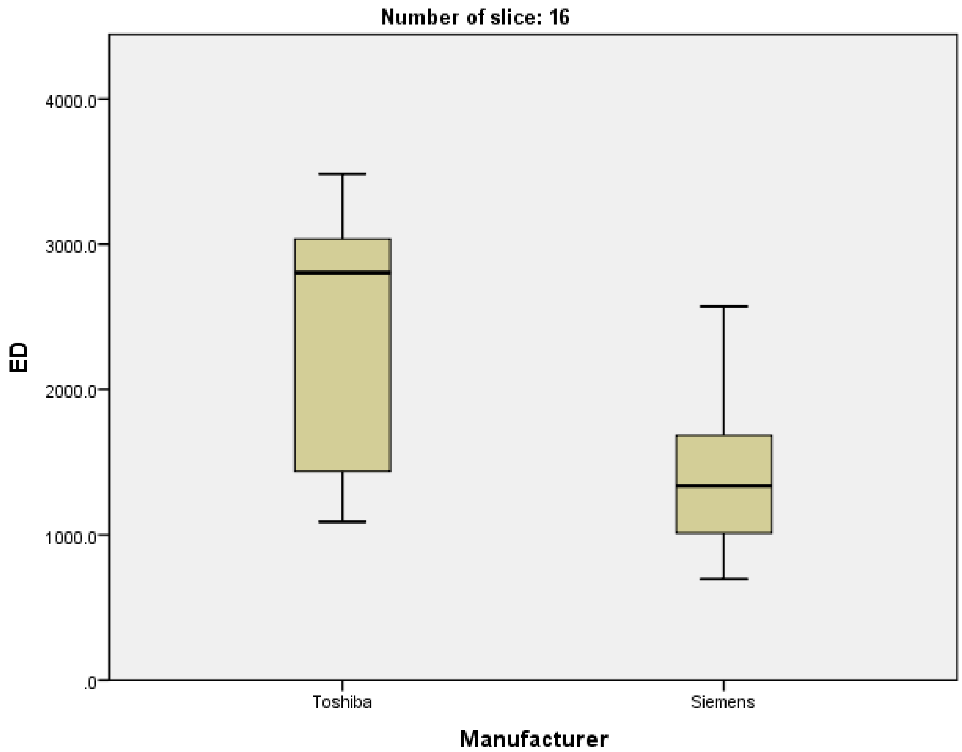

Figure (4.1): Shows comparison between Toshiba and Siemens 16 slices using independent sample T test (P = 0.00) wish is indicate a significant difference between manufacturers.

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion:

The aim of this study to estimate the effective dose of gonads during abdominal examinations (one to five runs) at radiology department of AL Zytona Hospital (16 slices),Alfisal Hospital (16 slices), AL Nileien Diagnostic Center (32 slices), Doctors Hospital(64 slices) and Omer Sawi. Hospital (128 slices).

The study was conducted on 140 patients who came to CT departments for abdominal examination they have a distribution of 72 males(51.4%) and 68 females (48.6%) with mean age of 46.8 years (table 4.1),and the means of their diameters; 21.9 for AP diameter and 31.2 for latero-lateral diameter (table 4.2).

The distribution of patients in different CT scanners 16,32,64and 128 slice are 56, 28, 28 and 28 patients respectively(table 4.4) ,and according to number of runs the highest read found in 4 runs with 16 slice are 54 patients.(table 4.3).

The highest effective dose of gonads was found in 64 slices scanner (278.0077 mSv) that because of the poor protocol (technical faults of selecting suitable slice thickness, collimation, exposure factors and pitch) which will increase the dose, and lowest ED was found in 128 slices scanner (84.2703mSv).

The highest effective dose of gonads found in 5 runs (212.828 msv) and lowest dose found in one run (32.3040 msv).

The statistical table showed different manufacture with same number of slice (16 slices) Toshiba was higher dose(248.0443msv) than Canon (138.0829msv) according to independent t test (p=0.00) which indicate significant difference between manufacture.

Comparing with previous studies we found that CTDI volume of our study (43 mGy) was higher than local and international previous studies (5.4 mGy and 35.6 mGy) respectively.

Comparing the present study with the national and international organization and diagnostic reference level worldwide; our present study found the DLP(2105.9mGy.cm) was higher than the international studies(1200 mGy.cm) in Germany and Australia and also higher than the study conducted in Sudan (459 mGy.cm)(2010) On the other hand the effective dose of the present study was higher than all national and international studies.

5.2 Conclusion:

Our study concluded that the highest effective dose of gonads from the CT abdomen examination in Neusoft 64 slices due to scanner type, technical faults in calibration of the tube current MAS, While the lower dose was found in siemens Aquilion 128 slices. And the DRLs are higher in the present study compared with the national and international studies.

5.3 Recommendations:

1. Appropriate selection of technical parameters so the exposure factors must be adjusted to accommodate the patient size without compromising image quality using automatic tube current modulation and avoid increasing MAS except when imaging obese patients.
2. Use a Siemens device for all computed tomography examinations as much as possible.
3. Use new equipment options that automatically adjust radiation exposure during scanning and the one that use good filtration and dose reduction technology.
4. Consider gonads shielding when gonads not a part of radiological examination.
5. Further studies should be done using optimum CT abdomen technique as possible with applying gonads shield then measures the effective dose and compares with this study results.

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Appendices

Appendix (I) CT images of abdomen taken from the sample of the study.

Image (1) : Shows measurement of Ap diameter and latero-lateral diameter at umbilical region

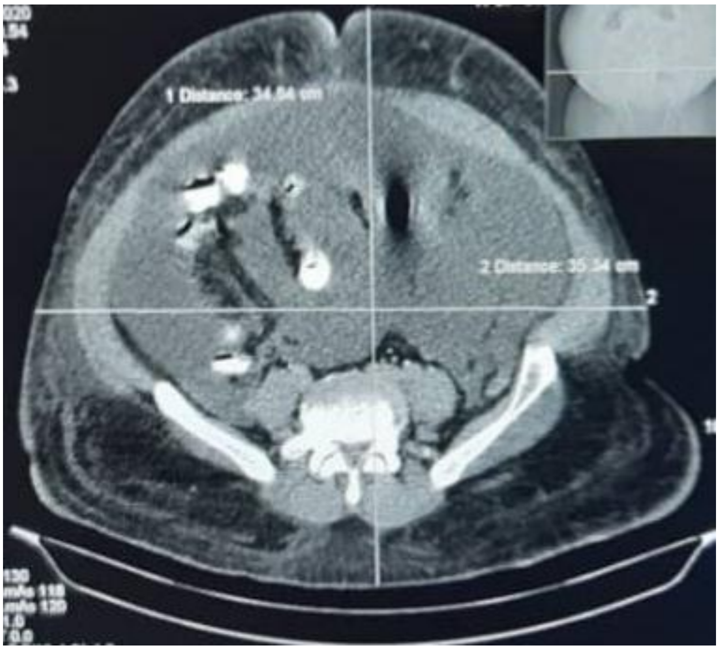
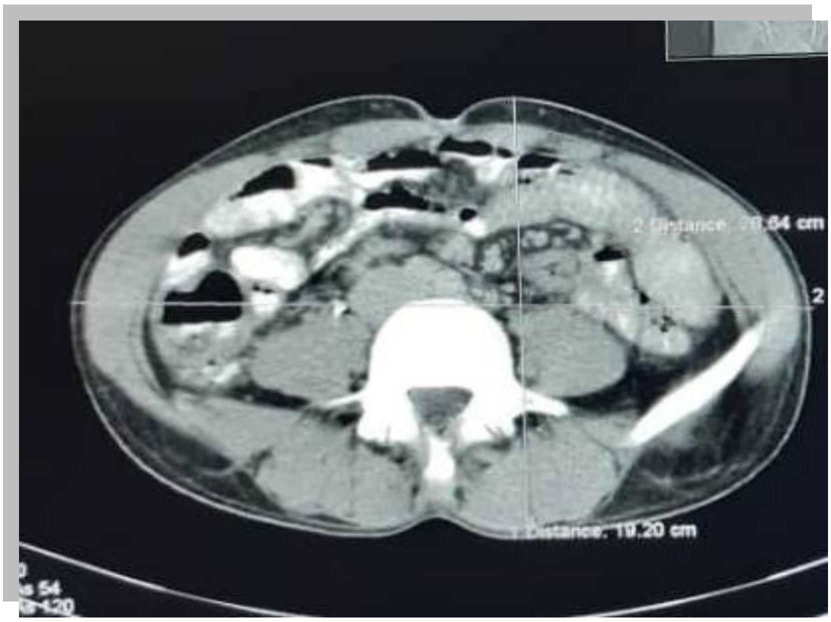


Image (2): Shows measurement of Ap and latero-lateral diameter at umbilical region



Image(3): Shows measurement AP and latero-lateral diameters

Appendix (II): Data collection sheet.

Datasheet

NO	Age	Gender	pitch	Collimation	MAS	KVP	Ap diameter	Latero lateral diameter	CTDI	DLP	ED