Sudan University of science and technology

Collage of graduated studies

Assessment of Radiation Dose and Noise in Chest Computed Tomography Examination

تقييم الجرعة الإشعاعية والتشويش في تصوير الصدر بالأشعة المقطعية

Thesis Submitted for Partial Fulfillment for The Requirement M.SC. Degree in medical physics

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2020

الآية

قَالَ تَعَالَىٰ:

﴿وَيَسۡـَٔلُونَكَ عَنِ ٱلرُّوحِۖ قُلِ ٱلرُّوحُ مِنۡ أَمۡرِ رَبِّي وَمَآ أُوتِيتُم مِّنَ ٱلۡعِلۡمِ إِلَّا قَلِيلٗا ٨٥﴾

سورة الإسراء الأية (85)

Dedication

I Dedicate this work to my

Parents whose encouraging, patient and supporting me all time

To my

Sisters and brothers whose assistance me to success

To my

uncle Who was gave me self confidence

To my

Grandma and grandpa whose prayers for me every time

T0 my

Teachers

To my

friends

,

Acknowledgement

I Firstly thank Allah for end of the study successfully.

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my supervisor Dr. Hussein A. Hassan who supported and helped me.

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hospitals managers for providing me all information.

Abstract

This research aims to assess radiation dose and noise for chest during CT examination in four centers of diagnostic images , A total of 100 patient undergoing chest CT exams ,CT machine were used to collect data during this study , General Electric(GE) optima ,GE bright speed, GE health care manufactured USA and Toshiba manufactured Japan .The radiation dose were assess using $CTDI_{vol}$, DLP and noise was assessed by stander deviation in region of interest. all data analyzed using SPSS analysis.

In this study I founded the mean effective dose, mean noise, mean Dose Length Product , CT Dose Index volume for chest in the first center (6.65msv), (13.84HU), (395.07mGy.cm), (11.57mGy) respectively, in second center (6.67msv), (8.79HU), (13.02mGy), (383.36mGy.cm), in 3rd center and (5.18msv), (11.34HU), (6.95mGy) and (280.89mGy.cm). In 4^{th} center mean E (6.26msv), noise (15.08HU), DLP (385.51mGy.cm) and CTDI (12.37). The effective dose and noise were observed difference in this four centers ,the difference was due to type and age of machine ,chest protocol and parameter used

Then the effective dose been compared with maximum permissible dose level MPDL and I founded with in MPDLs (2-20msv),the average dose length product and CT dose index volume compared with international diagnostic reference level and I were founded with in IDRLs for chest(650mGy.cm) (30mGy) respectively .

المستخلص

يهدف هذا البحث لتقييم الجرعة الاشعاعية والتشويش للصدر بالصور في التصوير باستخدام جهاز الأشعة المقطعية في أربعة مراكز، مجموع (100) مريض خضعوا لتصوير الصدر باستخدام جهاز الأشعة المقطعية ,أجهزة الأشعة التي أستخدمت لجمع البيانات أثناء الدراسة ,جهاز GE health , GE bright speed, GE optima care و توشيبا . قيمت الجرعة بإستخدام (حجم مؤشر جرعة التصوير، انتاج طول الجرعة، SD وROI)، حيث تم تحليل البيانات باستخدام البرنامج الاحصائي (SPSS).

توصلت في هذه الدراسة إلى أن متوسط الجرعة الفعالة، التشويش، DLP، CTDI للصدر في المركز الأول (msv6.65)، (13.84HU)، (395.07mGy.cm)، (11.57mGy) على التوالي، في المركز الثاني (msv6.67)، (8.79HU)، (13.02mGy)، (383.36mGy.cm)، في المركز الثالث (msv5.18)، (11.34HU)، (6.95mGy) و(mGy.cm.280.89)، أما في المركز الرابع (6.26msv) ، (15.08)، (12.37) و(385.51mGy.cm). ومن خلال الدراسة لوحظ التشويش والجرعة الفعالة أنهم يختلفوا في الأربعة مراكز ,الإختلاف نشأ من إختلاف في نوع و عمر الجهاز والبروتكول والمعاملات التي أستخدمت .

أيضا الجرعة الفعالة قورنت مع أقصى قيم للجرعة المسموح بها ووجدت أنها داخل المدى المسموح به (2—20msv) وايضا متوسط مؤشر الجرعة الحجمي ,إنتاج طول الجرعة قورنت مع المستويات المرجعية التشخيصية العالمية للصدر ووجدت أنها ضمن حدود المستويات العالمية للصدر (30mGy) و(650mGy.cm) على التوالي.

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List of abbreviations

CT	Computed tomography
HU	Hounsfield unit
CAT	Computed axial tomography
DAS	Data acquisition system
FOV	Field of view
SFOV	Scan field of view
DFOV	Display field of view
FSS	Focal spot size
MDCT	Multi detector computed tomography
WW	Window width
W.L	Window level
IV	In vivo
HRCT	High resolution computed tomography
KVP	Kilo voltage peak
MAS	Mile ampere second
ST	Slice thickness
Q.A	Quality assurance
Q.C	Quality control
PSF	Point spread function
LSF	Line spread function
CTF	Contrast transfer function
LP	Line par
SR	Spatial resolution
FWHM	Full width half maximum
SD	Stander deviation
D	Absorbed dose
E	Effective dose
Msv	Mile sievert
Gy	Gray
DLP	Dose length product
MTF	Modulation transfer function
$CTDI_{VOL}$	Computed tomography dose index volume

Chapter one

Introduction

Chapter one

introduction

1.1Introduction

CT is considered as one of the most important digital imaging techniques, in my study used three helical CT scan one Toshiba .

CT is a powerful tool for the examination the chest disorder, there are two methods in chest CT, conventional chest CT and HRCT.

In this research I used HRCT for chest because it differ from conventional CT by optimizing technical parameters ,put it high doses .

Patient dose during CT was originally measured according to the concepts of diagnostic radiology, to measure radiation dose to the patent during CT exams used CT dose index measured with in primary beam of CT scanners this are actual tissue doses ,CT dosimetry is currently based on the CTDI.

Effective dose (msv) related to the total patient (stochastic) radiation risk and radiation dose is being absorbed and radio sensitivity of tissue been irradiated .

In this study 100 patient underwent HRCT scans to assess effective dose and noise because effective dose effect in patients doses and nose effect in image quality hens needed to calculate them by uses CTDI volume ,MAS,DLP and SD .

1.2 Problem of study

Radiation dose received by the patient from CT scan is much higher than other diagnostic x-ray technique ,In CT images for chest the high level of noise represent main problem in HRCT image, that produce image with bad quality result bad diagnostic, also there are big variation in dose and noise between CT centers.

1.3 Objective

1.3.1 General objective

To assess radiation dose and noise for chest during computed tomography examination

1.3.2 Specific objective

-To assess effective dose.

-To assess noise.

-To calculate effective dose .

-To calculate noise.

-To study the correlation between effective dose and noise with MAS, DLP, $CTDI_{vol}$ and scan range .

-To compare the noise and effective dose between difference centers.

1.4 Outline of the study

In these study in chapter one history of CT, problem of study and objective , chapter two literature review, chapter three material and method, chapter four result and analysis, chapter five Discussion, conclusion, recommendations and references.

Chapter two

Literature review

Chapter two

Literature review

2.1 Computed Tomography (CT)

Tomo is old, Greek word means section, graphic means produce, conventional tomography is an image of a section of the patient that is oriented parallel to the film .after that they develop another tomography technique in which the section were transverse section (cross section) this technique was referred to transverse axial tomography .(G.DINKEL, 1994)

2.1.1 Definitions

CT uses a computer to process information collected, reconstruction from projection in slice by slice and collection of x-ray transmission measurement from the patient, CT is a diagnostic imaging used to create detailed in image, cross sectional generated during CT scan can be reformatted in multiple planes and even generate in three diminution image which can be viewed on a computer monitor. CT Is fundamentally a method for acquiring and reconstructing the image of a thin cross section on the basis of measurement of attenuation (G.DINKEL, 1994).

2.1.2 CT scanner genneration

1st generation has a pencil beam and one detector.

2nd has a narrow fan beam and multiple detectors .

3rd has a wide fan beam .

4th is equipped with a detector ring .

5th is electron beam tomography CT.

6th is helical (spiral) CT scanner.

7th is the multi-detector row CT.(G.Dinkel,1994)

.

Figure (2-1) computed tomography scanner

2.1.3 CT component

2.1.3.2 Gantry

Is the a ring shaped part of the CT scanner, it houses many of the components necessary to produce and detected x-ray, components are a mounted on a rotating scan frame, the gantry can be oblique either forward or back ward as needed to accommodate a variety of patient and examination protocols, the degree of tilt varies among systems, but ± 15 to ± 30 is usual The gantry containing x-ray tube, detectors, DAS, collimators and filters (mikhailovitsh, 2009).

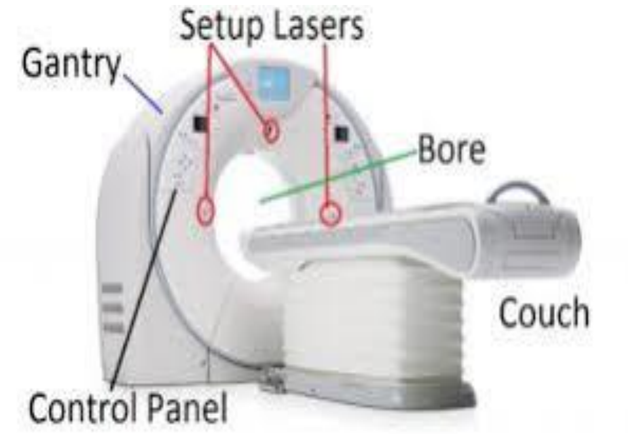


Figure (2.2) CT Components

2.1.4 Physical principles of CT

Involve physics and mathematical to show how the image is produced, the physical principles and technology of CT include three processes.

2.1.4.1 data aquisisition

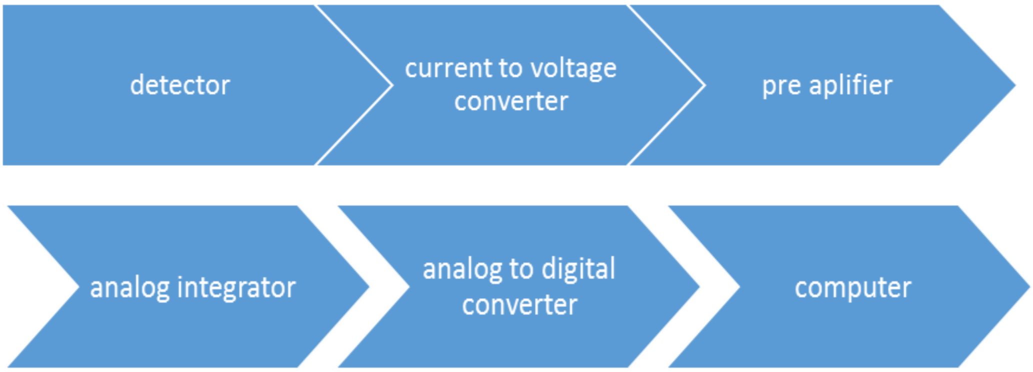
Collection of x-ray photons transmitted through the patient by the CT detectors, there are two methods of data acquisition, slice by slice data acquisition data are collected using a number of different beam geometries to scan the patient .

Volum data acquisition, a more recent method of data collection, a spatial beam geometry referred to as spiral or helical geometry is used to scan a volume of tissue rather than one slice at a time(mikhailovitsh, 2009).

2.1.4.1.1 The data acquisition system(DAS)

DAS consists of X-ray photons come on the detector, the detector detects the intensity in form of current, the current is converted into voltage, the analog signal is converted into digital form and the signal processed and reconstructed in the computer (mikhailovitsh, 2009).

the following



2.1.4.2 Image reconstruction

Transmission measurements collected by the CT detectors are send to the computer for the processing. Computer uses mathematical algorithm to reconstruct the image, image reconstruction from projection to produce sharp, clear images of cross sectional anatomy.

2.1.4.3 Image display

After reconstruction image can be displayed on the monitor. The digital image from the computer must be converted into analog signals by the digital -to -analog converter .these signals produce an electron beam that scans the phosphor screen, the scanning is such that the gray scale monitor can display the input digital image pixel by pixel, the display matrix can range from 64*64 to 1024*1024. High performance monitors can display an image with a 2048*2048 matrix (G.DINKEL, 1994).

2.1.4.4 Image storage

CT is a digital image modality, data are stored in digital form, to preserve the wide dynamic range of images including the capability for image processing, intensity transformation and to decease the possibility of lost records and reduce the space needed for archiving.

Digital images are stored in 2-D pixel arrays, each pixel point represented by a number of bits (G.DINKEL, 1994).

2.1.5Reformat of the CT

The reconstructed image is an array of numbers arranged in rows and columns, called matrix.

The size of the matrix is chosen by the technologist before the CT examination and depends on the anatomy under study.

During data collection and image reconstruction, a matrix is placed over the scan FOV to cover the slice to be imaged, the pixel is transformed into a voxel or volume element (Mikhailovitsh, 2009).

Relationship between FOV, pixel size and matrix size

Pixel size, d = field of view /matrix size (1)

2.1.6 Helical (spiral) scanning

Spiral scanning 6th generation in CT developed in 1990s, is a procedure in which both x-ray tube, detector array move continuously in a helical path, with couch came to clinical use, it has continuous acquisition of data while couch moves and gives complete volume data in a single exposure.

Helical CT require higher x-ray power due to continuous large volume data acquisition, smaller FSS and tube current can be alter during the source of scan, in this study used three helical CT scanners (G. Dinkel).

2.1.6 Multi-detector row CT scanning

In 1992 7th generation in CT produce technique that contained two rows of detectors, capturing data for two slices per gantry rotation and another scanners made multiple rows of detectors, allow data for many slice to be acquired with each gantry rotation, MDCT resulted in the development of high resolution CT (G. dinkel).

2.1.7 Comparison CT in the past and now

In the past CT take more time to make image 9 days for scan, 2.5 hours for computer process, 1 day for image production and uses gamma source for radiation source .put now CT image produce in fraction of second.

2.1.8 Advantages of CT

Three-dimensional image, free from superimposition, more sensitive to differences in tissue type and ability to manipulate, adjust image after scanning and contrast scale of the image can be varied to suit the needs of the observer.

2.1.9 Disadvantages of CT

High doses that can be make stochastic effect (mikhailovitsh, 2009).

2.1.10 TEARMS.

2.1.10.1 Hounsfield unit

Named after godfrey Hounsfield, the unit referred to as CT number and density values

H.U value is directly related to the linear attenuation coefficient.

HU value is given by

$HU=k*\mu - \mu_{water} / \mu_{water} - \mu_{air}$

K=scaling factor =1000

2.1.10.2 Window

Windowing refer to a method by which the CT image gray scale can be manipulated using CT number that make up the image

2.1.10.2.1W.W: Determine the number of HU represented on a specific image and how many HU within 256 shades of gray and determines the quantity of pixel value to the gray scale, in these study WW for lung equal 1500

2.1.10.2.2 W.L:

Central value of the window, central pixel value in gray scale, used for the display of the reconstructed CT image, it should be selected by the viewer according to the attenuation characteristics of the structure under examination and expressed in HU, W.L for lung equal -600.

2.1.10.3 Field of view (FOV)

Is the maximum diameter of the area of the scanned object that is represented in the reconstructed image.

2.1.10.3.1 Scan field of view (SFOV)

Selecting the SFOV determines the area within the gantry (area to be scanned)

2.1.10.3.2 Display field of view (DFOV)

Is a selectable scan factor measured from the center of patient to the most distant located edge of the patient.

2.1.10.4 PITCH

Relationship between tube rotation, table increment and beam width at the detector.

2.1.10.5 Detector

Is the system for quantitative recording of the incident radiation and converted to electrical signal (mikhailvitsh, 2009).

2.1.10.6 Collimator

Are present between x-ray source, the patient, patient and detec to use to shape x-ray fan, ensure good image quality and reduce unnecessary radiation dose to the patient, placed between the x-ray source and the patient due to remove scatter radiation (Mikhailvitsh, 2009).

2.2Anatomy

2.2.1 Chest Wall

Chest wall is made of bones and muscle, the bones is primarily ribs, sternum and internal and external inter costal of the rib

2.2.2 Lungs

Is a pair of respiratory organ situated in thoracic cavity right and left lung are separated by mediastinum, each lung is cone shaped with anterior, lateral and posterior surface contacting ribs, superior tip is apex, just deep to clavicle, inferior surface is a base rests on dome of diaphragm. lung texture is spongy, color is brown in young and mottled black due to deposition of carbon particle, the weight of right lung is 600gms but left lung is 500gms(Snell, 2008).

2.2.2.1 Fissure and lobes of lungs

Oblique fissure in left lung and oblique, horizontal fissure in right lung. In right lung three lobes upper lobe, middle lobe -separated by horizontal fissure and lower lobe separated by oblique fissure from the middle lobe (Michael, 2006).

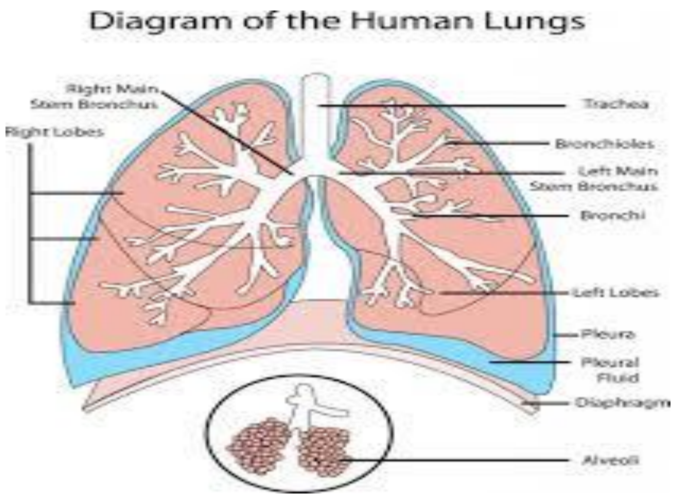


Figure (2.3) human lungs

2.2.2.2 Fissure and lobes of lungs

Oblique fissure in left lung and oblique, horizontal fissure in right lung. In right lung three lobes upper lobe, middle lobe -separated by horizontal fissure and lower lobe separated by oblique fissure from the middle lobe (Michael, 2006).

2.2.2.3 Surfaces of the lung

Costal surface: It is in contact with costal pleura and over lying thoracic wall.

Medal surface: Posterior vertebral part, anterior mediastinal part.

2.2.2.4 The lung consist of airway (trachea and bronchi)

2.2.2.4.1Trachea

The trachea bifurcates into two smaller tubes called right and left primary bronchi, each primary bronchus projects laterally toward each lung.

2.2.2.4.2 Broncho pulmonary segment

Right main bronchus shorter, wider and more in line with trachea.

Left main bronchus longer, narrower and more oblique than the right (Snell, 2008).

2.3 CT Chest

In the last years CT chest imaging was played a key role in the diagnosis of lung disease, chest CT was a crossed sectional computed tomography examination of the thoracic cavity was performed for variety reason from penetrating chest performed with or without contrast (Coilins, 2001).

2.3.1 Three views in CT chest: axial view, coronal view and sagittal view.

2.3.2 Three windows:

mediastina or soft tissue window, lung window and bone window

2.3.3 CT Chest type

2.3.3.1Stander CT chest

Regarded as the examination of choice for any patient with abnormal findings in chest x-ray, will be performed with (IV) contrast, supine patient position, use immobilization straps, 3-10mm slice thickness, low MAS, low radiation dose and cover whole lung (coilins, 2001).

2.3.3.1.1 Benefits:

Quick and relatively accessible, show anatomic detail, low radiation dose and minimal superimposition

2.3.3.1.2 Disadvantages:

Need (IV) contrast dye and no detect cystic pattern (coilins, 2001).

2.3.3.2 High resolution computed tomography (HRCT)

These technique developed in 1980 as a result of significant improvement in the CT process, optimize the spatial resolution of conventional scanners, it provide both structural and functional image and see more detail .

HRCT is most important in all cases breath hold, full inspiration, expiration image, prone and supine image

Figure (2.4) HRCT for chest

2.2.4.2.1 HRCT Parameters:

High KVp, high MAS, low scan time and thin slice thickness.

HRCT Advantages Give better quality, accurate, reduce artifact, high contrast, high sensitivity, detect cyst pattern and specify and no need to (IV) contrast dye .

HRCT disadvantages: High doses of radiation, unsuitable for the assessment of lung cancer or other localized lung disease and high level of noise due to thin section (loise, 2011).

2.4 Quality assurance program in CT (Q .A)

All those planed and systematic actions necessary to provide adequate confidence requirement for quality in CT scanners.

2.4.1 Q.A programs should be designed around three basic concepts

1-The test that make up the program must be performed on a regular basis.

2-The results from all tests must be recoded using a consistent format.

3-Documentation should be indicate whether the tested parameter with in specified guide lines (IAEA, 2012).

2.4.2 Quality control in CT (Q.C)

Q.C procedures is the regulatory process (day to day) through which the actual quality performance is measured, compared with existing standards, the action necessary to keep or regain conformance with the standards Q.C and designed to ensure that the CT system is producing the best possible image with minimal radiation dose to the patient.

These tests are semi quantitative procedures (G.Dinkel, 1994).

2.4.3 Image quality

Refer to the level of accuracy in which different imaging systems capture, process, store, and compress, transmit and display the signals that form an image.

Quality of CT image defined as a program that periodically test for the performance CT scanner and compare with the standard

High image quality in chest CT that provide the radiologist with maximum information to ability good diagnosis (G. Dinkel, 1994).

2.4.3.1 Many factor to determine the quality of image

Resolution, linearity, uniformity, noise, artifact and dose.

2.4.3.1.1 Resolution:

Is the measure of how far two objects adjacent can be seen as separate details in the image, for two objects to be seen as separate the detectors must be able to identify a gap between them, The resolution properties of an imaging system are described by the Method for quantifying resolution include PSF, LSF, CTF and MTF (G. Dinkel, 1994).Resolution is measured in line pairs per centimeter (lp/cm)**,** there are two type of resolution

2.4.3.1.1.1 Spatial resolution:

Is used to describe degree of blurring present in an image, is measured of the ability to discriminate object of varying density a small distance a part against a uniform background.

SR depend on reconstruction matrix detector width, slice thickness, matrix size and focal spot.

Spatial resolution is measured by MTF and FWHM

(MTF)is commonly used to descriptor of SR, response of imaging system to region of high, low densities adjacent to each other and describes the percentage of an object contrast that is recorded by the imaging system as a function of it is size (spatial frequency) (loise, 2011)

$$MTF(f)_{system} = MTF(f)_{geometry} - MTF(f)_{algorithm} \quad (2)$$

(f) spatial frequency

2.4.3.1.1.2 Spatial frequency:

is affected by two categories of factors geometric, reconstruction algorithm

2.4.3.1.1.3 Geometric factor:

Refer to factor that play a role in the data acquisition process, these include focal spot size, detector aperture width, slice thickness, distance between the focus and iso center

2.4.3.1.1.4 Reconstruction algorithm:

Kernel effecting in the appearance of the image structure and edge enhancing.

FSS decrease improve SR

Detector size decrease higher SR

FOV decrease increase SR

Pixel size decrease increase SR

Slice thickness decrease increase SR (loise, 2011)

2.4.3.1.2 Contract resolution:

Low contract resolution or tissue resolution is ability of an imaging system to demonstrate small changes in tissue contrast.

Contrast resolution affecting by several factor.

Photon flux, slice thickness, patient size, sensitivity of the detector and image display.

2.4.3.1.3 Linearity:

Refer to the relationship of ct number to linear attenuation coefficient off the object to imaged, this can be checked by a daily calibration test.

2.4.3.1.4 Uniformity:

Refer to the values of pixels in reconstructed image and constancy of CT number at any point in image, checked by a daily calibration test.

2.4.3.1.5 Image artifact:

Artifact is a distortion or error in an image that is unrelated to the subject being studied and features on the image which do not represent true tissue structure (loise, 2011)

Artifact arise from number of source

Patient, motion (voluntary, involuntary), metal, beam hardening.

2.4.3.1.6 Image noise:

Is a fluctuation around a mean value and random variation of CT number from point to point in the image, is the statistical SD of CT number of a homogeneous ROI, Noise can be describe using the standard deviation (σ)

$Noise(\sigma)=\sqrt{(x_i-x^-)^2/n-1}$ ……………………..(3)

X_i=individual pixel value

N=total number of pixel value

x^-=mean of pixel value

√ MASσ =1/ …………………(4)

If MAS reduced the noise increase

Noise inversely proportional to the squire root off the dose and thickness

$noise\ (\sigma) = 1/\sqrt{dose}$ (5)

We can measure noise in any uniform ROI the SD of the CT number in a selected ROI gives the mean noise measurement (G. Dinkle)

$noise\ (\sigma) = \{SD/HU_{average}-HU_{air}\}*100\%$ (6)

2.4.3.1.6.1 Noise level:

can be stated as a percentage of contrast or in CT number, if SD for CT unit with CT number rang from (+1000, -1000) is given to be 3, then the noise level expressed as a percentage of contrast is a follows

noise level (%)=3/1000*1000 =0.3% (7)

(2.3.3.1.6.2)Source of noise

Quantum noise and electronic noise

(2.3.3.1.6.2.1)Quantum noise

Quantum noise is determined by the x-ray photon that can be detected, occurs when an insufficient number of photon detected and affected by (KV, MA, slice thickness, scan speed and pitch (loise, 2011)

2.4.3.1.6.2 Electronic noise:

Reach from data acquisition and scatter radiation

Noise can be measured by noise power spectrum

Noise should be evaluate daily

Stander rang for noise in spiral CT scanner is 4 HU (G. Dinkel, 1994).

2.5 Radiation dose

2.5.1: CT dose:

Measurement of CT dose is essential to ensure the constancy of the CT scanner output and performance importantly to assist in optimization of procedures to achieve the image quality and acceptable radiation dose to the patient.

CT dose Varies significantly among different patient, CT scanner and HRCT protocol.

Radiation dose is directly related to the MA used and image quality

Decreased radiation dose is decreases image quality, increase image noise and decrease resolution but images generally remain diagnostic (Attix, 2004).

2.5.2 Absorbed dose (D):

Ionizing radiation absorbed in tissue and produces a chemical change (energy deposited per unit mass).(ATTIX, 2004)

The related stochastic quantity energy impact (AAPM, 1980)

Absorbed dose measure by gray and rad unit

1Gy = 100rad

2.5.3 Effective dose (E):

measurement for assessment of risks of radiation and allows comparison with other type of radiation exposure.

is measured by the Sievert and msvtypical chest CT effective dose(5-7msv) (descamps, at, al, 2012)

E(msv)=k*DLP(mGy.cm) (8)

K=conversion coefficients (mSv/mGy*cm) (Nicholson, 2002).

Table (2.1) published k conversion coefficients

Anatomic region	1999	EC (12) (2000)	EC(10) 2004)(	NRPB(14) (2005)
Head	0.0021	0.0023	0.0023	0.0021
Neck	0.0048	0.0054		0.0059
Chest	0.014	0.017	0.018	0.014
Abdomen	0.012	0.015	0.017	0.015
Pelvis	0.019	0.019	0.017	0.015

2.5.4 Dose length product (DLP)

Is absorbed dose to a scanned volume of tissue having a length l

Which is defined for a helical scans as.

$DLP=CTDI_{vol}(mGy)*l(mm)$ (9)

DLP measure by (mGy.cm)

l =scan length =T*N

T= slice thickness

N=number of slice (shrimpton pc, 2003)

2.5.5 CT dose index volume:

Represented the dose within the scan volume from a particular scan protocol and measure of dose output of CT scanner and not patient dose (NCRB, 1987).

2.5.6 Justification, optimization and dose limit:

ICRP defined the principle of justification as “any decision that alters the radiation exposure situation should do more good than harm” (john, 2019)

The aim of justification is to establish if the identified procedure will improve diagnostic and provide necessary management information optimization mean maximization of dose to the chest (area been imaged)and minimizing the dose to the other structures

Optimization means doing the best image you can under the prevailing condition, ALARA as low as reasonable achievable will be achieved.(Paula J, 2017). Dose limit is a dose value that is not to be exceeded ,diagnostic reference level can be exceeded if clinical needs demand ,dose limit apply to occupational and public exposure , not to exposure of patient .

2.6 Previous study

(Hanan elnour, 2017)

In your study measured noise of CT in three center in Sudan and found noise for chest (5.4HU), $CTDI_{VOL}$ (10.5mGy) and DLP(88mGy.cm) , put in this study I found noise(8.7HU), $CTDI_{VOL}$ (13.02msv) and DLP(383.36mGy.cm) the different in result from the different of machine type and machine old .

(H Jafarov, 2013)

In your study image quality of HRCT chest the noise (18.8±24.1HU), DLP(267±105.5mGy.cm), $CTDI_{vol}$(7.9±2.3mGy)and E(4.96±1.8msv)

(Abdelrahman M. at. al, 2010)

In your study of survey radiation dose in CT chest imaging trance E(8.2msv), $CTDI_{vol}$ (13, 7mGy)DLP(499.8mGy.cm)

Chapter three

Material and method

Chapter three
Material and method

3.1 Material

In these study collect data content 100 patient from four center of diagnostic (53male and 47 female)

3.1.1 CT scanners used

Table (3.1) show the machine used

centers	A	B	C	D
Name	GE health care	GE bright speed	Toshiba	GE optima
Model	Optima CT520	Bright speed edge selected	Alexion	Optima CT 520
NO of slice	16	16	16	16
Installation date	2017	2011	2009	2010

3.1.2 study group

Table (3.2)show patient data total of 100 patient in four center

Center / Patient data	gender	Total number	Average	Min	Max
A	M	14	25	16	80
	F	10	41	15	85
B	M	18	48	6	77
	F	12	50	18	75
C	M	13	50	21	75
	F	12	53	26	80
D	M	11	45	12	65
	F	10	50	42	60

3.2 Methods

3.2.1 CT protocol

Table (3.3)show the protocol in four center

Parameter	A	B	C	D
KV	120	120	120	120
Time/s	1	0.8	0.8	1
ST/mm	1.25	1.3	1.25	1.25
DFOV	36	38.5	36	35.5
WW	1500	1600	1700	1500
WL	-600	-620	-650	-650
Inter space	18.75	33.5	27.5	22.5
Noise index	9	20	20	20

3.2.2 Effective dose assessment

In these study used (k) factor and DLP to assessment the effective dose

$$E(msv)=k*DLP(mGy.cm)$$

3.2.3 Noise assessment

to assess the noise used equation

$$noise\ (\sigma)=\{SD/HU_{average}-HU_{air}\}*100\%$$

in the image made circle 5 mm diameter except in GE bright speed the diameter used 6.5 mm and read ROI and SD and applied in above formula

Chapter Four
Results

Chapter Four

Results

Statistical Methods: the use of comparative analytical method using the SPSS statistical program based descriptive statistics to demonstrate the differences in (mAs, $CTDI_{vol}$, DLP, effective dose, noise and scan rage) for (**four centers)** according used diagnosis machines.

Table (4.1): Participants distribution with respect gender:

Gender	**Frequency**	**Percent**
Male	53	53.0
Female	47	47.0
Total	**100**	**100.0**

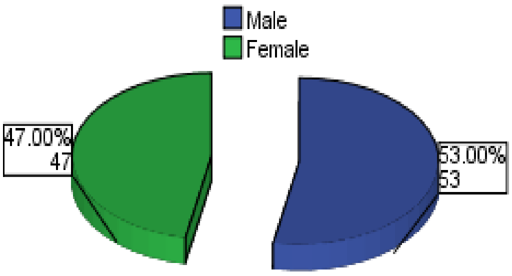


Figure 4.1: distribution of participants according to gender

Table (4.2): Participants distribution with respect to age:

Age	**Frequency**	**Percent**
Less than 10 years	1	1.0
10-20 years	5	5.0
21-30 years	11	11.0
31-40 years	15	15.0
41-50 years	17	17.0
51-60 years	24	24.0
61-70 years	17	17.0
More than 70 years	10	10.0
Total	**100**	**100.0**

Table (4.3): Descriptive statistics for study variables according to machine:

Machine		MAS	CTDI vol	DLP	Effective dose	Noise	Scan range
GE16 (optima)	Minimum	80.00	4.90	196.50	3.40	4.50	114.10
	Maximum	239.20	15.00	561.70	9.50	26.00	383.10
	Mean	180.77	11.57	395.07	6.65	13.84	272.20
	Std. Deviation	9.06	2.92	6.98	1.72	5.31	17.54
GE16 (health care)	Minimum	102.00	7.30	157.60	3.60	3.80	182.70
	Maximum	181.00	16.60	500.70	8.50	17.00	329.30
	Mean	159.88	13.02	383.36	6.67	8.79	242.53
	Std. Deviation	26.38	2.90	11.36	1.43	3.08	35.54
Toshiba	Minimum	37.00	3.30	67.70	1.60	5.50	139.00
	Maximum	150.00	13.40	510.00	11.50	18.90	312.00
	Mean	81.43	6.95	280.89	5.18	11.34	199.01
	Std. Deviation	12.71	3.72	18.12	2.99	4.18	49.13
GE16 (bright speed)	Minimum	95.20	6.90	153.20	2.60	7.00	40.70
	Maximum	237.60	19.40	897.80	10.60	26.50	307.00
	Mean	148.01	12.37	385.51	6.26	15.08	185.07
	Std. Deviation	12.68	4.46	15.61	2.32	5.68	26.98

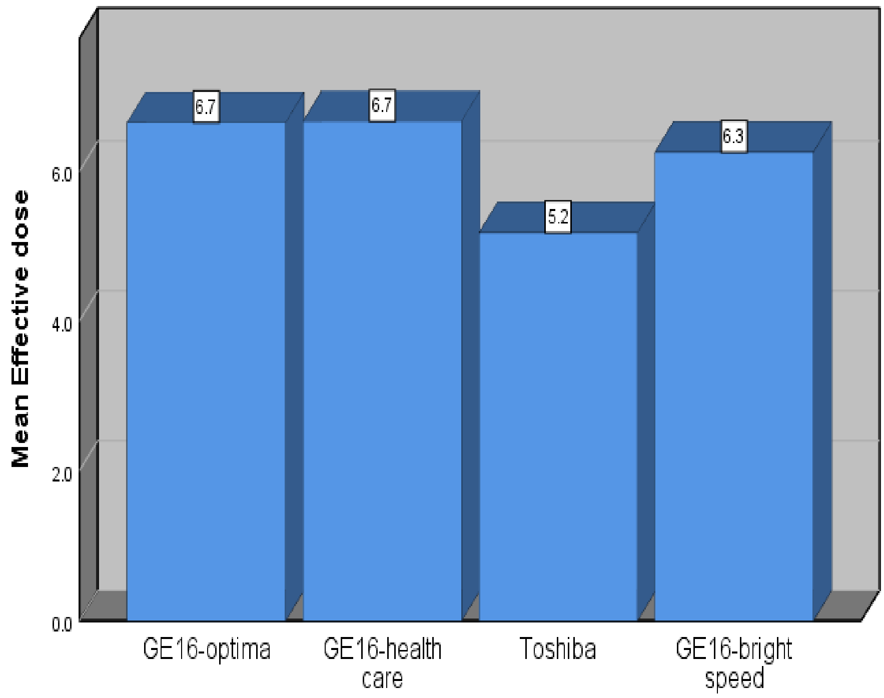


Figure (4.3): mean effective dose according to used machine

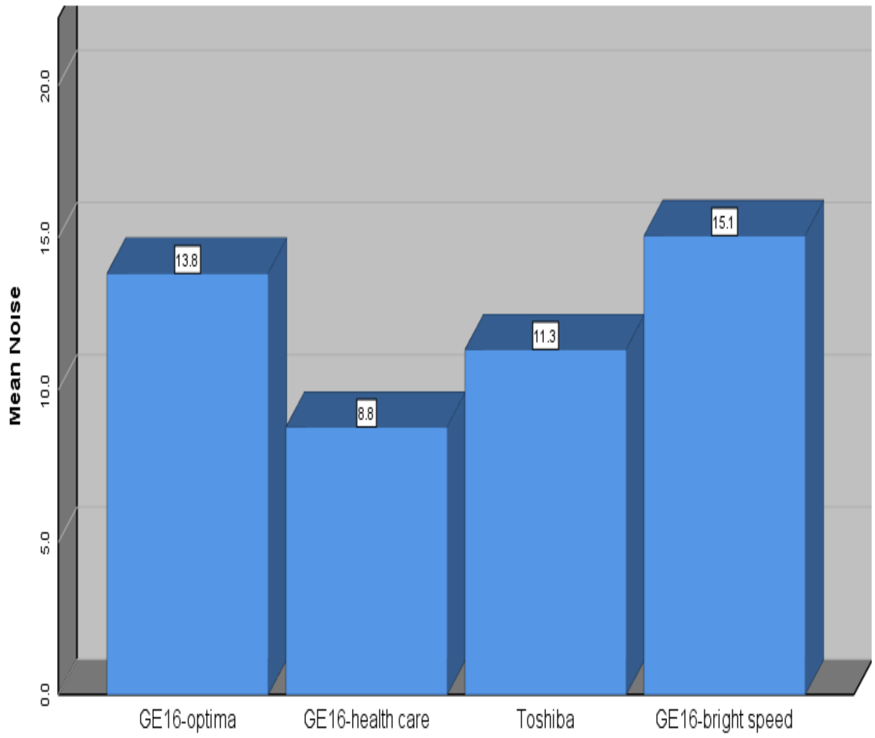


Figure (4.4): mean noise according to used machine

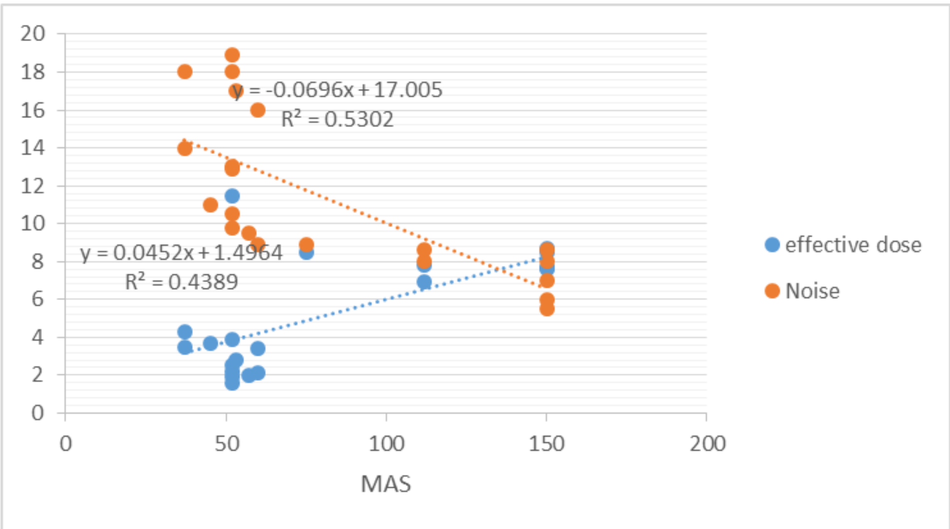


Figure (4.5-a): regression between mAs and (ED and noise) for GE16 (optima)

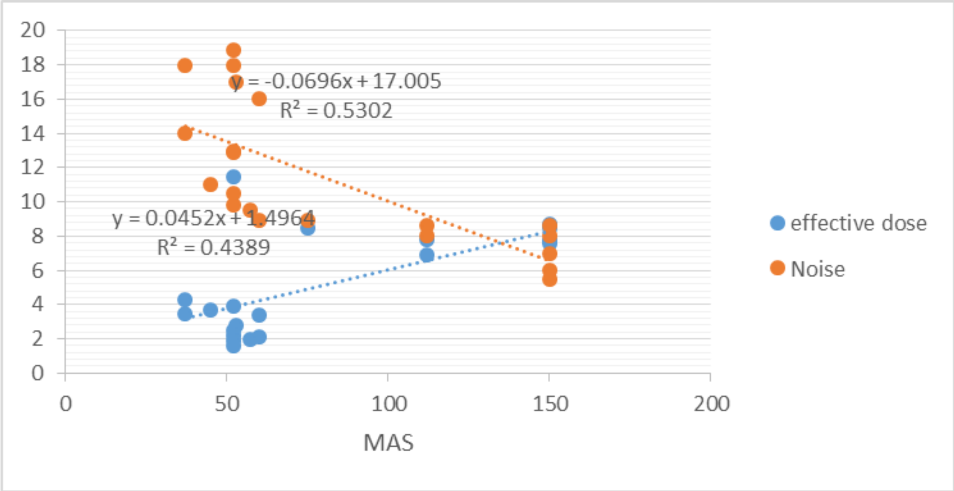


Figure (4.5-b): regression between mAs and (ED and noise) for GE16 (health care)

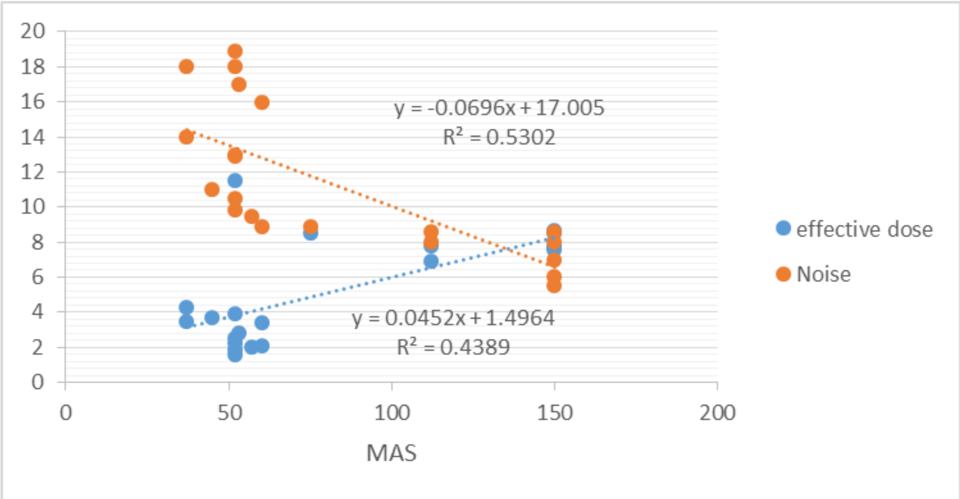


Figure (4.5-c): regression between mAs and (ED and noise) for Toshiba

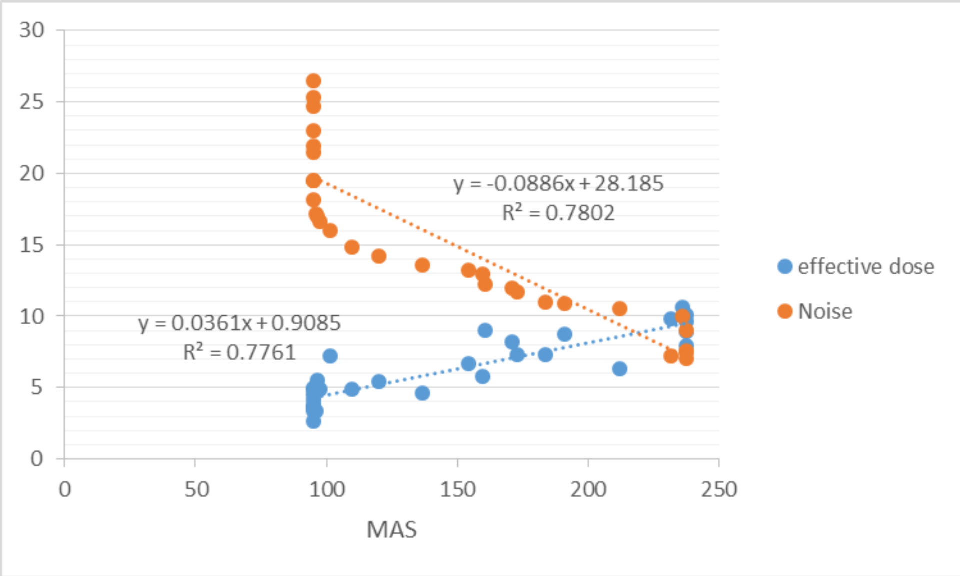


Figure (4.5-d): regression between mAs and (ED and noise) for GE16 (bright speed)

Table (4.4) Coefficients of linear regression model of mAs on and (ED and noise) with respect diagnoses machine:

Machine		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
GE16-optima	Effective dose	0.028	0.004	7.318	0.000
	Noise	-0.070	0.016	-4.398	0.000
GE16-health care	Effective dose	0.037	0.008	4.489	0.000
	Noise	-0.030	0.024	-1.258	0.222
Toshiba	Effective dose	0.045	0.012	3.855	0.001
	Noise	-0.070	0.015	-4.631	0.000
GE16-bright speed	Effective dose	0.036	0.004	9.851	0.000
	Noise	-0.089	0.009	-9.970	0.000

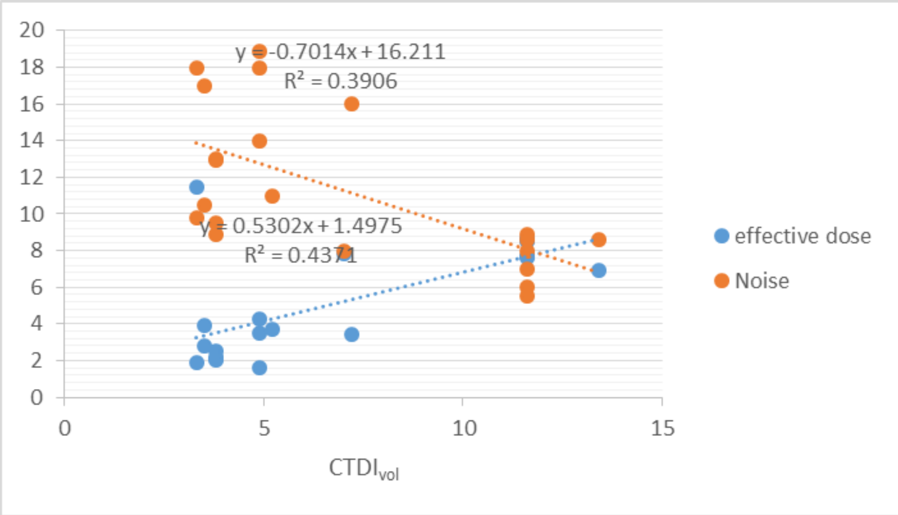


Figure (4.6-a): regression between $CTDI_{vol}$ and (ED and noise) for GE16 (optima)

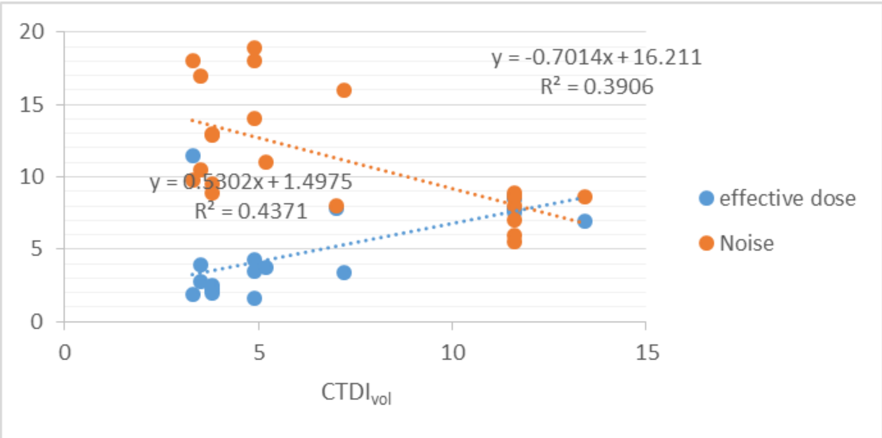


Figure (4.6-b): regression between $CTDI_{vol}$ and (ED and noise) for GE16 (health care)

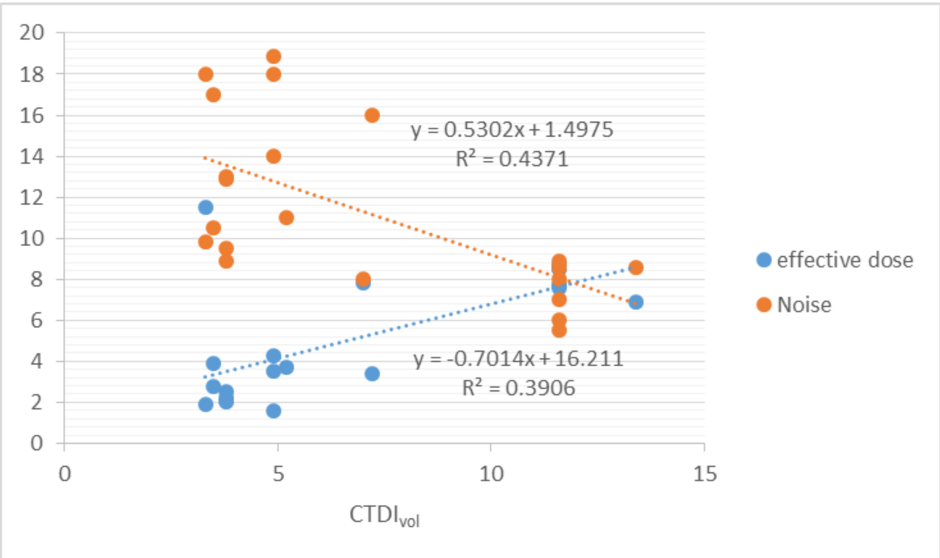


Figure (4.6-c): regression between $CTDI_{vol}$ and (ED and noise) for Toshiba

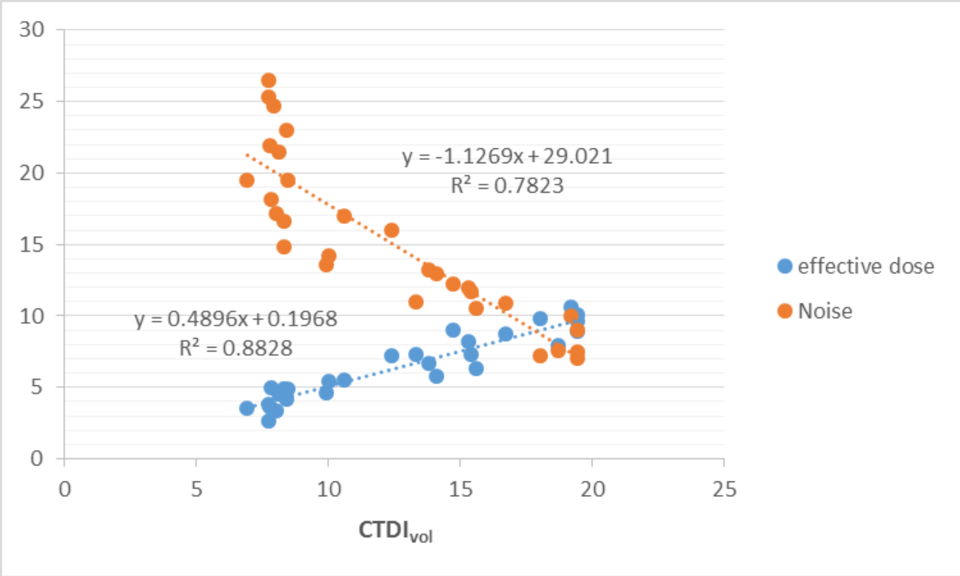


Figure (4.6-d): regression between $CTDI_{vol}$ and (ED and noise) for GE16 (bright speed)

Table (4.5) Coefficients of linear regression model of CTDIvol on and (ED and noise) with respect diagnoses machine:

		Unstandardized Coefficients			
Machine		B	Std. Error	t	Sig.
GE16-optima	Effective dose	0.521	0.057	9.096	0.000
	Noise	-1.249	0.275	-4.541-	0.000
GE16-health care	Effective dose	0.469	0.032	14.639	0.000
	Noise	-0.313	0.216	-1.448	0.162
Toshiba	Effective dose	0.530	0.138	3.841	0.001
	Noise	-0.701	0.201	-3.490	0.002
GE16-bright speed	Effective dose	0.490	0.034	14.522	0.000
	Noise	-1.127	0.112	-10.031	0.000

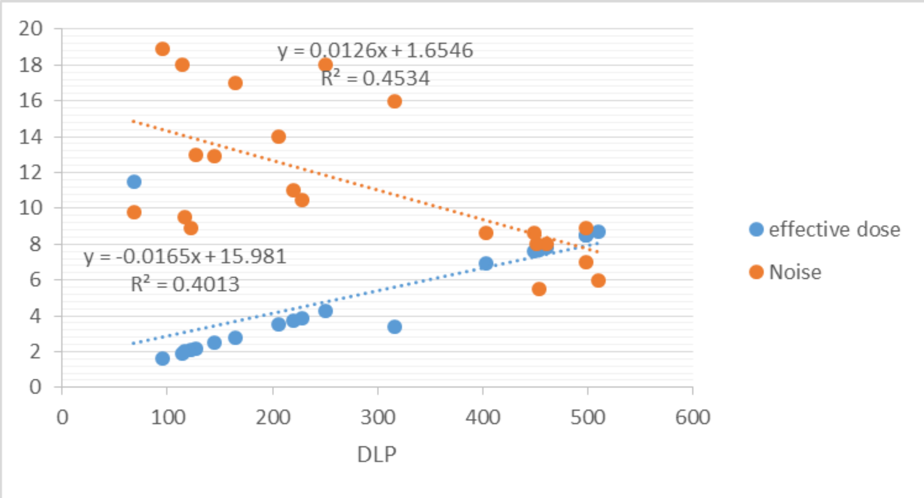


Figure (4.7-a): regression between DLP and (ED and noise) for GE16 (optima)

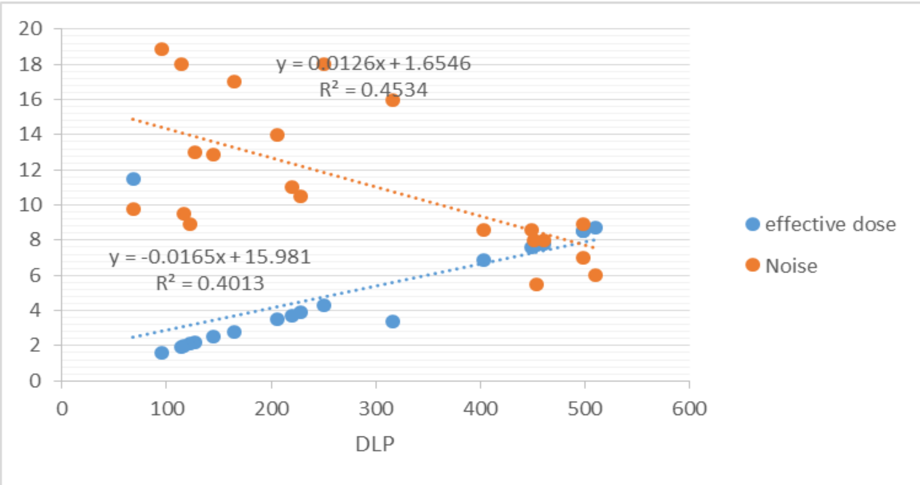


Figure (4.7-b): regression between DLP and (ED and noise) for GE16 (health care)

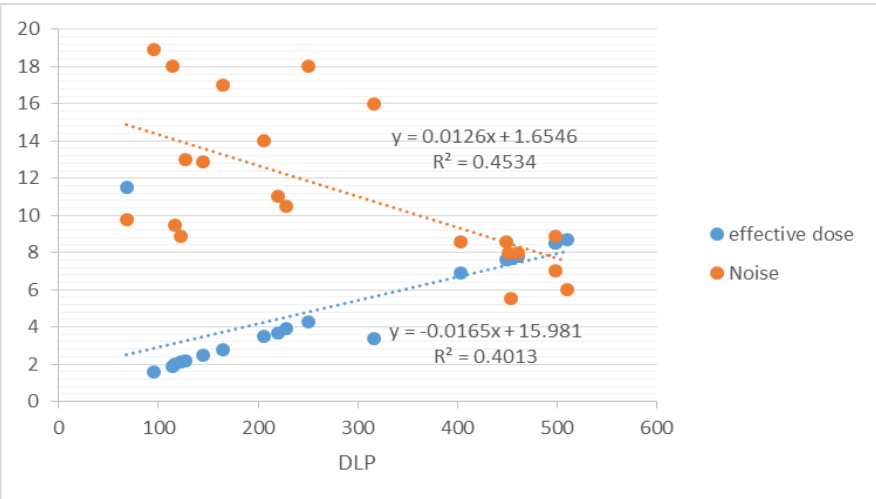


Figure (4.7-c): regression between DLP and (ED and noise) for Toshiba

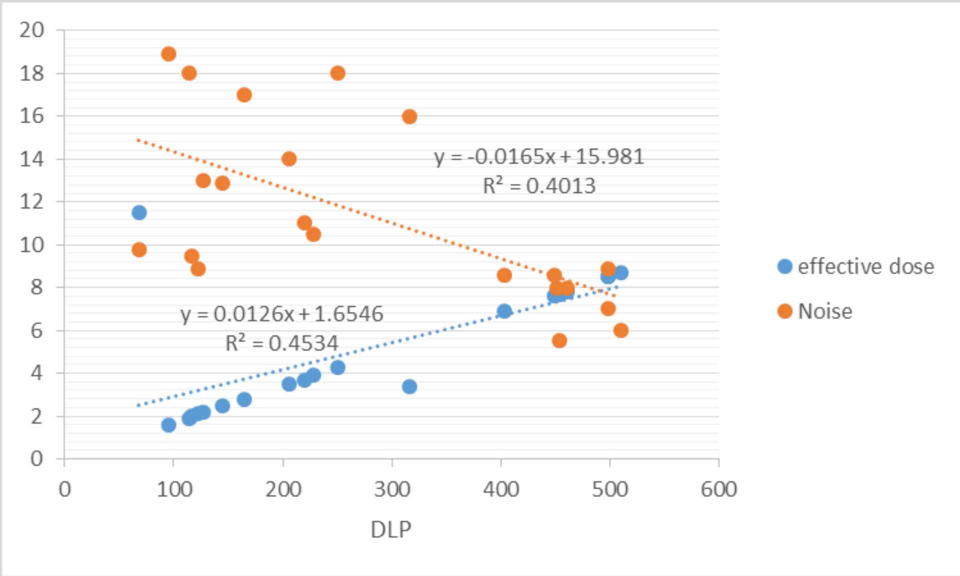


Figure (4.7-d): regression between DLP and (ED and noise) for GE16 (bright speed)

Table (4.6) Coefficients of linear regression model of DLP on and (ED and noise) with respect diagnoses machine:

Machine		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
GE16-optima	Effective dose	0.017	.001	20.365	0.000
	Noise	-0.029	.010	-2.946	0.007
GE16-health care	Effective dose	0.014	.001	15.999	0.000
	Noise	-0.005	.007	-0.809	0.427
Toshiba	Effective dose	0.013	.003	3.970	0.001
	Noise	-0.017	.005	-3.568	0.002
GE16-bright speed	Effective dose	0.012	.001	8.086	0.000
	Noise	-0.025	.004	-5.987	0.000

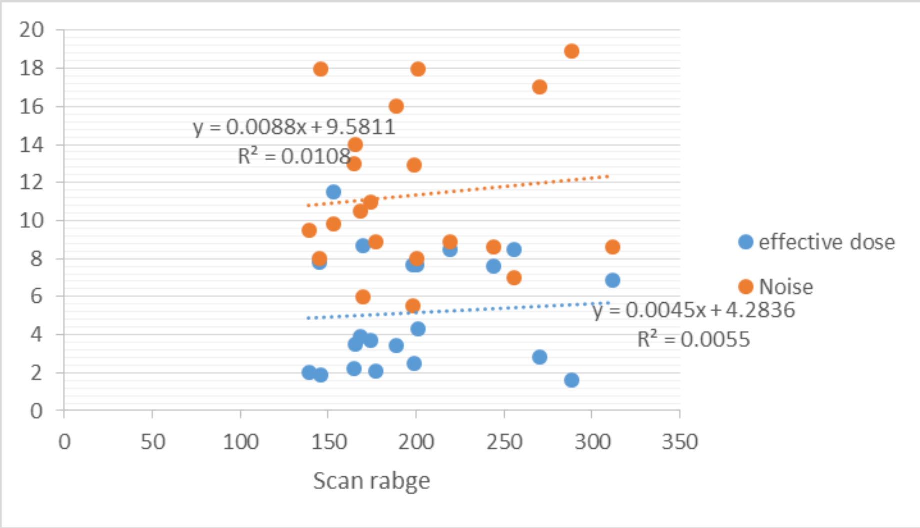


Figure (4.8-a): regression between scan range and (ED and noise) for GE16 (optima)

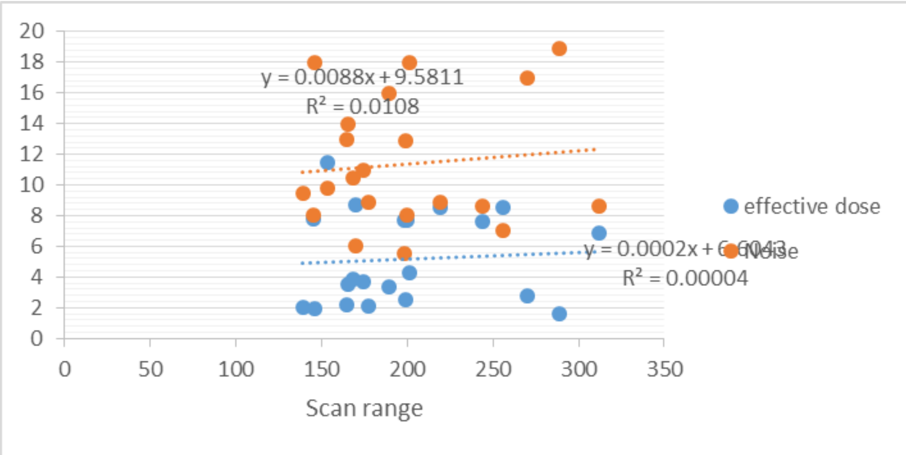


Figure (4.8-b): regression between scan range and (ED and noise) for GE16 (health care)

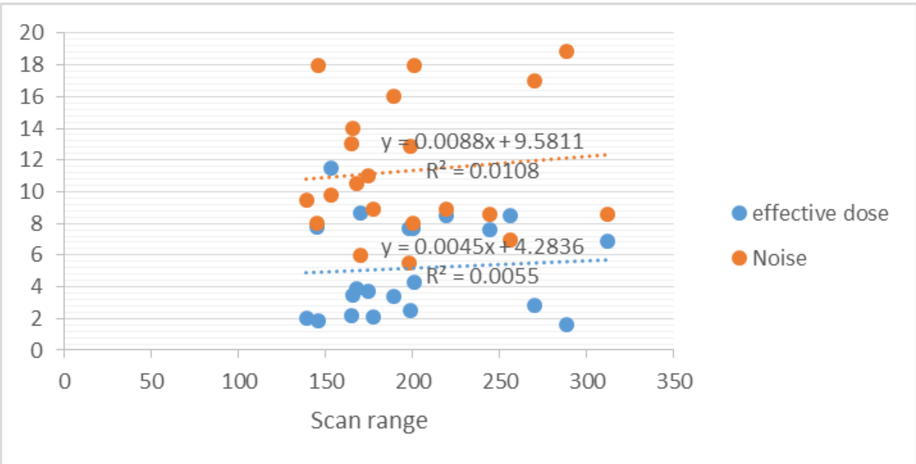


Figure (4.8-c): regression between scan range and (ED and noise) for Toshiba

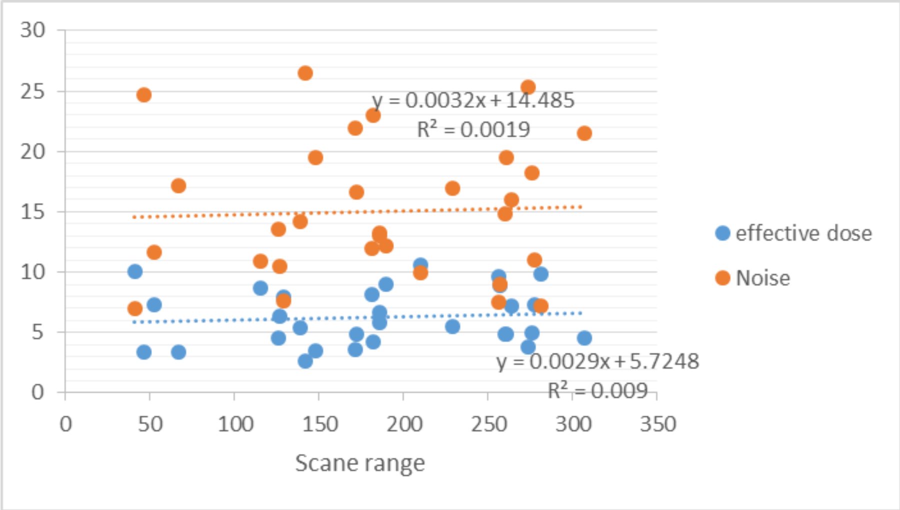


Figure (4.8-d): regression between scan range and (ED and noise) for GE16 (bright speed)

Table (4.7) Coefficients of linear regression model of scan range on and (ED and noise) with respect diagnoses machine:

Machine		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
GE16-optima	Effective dose	0.000	0.006	0.030	0.976
	Noise	0.033	0.017	1.957	0.063
GE16-health care	Effective dose	0.003	0.009	0.368	0.717
	Noise	0.008	0.018	0.433	0.669
Toshiba	Effective dose	0.005	0.014	0.324	0.749
	Noise	0.009	0.019	0.455	0.654
GE16-bright speed	Effective dose	0.003	0.006	0.505	0.618
	Noise	0.003	0.014	0.229	0.820

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion:

A sample of (100) patients represented by (56 males and 44 females) who mostly (83%) more than 30 years old (table 4.1), was selected from four centers (A, B, , C, D) to assess (effective dose and noise) according to used diagnosis machines and demonstrate the relationship between (effective dose and noise) with (MAS, $CTDI_{vol}$, DLP, and scan rage).

Table (4.2)presence180.77±9.06mmmAs, 11.57±2.92mGy $CTDI_{vol}$, 395.07±6.98mGy.cm DLP, 6.65±1.72ED, 13.84±5.31 noise and 272.20±17.54 scan range for GE16 (optima), since for GE16 (health care) were 159.88±26.38MAS, 13.02±2.90mmGy $CTDI_{vol}$, 383.36±11.36mGy.cm DLP, 6.67±1.43ED, 8.79±3.08noise and 242.53±35.54scan range and for Toshiba were 81.43±8.71MAS, 6.95±3.72mGy $CTDI_{vol}$, 280.89±18.12mGy.cm DLP, 5.18±2.99ED, 11.34±4.18noise and 199.01±49.13scan range, while for GE16 (bright speed) were 148.01±12.68 MAS, 12.37±4.46 mGy $CTDI_{vol}$, 385.51±15.61 mGy.cm DLP, 6.26±2.32 ED, 15.08±5.68 noise and 185.07±26.98 scan range.

Then in this study I founded differences between GE16machines and Toshiba machine to measure (effective dose), where the mean effective dose (Figure 4.3) was (6.7, 6.7 and 6.3) respectively for(GE16 (optima), GE16 (health care) and GE16 (bright speed) compared to (5.2) for Toshiba, while noise (Figure 4.4) is differs between all different machines, where the mean noise was (13.8) for GE16 (optima), compared to (8.8) for GE16 (health care), (11.3) for Toshiba and (15.1) for GE16 (bright speed).

(Figure 4.5 and table 4.4) show significant correlation between MAS and both (effective dose and noise), while all (Sig.) values are greater than test significance value (0.05), except for noise for (GE16-health care, Sig = 0.222), which indicate that effective dose is significantly increase with MAS for all machines, while nose is significantly decrease except for (GE16-health care).

(Figure 4.6 and table 4.5) show significant correlation between $CTDI_{vol}$ and both (effective dose and noise), while all (Sig.) values are greater than test significance value (0.05), except for noise for (GE16-health care, Sig = 0.162), which indicate that effective dose is significantly increase with $CTDI_{vol}$ for all machines, while nose is significantly decrease except for (GE16-health care).

(Figure 4.7 and table 4.6) show significant correlation between DLP and both (effective dose and noise), while all (Sig.) values are greater than test significance value (0.05), except for noise for (GE16-health care, Sig = 0.427), which indicate that effective dose is significantly increase with DLP for all machines, while nose is significantly decrease except for (GE16-health care).

(Figure 4.8 and table 4.7) show insignificant correlation between scan range and both (effective dose and noise), while all (Sig.) values are greater than test significance value (0.05), which indicate that effective dose and noise do not depend on scan range for all machines.

5.2 Conclusion

CT is always considers high dose diagnostic technique ,the purpose of these study to assess radiation dose and noise , total of 100 patient undergo chest CT exam in four centers in result I founded sig different in mean ED that effect directly in patient dose ,also sig different in mean noise that effect in image quality .

Mean ED is semi equal (6.65msv),(6.67msv) ,(6.26msv) from GE optima ,GE health care , GE bright speed respectively ,(11.34msv) for Toshiba machine because Toshiba uses MAS smaller than GE machine put all not exceeded IDRLs .

Mean noise (13.84HU), (8.79HU) ,(11.34HU) ,(15.08HU) from GE optima ,GE health care ,Toshiba ,GE bright speed respectively .in Toshiba high noise due to small MAS, in bright speed high noise due to diameter of ROI .

In general noise it high in HRCT chest due to thin section used .

5.3 Recommendations

I recommended by

-Continues calibration and maintenance CT scanners.

- Care layout of room CT scanners.

- Found Q.A phantom with each CT machine.

- Continence training for technologist, radiologist and physics.

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Appendix

Patient data			Scan parameter										Dose display		
NO	Age	Gender	KV	MA	S	ST	WW	WL	DFOV	ROI	SD	Noise	CTDI	E	DLP
1															
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