Sudan University of Science and Technology

College of Graduate Studies

Measurement of Radiation Dose In Brain Computed Tomography

قياس الجرعة الإشعاعية في التصوير المقطعي للدماغ

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

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2018

الآية

﴿قُلْ لَوْ كَانَ الْبَحْرُ مِدَاداً لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَنْ تَنْفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَداً
(109) قُلْ إِنَّمَا أَنَا بَشَرٌ مِثْلُكُمْ يُوحَى إِلَيَّ أَنَّمَا إِلَهُكُمْ إِلَهٌ وَاحِدٌ فَمَنْ كَانَ يَرْجُوا لِقَاءَ رَبِّهِ فَلْيَعْمَلْ عَمَلاً
صَالِحاً وَلَا يُشْرِكْ بِعِبَادَةِ رَبِّهِ أَحَداً (110)﴾

صدق الله العظيم

سورة الكهف الايات(109 _110)

Dedication

I dedicate this research to my family …
To my dear father, who support and encourage me to complete this work.

To my mother who guided me from the first step and never let me fall.

To my sisters who gave me a hope and enlighten my way to finish this task successfully.

To my husband and daughters and all people in my life who touch my heart.

Acknowledgements

I would like to express gratitude to my supervisor **Dr.Mona Ahmed Mohammed,** for her supervision and guidance that set me on the right track.

Special gratitude to Dr.Ahmed Almostafa and Dr. Hussein Ahmed .

My thanks also to staff at hospital for their help and providing this data .

Finally, I would like to sincerely thank my family for their consistent mental support.

Abstract

Computed tomography (CT), is an X-ray procedure that generates high quality cross-sectional images of the body, and comparison to other radiological diagnosis, CT is responsible for higher doses to patients.

The general objective of this study to measure effective radiation dose of brain and confirm is there any difference between effective dose of male brain and female brain according to differences at anatomical structure of male brain and female brain, then correlation between effective radiation dose and mAs.

The data of this study were collected from IBN AL Haitham DIAGNOSTIC CENTER ,Anumber of 60 patients(50% male and 50%female) by used Asteion Toshiab (4 slice) by selected same value of KVP(120).

The study showed amount of average effective radiation dose (1.8776 msv) and it's not above from standard effective dose of brain (2 mSv) that recommended by ICRP. Also there is no any difference between effective dose of male brain and female brain according to differences at anatomical structure of brain we found the effective radiation dose of male equal (1.9601 msv) and effective radiation dose of female equal (1.7952 msv) .and proportional relation between effective radiation dose and mAS.

ملخص البحث

التصوير المقطعي هو عملية التصوير بالاشعة السينية التي تنتج صور لمقاطع جسم المريض بجودة عالية وبالمقارنة مع التشخيص بالاشعة العادية هو ذات تعريض جرعات اكبر للمرضي

الهدف من هذه هذه الدراسة حساب الجرعة الاشعاعية المؤثر للدماغ ومعرفة اذا كان هنالك اختلاف في الجرعة الموثرة بين الذكر والانثي بناءا علي الاختلافات الموجودة في التركيب التشريحي.

وايضا معرفة العلاقة بين الجرعة الموثرة وmAs

تم جمع بيانات هذه الدراسة من مركز ابن الهيثم التشخيصي وكان عدد المرضي 60 مريضا (50% ذكور و50% اناث) باستخدام جهاز توشيبا ذو الاربعة شرائح وتم استخدام نفس الفولتية لجميع المرضي

التي تساوي 2msv اوضحت الدراسة ان الجرعة الاشعاعية علي المرضي بعد حساب قيمتها(1.8776) غير زائدة عن القيمة المعيارية للجرعة الموثرة الموصي بهامن قبلICRP

ووضحت الدراسة انه لا يوجد اختلاف في الجرعة الموثرة بين الذكر والانثي بناءا علي الاختلافات الموجودة في التركيب التشريحي للمخ لكل من الذكر والانثي حيث وجدت الجرعة الاشعاعية المؤثرة علي الذكور تساوي (1.9601 msv) والجرعة الاشعاعية المؤثرة علي الاناث تساوي(1.7952 msv)وايضا وضحت العلاقة الطردية بين الجرعة الموثرة وmAS

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List of abbreviations

CT	Computer tomography
CAT	Computed Axial Tomography
CTDI	computed tomography Dose Index
C TG	Computed tomography generation
CSF	Cerebrospinal fluid
CTDIvol	CT Dose Index volume
Y	Year
IV	INTRAVENOUS
ICRP	International Commission of Radiation Protection
KV	Kilo volte
MDCT	Multidetector computed tomographic.
ERD	Effective Radiation Dose
MRI	Magnetic resonance image
mGy	milli Gray
mSV	milli Sievert
mAs	Miliamper second
DLP	Dose Length Product
GBM	Glioblastomas

Chapter One

Introduction

1.1 Computed Tomography :

Computed tomography (CT) is a medical imaging method employing tomography and digital geometry processing, it use constant two-dimensional xray images taken a round a single axis of rotation. (Goldman, 2008).

It is also known as a CAT Computed Axial Tomography scan. It is a medical imaging method that employs tomography. Although most common in medicine, Tomography is the process of a two-dimensional image of slice or section through a 3-dimensional object (a tomogram).The medical device (the machine) is a large machine and use X-rays, CT scanner is a special kind of x-ray machine. Instead of sending out a single x-ray through the body as with ordinary x-rays, several beams are sent simultaneously from different angles,The x-rays from the beams is detected after they have passed through the body and their strength is measured, each set of measurement made by the scanners is in effect, a cross-section through the body. The computer process the result, displaying them as a two dimensioned picture shown on monitor. The information from the two dimensional computer images can be reconstructed to produce 3-dimensional images by some modern CT scanners. They can be used to produce virtual images that show what a surgeon would see during an operation. CT scan have already allowed doctors to inspect the inside of the body without having to operate or perform unpleasant examinations, CT scanning has also proven invaluable in pinpointing tumors and planning treatment with radiotherapy. (Gold man,2008)

1.1.1Development of CT:

The first clinical CT scanners were installed between 1974 and 1976. The original systems were dedicated to head imaging only, but (whole body) systems with larger patient opening became available in 1976. CT became widely available by about 1980. The first CT scanner developed by Haounsfield at EMI took several hours to acquire the raw data for a single scan or slice and took days to reconstruct a signal image from this row data. The lastest multi-slice CT systems can collect up to 4 slices of data in about 350 ms and reconstruct a 512 x512-matrix image from millions of data points in less than a second. An entire chest can be scanned in five to ten seconds using the most advanced multi-slice CT system. (chummy,1999)

Figure (1.1):shows computed tomography instrument

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.

1.2. Problem of the study:

Increasing of CT examinations for brain in Sudan and the area of scanning have sensitive anatomical organs (eyes) , exposed high Radiation dose.

1.3. Objectives:

1.3.1. General objective:

To measure effective radiation dose during CT brain.

1.3.2. Specific objective:

- To measure effective radiation dose of CT brain to compare with ICRP
- To compare effective radiation dose of brain in male and female according to anatomical structure
- To correlate between mAs and effective radiation dose(ERD)

1.4. Duration of research:

Three months

1.5. Area of study :

IBN Alhaitham Diagnostic center

1.6. 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 tow

2.1Theoretical background

2.1.1 Anatomy of brain

The central nervous system consists of the brain and the spinal cord, The brain is composed of 3 main structural divisions: the cerebrum, the brain stem, and the cerebellum (see the Figure 2-1 below). At the base of the brain is the brainstem, which extends from the upper cervical spinal cord to the diencephalon of the cerebrum. The brainstem is divided into the medulla, pons ,and midbrain. Posterior to the brain stem lies the cerebellum. (Nolte,1993) .

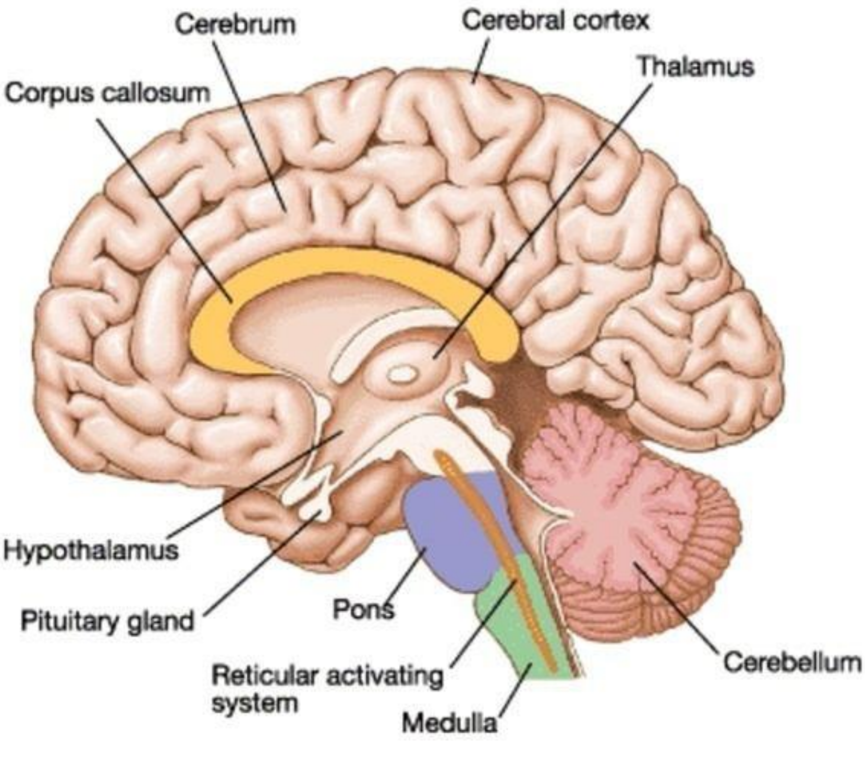


Figure (2-1):Anatomy of brain

2.1.1.1 Cerebrum

The largest part of the human brain is the cerebrum, which consists of two hemispheres separated by the longitudinal fissure. At the base of this deep groove is the corpus callosum, a band of 200 million neurons that connects the right and left hemispheres. Within each hemisphere is a lateral ventricle.

The surface of the cerebrum is gray matter called the cerebral cortex. Gray matter consists of cell bodies of neurons, which carry out the many functions of the cerebrum. Internal to the gray matter is white matter, made of myelinatedaxons and dendrites that connect the lobes of the cerebrum to one another and to all other parts of the brain in the human brain the cerebral cortex is folded extensively. The folds are called convolutions or gyri and the grooves between them are fissures or sulci this folding permits the presence of millions more neurons in the cerebral cortex. The cerebral cortex is divided into lobes that have the same names as the cranial bones external to them. Therefore, each hemisphere has a frontal lobe, parietal lobe, temporal lobe, and occipital lobe. . (Maria and Leslie 2006)

2.1.1.1.1 Frontal lobes

On its lateral aspect, the frontal lobe extends from the frontal pole to the central sulcus, constituting the anterior one-third of the cerebral cortex. Its posterior most gyrus, the pre central gyrus, consists of the primary motor area and is bordered anteriorly by the pre central sulcus and posteriorly by the central sulcus. The region of the frontal lobe located anterior to the pre central sulcus is subdivided into the superior, middle, and inferior frontal gyri. This sub division is due to the presence, though inconsistent, of two longitudinally disposed sulci, the superior and inferior frontal sulci. The inferior frontal gyrus is demarcatedby extensions of the lateral fissure into three subregions: the pars triangularis,pars opercularis, and pars orbitalis. In the dominant hemisphere, a region of the inferior frontal gyrus is known as Broca‘s area, which functions in the production of speech. On its inferior aspect, the frontal lobe presents the longitudinally disposed olfactory sulcus. Medial to this sulcus is the gyrus rectus(also known as the straight gyrus), and lateral to it are the orbital gyri. The olfactory sulcus is partly occupied by the olfactory bulb and olfactory tract its posterior extent, the olfactory tract bifurcates to form the lateral and medial olfactory striae. The intervening area between the two striae is triangular in shape and is known as the olfactory trigone and it abuts the anterior perforated substance. On its medial aspect, the frontal lobe is bordered by the archedcingulate sulcus, which forms the boundary of the superior aspect of the cingulate gyrus. The quadrangular-shaped cortical tissue anterior to the central sulcus is a continuation of the pre central gyrus and is known as the anterior paracentral lobule (Maria and Leslie 2006)

2.1.1.1.2 Parietal Lobes

The parietal lobe is interposed between the frontal and occipital lobes and is situated above the temporal lobe. On its lateral aspect, its anterior most gyrus ,the post central gyrus, is the primary somesthetic area to which primary somatosensory information is channeled from the contra lateral half of the body. The remainder of the parietal lobe, separated from the post central gyrus by the post central sulcus, is subdivided by the inconsistent intra parietal sulcus, into the superior and inferior parietal lobules. The former is an association area involved in somatosensory function, whereas the latter is separated into the supra marginalgyrus, which integrates auditory, visual, and somatosensory information, and the angular gyrus on its medial aspect, the parietal lobe is separated from the occipital lobe by the parieto-occipital sulcus and its inferior continuation, the calcarine fissure. This region of the parietal lobe is subdivided into two major structures, the interiorly positioned posterior par central lobule and the posteriorly situated precuneus. (Maria andLeslie 2006)

2.1.1.1.3 Temporal Lobe:

The temporal lobe is separated from the frontal and parietal lobes by the lateral fissure and from the occipital lobe by an imaginary plane that passes through the parieto-occipital sulcus. The anterior most aspect of the temporal lobe is known as the temporal pole. On its lateral aspect, the temporal lobe exhibits three parallel gyri, the superior, middle, and inferior temporal gyri, separated from each other by the inconsistently present superior and middle temporal sulci. The superior temporal gyrus of the dominant hemisphere contains Wernicke‘s area,The inferior aspect of the temporal lobe is grooved by the inferior temporalsulcus that is interposed between the inferior temporal gyrus and the lateraloccipitotemporalgyrus (fusiform gyrus). The collateral sulcus separates the fusiform gyrus from the parahippocampalgyrus of the limbic lobe (Maria andLeslie 2006)

2.1.1.1.4Occipital Lobe:

The occipital lobe extends from the occipital pole to the parieto-occipital sulcus. On its lateral aspect, the occipital lobe presents the superior and inferior occipital gyri, separated from each other by the horizontally running lateral occipital sulcus. On its medial aspect, the occipital lobe is subdivided into the superiorly located cuneate gyrus (cuneus) and the inferiorly positioned lingual gyrus, separated from each other by the calcarine fissure. The cortical tissue on each bank of this fissure is known collectively as the striate cortex (calcarinecortex), and forms the primary visual cortex(Maria and Leslie 2006)

2..1.1.1.5 Limbic lobe:

The limbic lobe is a complex region and includes the cingulate gyrus,parahippocampalgyrus, hippocampal formation, subcallosalgyrus, parolfactorygyrus, and the preterminalgyrus. The following description is a view of the medial aspect of the hemisected brain and the various regions of the corpus callosum are obvious landmarks. Therefore, the corpus callosum will now be described, even though it is not a part of the limbic lobe. The anterior extent of the corpus callosum, known as the genu, bends inferiorly and turns posteriorly,where it forms a slender connection, the rostrum, with the anterior commissure.

The posterior extent of the corpus callosum is bulbous in shape, and is known as the splenium the cingulate gyrus is located above the corpus callosum and is separated from it by the callossal sulcus. As the cingulate gyrus continuesposteriorly, it follows the curvature of the corpus callosum and dips beneath the splenium to continue anteriorly as the isthmus of the cingulate gyrus. The anterior continuation of the isthmus is the para hippocampalgyrus whose anterior most extent is known as the uncus,Above the parahippo campalgyrus is the hippo campal sulcus, which separate the parahippo campalgyrus from the hippocampal formation (composed of the hippocampus, subiculum, and dentate gyrus). Just beneath the rostrum of the corpus callosum is the subcallosalgyrus. The connection between the anteriorcommissure and the optic chiasma is the lamina terminalis and the cortical tissueanterior to the lamina terminals is the parolfactorygyrus and preterminalgyrus, Thesubcallosal, parolfactory, and preterminalgyri are referred to as thesubcallosal area (Maria and Leslie 2006).

The cerebrum is further divided into the telencephalon and diencephalon. The telencephalon consists of the cortex, the sub cortical fibers, and the basal nuclei. The diencephalon mainly consists of the thalamus and hypothalamus

2.1.1.1.6 Cortex and sub cortical fibers

The outermost layer of the cerebrum is the cortex, which has a slightly gray appearance--hence the term "gray matter." The cortex has a folded structure; each fold is termed a gyrus, while each groove between the folds is termed a sulcus. Cortical anatomy is discussed in greater detail below ,Below the cortex are axons, which are long fibers that emanate from and connect neurons. Axons are insulated by myelin, which increases the speed of conduction. Myelin is what gives the white appearance to these fibers of the brain--hence the term "white matter." (Chummys, 2011)

2.1.1.1.7 *Limbic system*

The limbic system is a grouping of cortical and sub cortical structures involved in memory formation and emotional responses. The limbic system allows for complex interactions between the cortex, the thalamus, the hypothalamus, and the brainstem. . (Chummys, 2011)

2.1.1.1.8 Basal nuclei (ganglia)

The basal nuclei (formerly referred to as the basal ganglia) comprise the caudate nucleus, putamen, globuspallidus, subthalamic nucleus, and substantianigra.

2.1.1.1.9 Thalamus

Positioned between the brainstem and the telencephalon, the diencephalon is composed of the thalamus, the epithalamus, the subthalamus, and the hypothalamus. The thalamus serves as a relay station for ascending input to the cortex and receives information from each of the cardinal senses (except smell). It is hypothesized that the thalamus serves a gating function in filtering information. ,Left and right sides of the thalamus are divided by the third ventricle. Each side is then divided by the internal medullary lamina into a series of anterior nuclei, ventrolateral nuclei, and medial nuclei. Smaller nuclei are found within these regions, numbering perhaps in excess of 100.

2.1.1.1.9.1Epithalamus

The epithalamus is made up of the habenula, the habenular commissure, the posterior commissure, and the pineal gland. . (Chummys 2011)

2.1.1.1.9.2Subthalamus

Located between the midbrain and the thalamus, the subthalamus contains the subthalamic nucleus, the red nucleus, and the substantianigra. Subthalamic structures are closely integrated with the basal nuclei and play a role in modulation of movement. . (Chummys, 2011)

2.1.1.1.9.3 Hypothalamus

Thy hypothalamic nuclei lie in the walls of the third ventricle anteriorly. The hypothalamus is involved in mediating endocrine, autonomic, visceral, and homeostatic functions. It can roughly be divided into anterior, posterior, and middle groups of nuclei. ,The anterior nuclei include the preoptic, the supra optic, and paraventricular nuclei. The posterior nuclei include the supramammillary nucleus, the mammillary nucleus, the intercalate nucleus, and the posterior nucleus. The middle nuclei include the infundibular, tuberal, dorsomedial, ventromedial, and lateral nuclei.

Parasympathetic control can be attributed to the anterior and medial nuclear groups, whereas sympathetic control can be attributed to the posterior and lateral nuclear groups. Satiety can be localized to stimulation of medial nuclei, and hunger can be localized to stimulation of lateral nuclei. Other functions of the hypothalamus include regulation of body temperature, heart rate, blood pressure, and water balance, The hypothalamus has close connections with the cingulate gyrus, frontal lobe, hippocampus, thalamus, brainstem, spinal cord, basal nuclei, and pituitary gland. . (Chummys, 2011)

2.1.1.2 cerebellum

The cerebellum is located in the posterior aspect of the brain, just below the occipital lobes of the cerebrum. It is separated from the cerebrum via ahorizontal dural reflection, the tentorium cerebelli. The cerebellum is connected to the midbrain, pons, and medulla of the brainstem via three pairs of fiber bundles, the superior, middle, and inferior cerebellar peduncles, respectively.

Viewing the cerebellum, it can be seen that it is composed of the right and left cerebellar hemispheres and the narrow, intervening vermis. The vermis is also subdivided into a superior and an inferior portion, where the superior portion is visible between the two hemispheres, while its inferior portion is buried between the two hemispheres. The surface of the cerebellum has horizontal elevations ,known as folia, and indentations between the folia, known as sulci. Some of these sulci are deeper than others and they are said to subdivide each hemisphere into three lobes, the small anterior lobe, the much larger posterior lobe, and the inferiorly positioned flocculonodular lobe (formed from the nodule of the vermis and the flocculus of each cerebellar hemisphere). The anterior lobe is separated from the posterior lobe by the primary fissure, and the posterolateral fissure separates the flocculonodular lobe from the posterior lobe. Similar to the cerebrum, the cerebellum has an outer rim of gray matter, the cortex, an inner core of nerve fibers, the medullary white matter, and the deep cerebellar nuclei, located within the white matter. The cortex and white matter are easily distinguished from each other in a mid sagittal section of the cerebellum, where the white matter arborizes, forming the core of what appears to be a tree-like architecture, known as the arbor vitae. Histologically, the cerebellar cortex is three-layered structure, the outermost molecular layer, the e Purkinje layer,

and the innermost granular layer. The granular layer is well defined due to the presence of nucleic acids in the nuclei of its numerous, small cells. The Purkinje layer, composed of a single layer of large Purkinje cell perikaryons, is also easily recognizable. The molecular layer is rich in axons and dendrites as well as capil laries that penetrate deep into this layer. Four pairs of nuclei are located within the substance of the cerebellar white matter. These are the fastigial,dentate, emboli form, and globose nuclei. The connections between the corticalregions and the deep nuclei of the cerebellum permit the subdivision of the cerebellum into three zones— the vermal, paravermal, and hemispheric—

where each zone is composed of deep cerebellar nuclei, white matter, and cortex.(Maria and Leslie 2006)

2.1.1.3 The brain stem:

The brain stem is composed of medulla, pons and midbrain

2.1.1.3.1 Medulla:

The medulla extends from the spinal cord to the pons and is anterior to the cerebellum.

2.1.1.3.2 Pons:

The Pons bulges anteriorly from the upper part of the medulla. Within the pons are two respiratory centers that work with those in the medulla to produce anormal breathing rhythm.The many other neurons in the pons (pons is from the Latin for ―bridge‖)connect the medulla with other parts of the brain. (Chummys,2011)

2.1.1.3.3 Mid brain:

The midbrain extends from the pons to the hypothalamus and encloses the cerebral aqueduct, a tunnel that connects the third and fourth ventricles. (Chummys,2011)

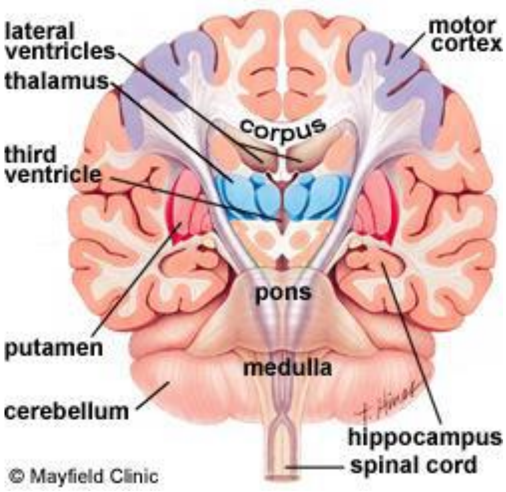


Figure (2-2) Coronal cross-section showing the basal ganglia

2.1.1.4 Ventricles and Cerebrospinal Fluid

The brain is bathed in cerebrospinal fluid (CSF), which is continuously produced and absorbed. The ventricles are CSF-containing cavities within the brain. The structures that produce CSF are contained within the ventricles and are called the choroid plexuses. CSF is produced at a rate of about 450 mL/day, although at any given time about 150 mL can be found within the CSF spaces. Thus, the volume of CSF in most adults is turned over about 3 times per day,

The brain has 4 ventricles ,Within the cerebral hemispheres are the lateral ventricles, which are connected to each other and to the third ventricle through a pathway, called the inter ventricular foramen (of Monro). The third ventricle lies in the midline, separating deeper brain structures such as the left and right thalami. The third ventricle communicates with the fourth ventricle through the cerebral aqueduct (of Sylvius), which is a long narrow tube. ,From the fourth ventricle, CSF flows into the subarachnoid space around both the brain and the spinal cord. From the subarachnoid space, CSF is then absorbed into the venous system. Arachnoid granulations or villi are structures projecting into the superior sagittal sinus that release CSF back into the venous system. .(Maria and Leslie 2006)

Hydrocephalus is a condition in which production of CSF is disproportionate to absorption. This is most commonly caused by impaired absorption resulting from obstruction of the CSF circulatory pathways, in which case it is termed obstructive hydrocephalus. This also occurs when the absorption of CSF is impaired, in which case it is termed communicating hydrocephalus. Rarely is hydrocephalus caused by increased CSF production. (Ronald L and Nancy M.20012)

2.1.1.5 **Blood Vessels**

2.1.1.5.1 Cerebral circulation

Is the movement of blood through the network of blood vessels supplying the brain. The rate of the cerebral blood flow in the adult is typically 750 milliliters per minute, representing 15% of the cardiac output. The arteries deliver oxygenated blood, glucose and other nutrients to the brain and the veins carry deoxygenated blood back to the heart, removing carbon dioxide, lactic acid, and other metabolic products ,The amount of blood that the cerebral circulation carries is known as cerebral blood flow. ,(Chammy.2011)

Arteries supply blood to the brain via 2 main pairs of vessels: the internal carotid artery and the vertebral artery on each side. The internal carotid artery on each side terminates into the anterior cerebral artery, the middle cerebral artery,and the posterior communicating artery. The vertebral arteries on each side join to form the basilar artery. The basilar artery then gives rise to the posterior cerebral arteries and the superior cerebellar arteries. The basilar artery, the posterior cerebral arteries, the posterior communicating arteries, and the anterior cerebral arteries, along with the anterior communication artery, form -anim portant collateral circulation at the base of the brain termed the cerebral arterial circle (of Willis). These vessels lie within the subarachnoid space and area common location for cerebral aneurysms to form.(Nolte1993).

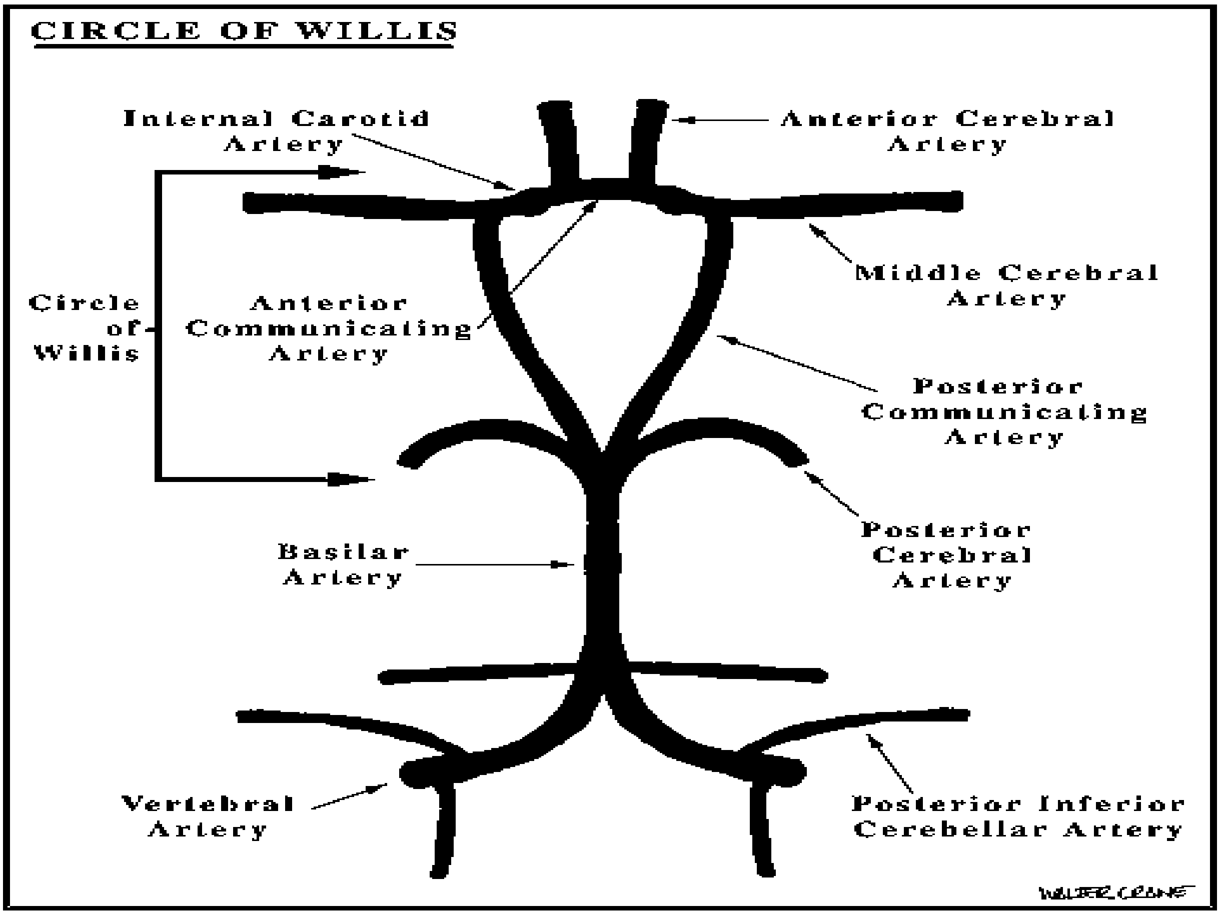


Fig.(2.3):The arterial supply of the brain.

2.1.1.5.2Venous drainage

The venous drainage of the cerebrum can be separated into two subdivisions, superficial and deep, The superficial system is composed of dural venous sinuses, which have wall composed of dura mater as opposed to a traditional vein. The dural sinuses are, therefore located on the surface of the cerebrum. The most prominent of these sinuses is the superior sagittal sinus which flows in the sagittal plane under the midline of the cerebral vault, posteriorly and inferiorly to the torcula, forming the confluence of sinuses, where the superficial drainage joins with the sinus that primarily drains the deep venous system. From here, two transverse sinuses bifurcate and travel laterally and inferiorly in an S-shaped curve that forms the sigmoid sinuses which go on to form the two jugular veins. In the neck, the jugular veins parallel the upward course of the carotid arteries and drain blood into the superior vena cava,The deep venous drainage is primarily composed of traditional veins inside the deep structures of the brain, which join behind the midbrain to form the vein of Galen. This vein merges with the inferior sagittal sinus to form the straight sinus which then joins the superficial venous system mentioned above at the confluence of sinuses.(Maria and Leslie 2006)

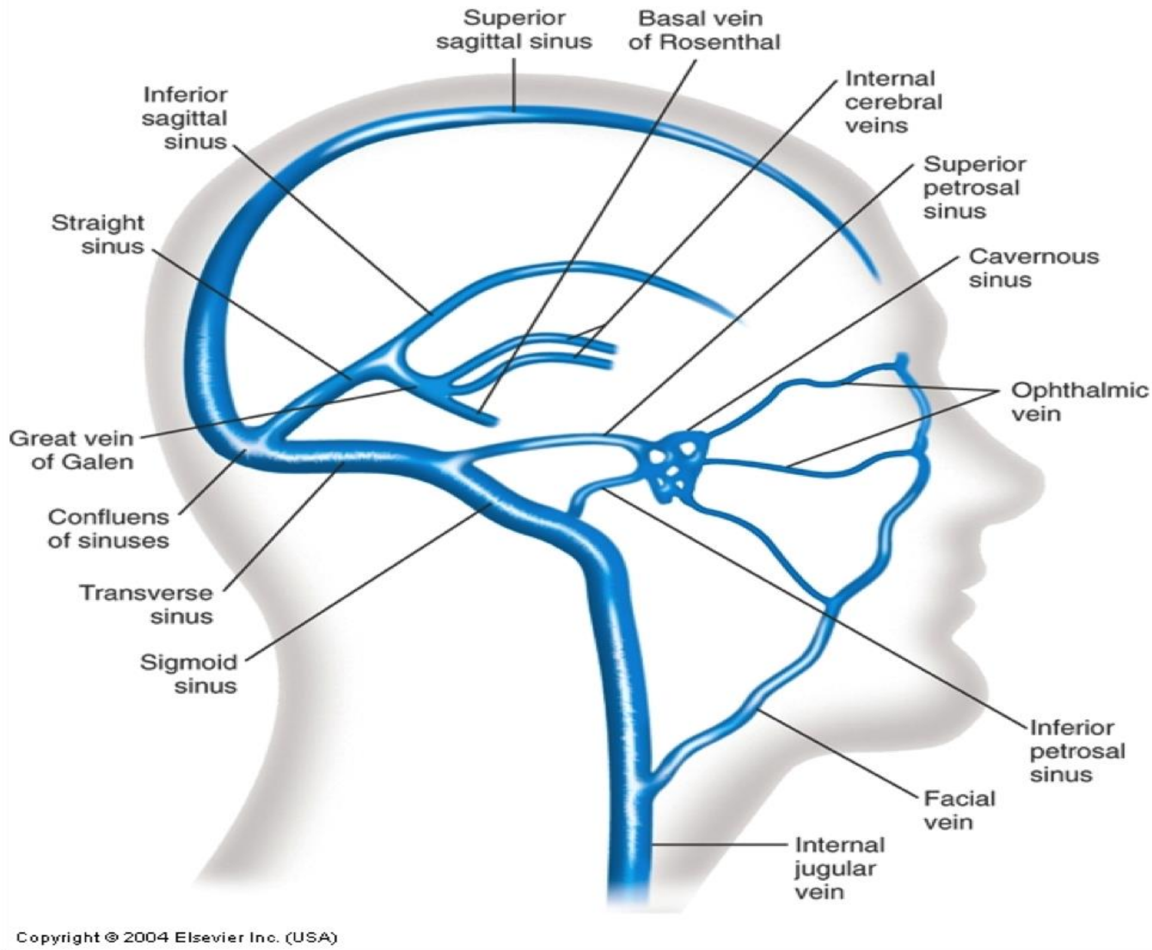


Fig.(2.4): The Venous drainage of the brain.

2.1.2 Physiology of the brain

The brain and nervous system are made of nerve cells called neurons. Neuronssend electrochemical signals to one another, forming the basis of the brain'scomplex, essential functions: to form memories and thoughts, to produceactions, and to interpret the world around us. The brain contains approximately

86 billion neurons. But neurons don’t work alone. In fact, there are as many nonneuronalcells, called glia, in the brain as there are neurons, if not more.,The brain is found in the cranial cavity. Within it are found the higher nervecenters responsible for coordinating the sensory and motor systems of the body.
The brain stem houses the lower nerve centers (consisting of midbrain, pons,and medulla),(Crossman,2000)

2.1.2.1 Cerebrum:

The cerebrum, or top portion of the brain, is divided by a deep crevice, called the longitudinal sulcus. The longitudinal sulcus separates the cerebrum in to the right and left hemispheres. In the hemispheres you will find the cerebral cortex ,basal ganglia and the limbic system. The two hemispheres are connected by abundle of nerve fibers called the corpus callosum. The right hemisphere is responsible for the left side of the body while the opposite is true of the left hemisphere. Each of the two hemispheres are divided into four separated lobes:
the frontal in control of specialized motor control, learning, planning and speech; parietal in control of somatic sensory functions; occipital in control of vision; and temporal lobes which consists of hearing centers and some speech. Located deep to the temporal lobe of the cerebrum is the insula.

2.1.2.2 Cerebellum:

The cerebellum is the part of the brain that is located posterior to the medullaoblongata and pons. It coordinates skeletal muscles to produce smooth, gracefulmotions. The cerebellum receives information from our eyes, ears, muscles, and joints about what position our body is currently in. It also receives output from the cerebral cortex about where these parts should be. After processing this information, the cerebellum sends motor impulses from the brainstem to the skeletal muscles. The main function of the cerebellum is coordination. The cerebellum is also responsible for balance and posture. It also assists us when we are learning a new motor skill, such as playing a sport or musical instrument.

2.1.2.3 Medulla:

The medulla is the control center for respiratory, cardiovascular and digestive functions.

2.1.2.4 Pons:

The pons houses the control centers for respiration and inhibitory functions.
Here it will interact with the cerebellum.

2.1.2.5The Limbic System

The Limbic System is a complex set of structures found just beneath the cerebrum and on both sides of the thalamus. It combines higher mental functions, and primitive emotion, into one system. It is often referred to as the emotional nervous system. It is not only responsible for our emotional lives, but also our higher mental functions, such as learning and formation of memories.
The Limbic system explains why some things seem so pleasurable to us, such as eating and why some medical conditions are caused by mental stress, such as high blood pressure. There are two significant structures within the limbic system and several smaller structures that are important as well. They are: The Hippocampus, amygdale, thalamus, hypothalamus, fornix and Para hippo campus, and the cingulate Gyrus.

2.1.3Brain pathology

2.1.3.1 Brain Tumors

A brain tumor, known as an intracranial tumor, is an abnormal mass of tissue in which cells grow and multiply uncontrollably, seemingly unchecked by the mechanisms that control normal cells. More than 150 different brain tumors have been documented, but the two main groups of brain tumors are termed primary and metastatic (Kwabi-Addo et.al 2011).
Primary brain tumors include tumors that originate from the tissues of the brain or the brain's immediate surroundings. Primary tumors are categorized as glial(composed of glial cells) or non-glial (developed on or in the structures of

thebrain, including nerves, blood vessels and glands) and benign or malignant(Kwabi-Addo et.al 2011).

Metastatic brain tumors include tumors that arise elsewhere in the body (such asthe breast or lungs) and migrate to the brain, usually through the bloodstream. Metastatic tumors are considered cancer and are malignant. Metastatic tumors tothe brain affect nearly one in four patients with cancer, or an estimated 150,000people a year. Up to 40 percent of people with lung cancer will develop metastatic brain tumors. In the past, the outcome for patients diagnosed with these tumors was very poor, with typical survival rates of just several weeks. More sophisticated diagnostic tools, in addition to innovative surgical and radiation approaches, have helped survival rates expand up to years; and also allowed for an improved quality of life for patients following diagnosis(Kwabi-Addo et.al 2011).

2.1.3.1.1 Types of Benign Brain Tumors

2.1.3.1.1.1Chordomasare benign, slow-growing tumors that are most prevalent in people ages 50 to 60. Their most common locations are the base of the skull and the lower portion of the spine. Although these tumors are benign, they may invade the adjacent bone and put pressure on nearby neural tissue. These are rare tumors ,contributing to only 0.2 percent of all primary brain tumors (Bosc, Romain et.al2011).

2.1.3.1.1.2Craniopharyngiomastypically are benign, but are difficult tumors to remove because of their location near critical structures deep in the brain. They usually arise from a portion of the pituitary gland (the structure that regulates many hormones in the body), so nearly all patients will require some hormone replacement therapy (Bosc et.al 2011).

2.1.3.1.1.3Gangliocytomas, gangliomas and an aplastic gangliogliomas are rare tumors that include neoplastic nerve cells that are relatively well-differentiated ,occurring primarily in young adults (Bosc et.al 2011)

.**2.1.3.1.1.4Glomus jugulare** tumors most frequently are benign and typically are located just under the skull base, at the top of the jugular vein. They are the most common form of glomus tumor. However, glomus tumors, in general, contribute to only 0.6 percent of neoplasms of the head and neck(Bosc et.al 2011).

2.1.3.1.1.5 Meningiomasare the most common benign intracranial tumors, comprising 10 to 15 percent of all brain neoplasms, although a very small percentage are malignant. These tumors originate from the meninges, the membrane-like structures that surround the brain and spinal cord (Bosc et.al2011)

2.1.3.1.1.6 **Pituitary adenomas** are the most common intracranial tumors aftergliomas, meningiomas and schwannomas. The large majority of pituitary adenomas are benign and fairly slow-growing. Even malignant pituitary tumors rarely spread to other parts of the body. Adenomas are by far the most common disease affecting the pituitary. They commonly affect people in their 30s or 40s,al though they are diagnosed in children, as well. Most of these tumors can be treated successfully (Bosc et.al 2011).

2.1.3.1.2 Types of Malignant Brain Tumors

2.1.3.1.2.1 Gliomasare the most prevalent type of adult brain tumor, accounting for78 percent of malignant brain tumors. They arise from the supporting cells of the brain, called the glia. These cells are subdivided into astrocytes, ependymal cells and oligodendroglial cells (or oligos). Glial tumors include the following:

2.1.3.1.2.2 Astrocytomasare the most common glioma, accounting for about half of all primary brain and spinal cord tumors. Astrocytomas develop from star-shaped glial cells called astrocytes, part of the supportive tissue of the brain. They may occur in many parts of the brain, but most commonly in the cerebrum. People of allages can develop astrocytomas, but they are more prevalent in adults (Ronald and Nancy 2012)

2.1.3.1.2.3 Ependymomasare derived from a neoplastic transformation of the ependymal cells lining the ventricular system and account for two to three percent of all brain tumors. Most are well-defined, but some are not.(Roland and Nancy.2012)

2.1.3.1.2.4 Glioblastomamultiforme(GBM) is the most invasive type of glial tumor.

These tumors tend to grow rapidly, spread to other tissue and have a poorprognosis. They may be composed of several different kinds of cells, such asastrocytes and oligodendrocytes. GBM is more common in people ages 50 to 70and are more prevalent in men than women (Roland and Nancy.2012)

2.1.3.1.2.5Medulloblastomasusually arise in the cerebellum, most frequently in children. They are high-grade tumors, but they are usually responsive to radiation and chemotherapy.

2.1.3.1.2.6Oligodendrogliomasare derived from the cells that make myelin, which is the insulation for the wiring of the brain (Bosc et.al 2011

2.1.3.2 Inflammatory Diseases :

2.1.3.2.1 Brain Abscess

Brain abscesses are usually a result of chronic infections of the middle ear, paranasal sinuses, or mastoid air cells, or of systemic infections (pneumonia, bacterial endocarditis , osteomyelitis). The organisms that most commonly cause brain abscesses are streptococci. In patients with acquired immunodeficiency syndrome (AIDS),un usual infections such as toxoplasmosis and crypto coccosis

often cause brain abscesses. The micro organisms lodge preferentially in the gray matter and spread to the adjacent white matter.(Roland and Nancy.2012)

2.1.3.2..2Encephalitis

Encephalitis, a viral inflammation of the brain and meninges (meningoencephalitis), produces symptoms ranging from mild headache and fever to severe cerebral dysfunction, seizures, and coma. About 30% of cases occur in children. Encephalitis caused by herpes simplex is an often fatal, fulminant (sudden severe infection, fever, or hemorrhage) process(Roland and Nancy.2012)

2.1.3.2..3Meningitis

Meningitis is an acute inflammation of the pia mater andarachnoid, two of the membranes covering the brain and spinal cord. Infecting

2.1.3.3 Vascular diseases

Stroke interruption of the blood supply to the brain can lead to paralysis and other complications. The risk factors for stroke include high blood pressure , diabetes, obesity, high blood cholesterol, smoking, excessive alcohol abuse, previous stroke, use of birth control pills and genetic predisposition.(Roland and Nancy.2012)

2.1.3.4Degenerative Diseases

Multiple sclerosis Multiple sclerosis describes a condition where the protective myelin coating surrounding nerve fibers is damaged in the brain and spine causing problems with muscle movement, vision and balance.

2.1 .4 System Components of CT scanner:

2.1.4.1 CT Gantry:

The first major component of a CT system is referred to as the scaner or imaging system. The imaging system primarily includes the gantry and patient table or couch. The gantry is a moveable frame that contains the X-ray tube including collimators and filters, detectors, data acquisition system (DAS), rotational components including slip ring systems and all associated electronics such as gantry angulation motors and positioning laser lights. In older CT systems a small generator supplied power to the X-ray tube and the rotational components via cables for operation. This type of generator was mounted on the rotational component of the CT system and rotated with the X-ray tube. Some generators remain mounted inside the gantry wall. Some newer scanner designs utilize a generator that is located outside the gantry. Slip ring technology eliminated the need for cables and allows continuous rotation of the gantry components. The inclusion of slip ring technology into a CT system allows for continuous scanning without interference of cables. A CT gantry can be angled up to 30° toward a forward or backward position. Gantry angulation is determined by the manufacturer and varies among CT systems(Karthikeyan 2005). Gantry angulation allows the operator to align pertinent anatomy with the scanning plane. The opening through which a patient passes is referred to as the gantry aperture. Gantry aperture diameters generally range from 50 to 85 cm. Generally, larger gantry aperture diameters, 70 to 85 cm, are necessary for CT departments that do a large volume of biopsy procedures. The larger gantry aperture allows for easier manipulation of biopsy equipment and reduces the risk of injury when scanning the patient and the placement of the biopsy needle simultaneously. The diameter of the gantry aperture is different for the diameter of the scanning circle or scan field of view. If a CT system has a gantry aperture of 70 cm diameter it does not mean that you can acquire patient data utilizing a 70 cm diameter. Generally, the scanning diameter in which patient or projection data is acquired is less than the size of the gantry aperture. Lasers or high intensity lights are included within or mounted on the gantry. The lasers or high intensity lights serve as anatomical positioning guides that reference the center of the axial, coronal, and sagittal planes. (Romans2011)

2.1.4.2X-Ray Tube, Collimation, Filtration:

X-ray is produced by an X-ray tube. The three main parts of any X-ray tube are the anode, cathode and the filament. When the filament is heated, electrons are ejected from its surface. A large voltage between the cathode and the anode force electrons to accelerat towards the anode. The electrons hitting the anode(tungsten) produce Bremstrahlung radiation at an efficiency of only 1 percent. The other 99 percent of the electrons energy is converted into heat .Most modern system use tubes with two focal spot small spot is used for high resolution examination. And large spot is used for larger anatomic coverage.

Stationary anode—Used in eary scanners, oil cooled, large focal spot giving rise to higher potential radiation. Rotating anode—Air cooled, small focal spot requires large heat capacity and fast cooling rates. Mechanical stresses due to tube rotation—Up to 13 G for0.5 second rotation. CT procedures facilitate the use of large exposure factors, (high mA and kVp values) and short exposure times. The development of spiral/helical CT allows continuous scanning while the patient table or couch moves through the gantry aperture (Karthikeyan ,2005). A typical spiral/helical CT scan of the abdomen may require the continuous production of X-rays for a 30 to 40 second period. The stress caused by the constant build up of heat can lead to a rapid decrease of tube life. When an X-ray tube reaches a maximum heat value it simply will not operate until it cools down to an acceptable level. CT systems produce X-radiation continuously or in short millisecond bursts or pulses at high mA and kVp values. CT X-ray tubes must possess a high heat capacity which is the amount of heat that a tube can store without operational damage to the tube. The X-ray tube must be designed to absorb high heat levels generated , An X-ray tubes heat capacity is expressed in heat units. Modern CT systems utilize X-ray tubes that have a heat capacity of approximately 3.5 to 5 million heat unit (MHU). A CT X-ray tube must possess a high heat dissipation rate. Many CT X-ray tubes utilize a combination of oil and air cooling systems to eliminate heat and maintain continuous operational capabilities. A CT X-ray tube anode has a large diameter with a graphite backing. The large diameter backed with graphite allows the anode to absorb and dissipate large amounts of heat. The focal spot size of an X-ray tube is determined by the size of the filament and cathode which is determined by the manufacturer. Most X-ray tubes have more than one focal spot size. The use of a small focal spot increases detail but it concentrates heat onto a smaller portion of the anode, therefore, more heat is generated. As previously described, when heat is building up faster than the tube can dissipate it the X-ray tube will not produce X-rays until it has sufficiently cooled. CT tubes utilize a bigger filament than conventional radiography X-ray tubes. The use of a bigger filament increases the size of the effective focal spot. Decreasing the anode or target angle decreases the size of the effective focal spot. Generally, the anode angle of a conventional radiography tube is between12 and 17 degrees. CT tubes employ a target angle approximately between 7 and 10 degrees. The decreased anode or target angle also helps alleviate some of the effects caused by the heel effect. CT can compensate any loss of resolution due the use of larger focal spot sizes by employing resolution enhancement algorithms such as bone or sharp algorithms, targeting techniques, and decreasing section thickness.(Karthikeyan 2005)Collimation: Important Component for Reducing Patient Dose and Improving Image Quality by Reducing Scatter Radiation In CT collimation of the X-ray beam includes tube collimators, a set of pre-patient collimators and post patient or pre-detector collimators. Some CT systems utilize this type of collimation system while other do not. The tube or source collimators are located in then X-ray tube and determine the section thickness that will be utilized for a particular CT scanning procedure. When the CT technologist selects a section thickness he or she is determining tube collimation by narrowing or widening the beam. A second set of collimators located directly below the tube collimators maintain the width of the beam as it travels toward the patient. A final set of collimators called post-patient or pre-detector collimators are located below the patient and above the detector. The primary responsibilities of this set of collimators are to insure proper beam width at the detector and reduce the number of scattered photons that may enter detector. Pre-patient collimation Depends on the focal spot size, Mounted on the tube housing, Creates more parallel beam, Reduces patient dose Pre-detector collimation, Restricts the field of view of detectors, Reduces the scatter radiation on the detector ,Aperture width helps determine the slice thickness ,The X-ray field is filtered to reduce the low energy X-rays which are not useful for imaging but that increase the radiation dose received by the patient. This process is called collimation. The beam undergoes two-levels of collimation:(1) source collimation, and (2) detector collimation. The source collimator controls the thickness of the tomographic slice (most common thickness are 1, 2,5 or 10 mm)..(Romans 2011)

2.1.4.3Filtration:

There are two types of filtration utilized in CT. Mathematical filters such as bone or soft tissue algorithms are included into the CT reconstruction process to enhance resolution of a particular anatomical region of interest. Inherent tube filtration and filters made of aluminiumor Teflon are utilized in CT to shape the beam intensity by filtering out low energy photons that contribute to the production of scatter. Special filters called "bow-tie" filters absorb low energy photons before reaching the patient. X-ray beams are polychromatic in nature which means an X.ray beam contains photons of many different energies. (Karthikeyan 2005). Ideally, the X-ray beam should be monochromatic or composed of photons having the same energy. Heavy filtration of the X-ray beam results in a more uniform beam. The more uniform the beam, the more accurate the attenuation values or CT numbers are for the scanned anatomical region. Provides for a equal photon distribution across theX-ray beam. Allows equal beam hardening were the X-ray passes through the filter and object. Lessens overall patient dose by removing softer radiation. Made of aluminium, grafite can be curved, wedge or flat in shape (Karthikeyan 2005).

2.1.4.4 Detectors:

Detectors gather information by measuring the X-ray attenuation through objects. The most important properties of X-ray detectors used in CT are: a. Efficiency b. Response time (after glow)c. Linearity Efficiency is related to the number of X-rays reaching the detector that are detected. Response time is related to how fast the detected X-ray is converted into an electrical pulse or current..(Romans 2011)

2.1.4.5 Operator Console: Scan Console Technical factors, slice thickness, no of scans, angle of gantry. Initiates scan, record patient data, sets FOV.

Display Console: Used to manipulate post scan data, Post processing work—measurements, MIPS, 3Dformations. Window level and width. Computer The computer processes convert the signal from analog to digital by using a analog to digital convertor. It stores the digital signal during the scan and reconstructs the images after the scan is complete. This reconstruction can be done immediately or later. Data can be manipulated to reconstruct into various planes .Summary of Processes: The formation of a CT image is a distinct three phase process. The reconstruction phase processes the acquired data and forms a digital image. The scanning phase produces data, but not an image. The visible and displayed analog image (shades of grey) is produced by the digital-to analog conversion phase.(Romans 2011)

2.1.4.2 CT Generations

2.1.4.2.1First-Generation CT Scanners

The EMI Mark I scanner, the first commercial scanner invented by Houns field, was introduced in 1973. This scanner acquired data with an x-ray beam collimated to a narrow pencil beam directed to a single detector on the other side of the patient; the detector and the beam were aligned in a scanning frame. A single projection was acquired by moving the tube and detector in a straight-line motion (translation) on opposite sides of the patient (Mahadevappa Mahesh, 2002). To acquire the next projection, the frame rotated 1, and then translated in the other direction. This process of translation and rotation was repeated until 180 projections were obtained. The earliest versions required about 4.5 minutes for a single scan and thus were restricted to regions where patient motion could be controlled (the head). Since procedures consisted of a series of scans, procedure time was reduced somewhat by using two detectors so that two parallel sections were acquired in one scan (Mahadevappa Mahesh, 2002).

Although the contrast resolution of internal structures was unprecedented, images had poor spatial resolution (on the order of 3 mm for a field of view of 25 cm and 80 matrixes) and very poor z-axis resolution (13-mm section thickness) (Mahadevappa Mahesh, 2002).

2.1.4.2.2Second 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).

2.1.4.2.3Third 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)

2.1.4.2.4Fourth 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)

2.1.4.2.5Multidetector CT scanner:

(MDCT) Aform 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)

2.1.4.3 CT dosimeter:

The dosimetric quantities typically used in CT are the “CT dose index” (CTDI) and the “dose length product” (DLP). The CTDI is defied for an axial CT scan (one rotation of the X-ray tube) by dividing the integral of the absorbed dose along the z axis by the nominal beam width.

The CTDI is measured either free in air (CTDIair) or in a specified phantom made of PMMA. Different phantom sizes are used to reflect differences in body anatomy,This is mainly realized by different phantom diameters (16-cm diameter for head investigations, 32-cm diameter for body investigations). In practice, CTDI measurements are usually performed with a pencil ionization chamber with an active length of 100 mm, which is positioned at the center (CTDI100,c) and at the periphery (CTDI100,p) of either a standard head or body CT dosimetry phantom. On the assumption that the dose decreases linearly with the radial position from the surface to the center of the phantom, the average dose is given by the "weighted CTDI" (CTDIw) that is a weighted linear combination of the central and peripheral CTDI values,The CTDI is directly proportional to the electrical current-time product

2.1.4.3.1 Determination of the Effective Dose:

Calculated effective dose in CT is , at best a rough estimate due to many factors ,such as variations on patient size and limitations of dose measurement and calculation method . Consequently, the effective dose are based on published CT dose data adjusted for irradiated length ,patient age , tube current reduction recommended by Image Gently and effective dose per dose length product (DLP),Different tissue and organs have different radiation sensitivities .For example, bone marrow is much more radiosensitive than muscle or nerve tissue .To obtain an indication of how exposure can affect overall health ,the equivalent dose can be multiplied by a factor related to the risk for aparticular tissue or organ .This multiplication provides the effective dose absorbed by the body , the unit of effective dose seivert .From Device and scan Parameters a simple, but coarse estimation of effective dose can be derived from the DLP using representative conversion confidents provided by the ICRP ,where conversion confidents (in mSv · mGy-1 · cm-1), depending on the scanned body region and patient size (respectively age). Some values of k for adult patients are presented in Table (2.1).(Reiser et al 2009)

Table (2.1): show conversion factor (k) for head

Conversion factor from DLP to Effective Dose in [mSv/(mGy·cm)]					
Region of the Body	0-year-old	1-year-old	5-year-old	10-year-old	Adult
Head and neck	0.013	0.0085	0.0057	0.0042	0.0031
Head	0.011	0.0067	0.0040	0.0032	0.0021
Neck	0.017	0.012	0.011	0.0079	0.0059
Chest	0.039	0.026	0.018	0.013	0.014
Abdomen and pelvis	0.049	0.030	0.020	0.015	0.015
Trunk	0.044	0.028	0.019	0.014	0.015

Effective dose is becoming a very useful radiation quantity for expressing relative risk to humans , both patients and other personnel. It is actually a simple and very logical concept. It takes into account the specific organs and areas of body that are exposed. the point is that all parts of the body and organs are not equally sensitive to the possible adverse effects of radiation , such as cancer induction and mutations.

Table (2.2):Shows average radiation dose for typical adult CT examinations

CT examination	**(mSv) average Effective dose**	**Values reported in literature(mSv)**
Head	2	0.9 4.0
Chest	7	4.0 18.0
Chest for pulmonary embolism	15	13.0 40.0
Abdomen	8	3.5 25.0
Pelvis	6	3.3 10.0
Spine	6	1.5 10.0

2.1.3.2Advantages and limitations of CT:

CT provides a rapid, non-invasive method of assessing patients. A whole body scan can be performed in a few seconds on a modern multi slice scanner with very good anatomical detail. CT is particularly suited to high X-ray contrast structures such as the bones and the lungs, and remains the cross-sectional imaging modality of choice for assessing these. It has less contrast resolution than MRI for soft tissue structures particularly for intracranial imaging, spinal imaging, and musculoskeletal imaging. ..(Paul etal 2007)

2.2. Previous study :

In this study by Musab Mohammed 2016 calculated effective dose of CT scanner on brain at Modern medical center on Sudan .This study performed on study group about (50 patient). He found that the effective dose (1.26756002_+0.2 mSv) and it's not equal or above than standard effective dose of brain (2 mSv) that recommended by ICRP . Also there is no any difference between effective dose of male brain and female brain according to differences at anatomical structure of brain.(Musab,2006)

In this study by Khalid Alzimami (2014) calculated effective dose of CT scanner on brain at Nilien Medical Diagnostic Center on Sudan .This study performed on study group about (102 patient) .He found that the effective dose (2.05mSv) (Khalid , 2014)

In other study by Ralaph Marcus etal (2008) calculated effective dose of CT scanner on brain at San Francisco Bay Area Institution in California .This study performed on (1119 patient) .They found that the effective dose (2 mSv)(Marcus,2008)

In other study by Ernest K.Ossei…etal (2012) calculated effective dose ofCT scanner on brain at Department of physics and Astronomy ,Universityof waterloo on Canada . This study performed on study group about (94 patient) . They found that the effective dose (1.45 mSv) (K.Ossei,2012).

In other study by N.H.bert etal (2000) calculated effective dose of CT scanner on brain at Department of radiodiagnosis ,Christian Medical Collage on India . This study performed on study group about (101patient). They found that the effective dose (0.061 mSv)

Chapter three

3. Material and methods

3.1 Material :

3.1.1. Study Group (Population) :

The study group consist of 60cases (30 males and 30 females). This group with age ranging from (15y to 80y) ,check up for CT brain

3.1.2 Inclusion and Exclusion criteria:

All patient check up for ct brain not need IV contrast were included

3.1.3. Machine used :

Asteion Toshiba 4 slices(the Asteion has flexible options for speed and accuracy of the scan)

Features;

,0.75 second per rotation, tilted helical up to 30 and sure scan real time helical scanning at 12 frames-second,4x0.5mm slice thickness, matrixes,pixels;12808 *1024

3.2. Method :

3.2.1Examination technique

3.2.1.1 Patient preparation:

All metallic object were removed from the head to be studied (earning, pins and ,necklaces), no patient motion

3.2.1.2 Patient position:

Supine , Arms along the side of the body and head immobilized in the head holder

3.2.1.3 Technique:

Brain CT head first used KVP 120,slice thickens 5mm

3.2.1.3.1Scout: lateral

3.2.1.3.2 Start location and end:

from foramen magnum to vertex

3.2.1.3.3 Slice plane

Axial

3.2.1.3.4 IV contrast:

none

3.2.2.Data collection:

Data were collected using a sheet for all patients in order to maintain consistency of the information from display (Appendix).A data collection sheet was designed to evaluate the patient doses and the radiation related factor. ,at this study assessed radiation dose by calculated effective dose .effective dose [ED] equal Dose Length Product(DLP) multiply by brain conversion factor .

3.2.3 Data analysis

Microsoft Excel and SPSS program were used to analyze the data of this study

Chapter four

Results

Table (4.1):Participants distribution with Respect to age:

Age	**Frequency**	**Percent**
15-20 years	35	58.3
20-30 years	7	11.7
31-40 years	5	8.3
41-50 years	4	6.7
More than 50 years	9	15.0
Total	60	100.0

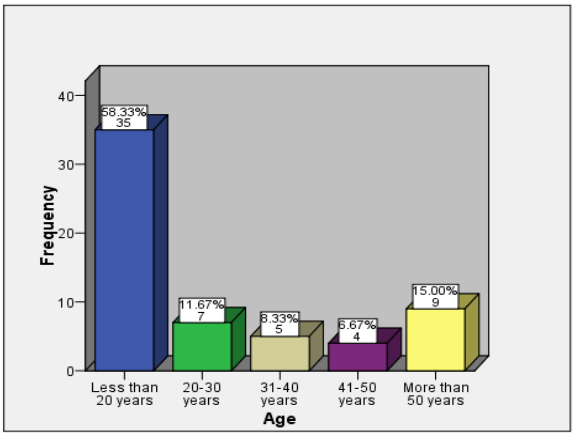


Figure (4.1): Participants distribution with Respect to age

Table (4.2): distribution of ERD according to Mean and standard deviation:

	Mean	Std. Deviation
mAS	4845.7	2064.12352
ERD	1.8776	1.19725

Table (4.3): Mean (ERD) for two groups (Male50% and Female 50%):

	Sex	Mean	Std. Deviation	Std. Error Mean
ERD	Male	1.9601	1.08007	0.19719
	Female	1.7952	1.31742	0.24053

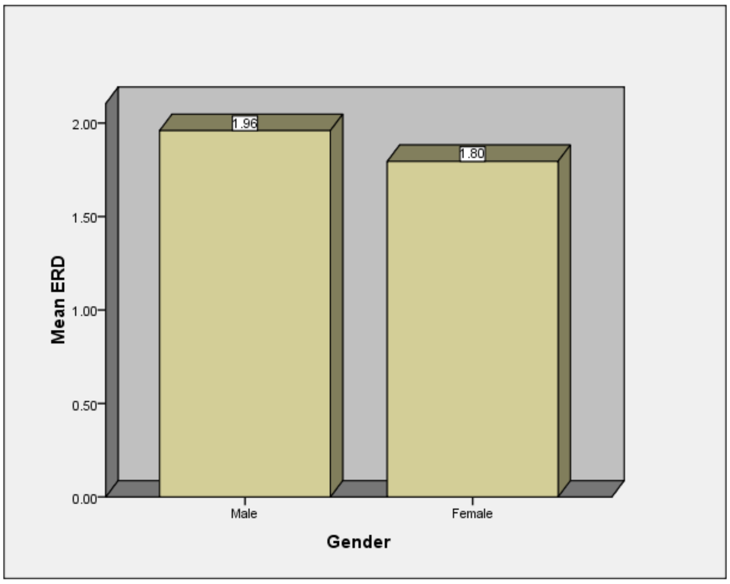


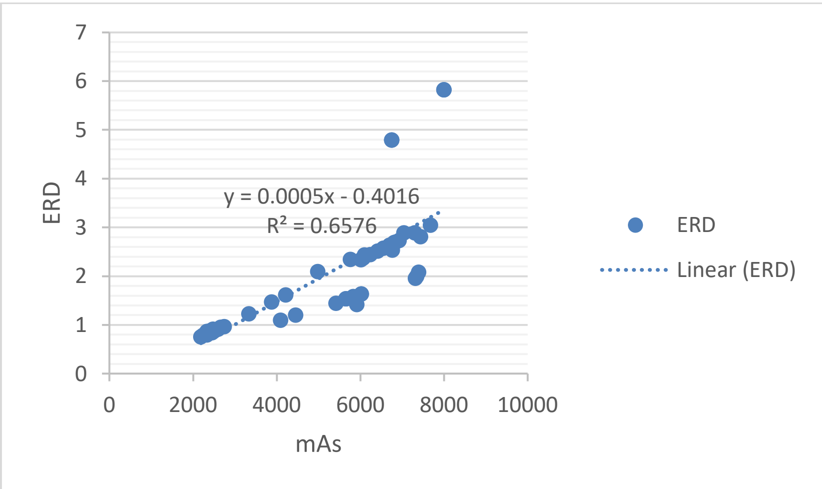
Figure (4.3): Mean (ERD) for two groups (Male and Female)

Table (4.4): t-test for Equality of Means of two groups (Male and Female):

	t-test for Equality of Means				
	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
ERD	0.530	58	0.598	0.16490	0.31103

Table (4.5): Measure of patient's mAs to ERD:(R saqure)

R	R Square	Std. Error of the Estimate
0.811	0.652	0.70655



Figure(4.5):the linear relationship between ERD and mAs:

Table (4.6): Model coefficients test: for mAs

Model	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	-0.402	0.234	-1.713	0.092
mAs	0.0005	0.0003	10.555	0.000

Chapter five

5.1.Discussion:

The data of this research were collected from 60 patient different age ranges show in the table and figure (4-1).

In this study the effective radiation dose of brain in IBN ALhaitham Diagnostic Center is measure equal (1.8776) This value is suitable according to international Commission Of Radiation Protection show in table (4.2) this the same result as (Musab, 2016) and (Khalid, 2014) and (Ernest , 2012).

In This Study according to gender we found no different between male and female by used descriptive statistics for the two groups that compared, including the mean and standard deviation show in table and figure (4-3), this is symmetrical result as (Musab, 2016). ,Also used t-test results for further more demonstrated we found not significantly different because the value in the "**Sig. (2-tailed) = 0.598**" is more than 0.05. Looking at the table (4-4),we can conclude that there is no statistically significant difference between the mean ERD for males and females.

In this study we found proportional relation between effective radiation dose and mAs show in the table (4-5) by used R and R^2 values, The R value represents the simple correlation is 0.811 (the "R" Column), which indicates a strong degree of correlation between patient’s ERD and their mAS. The R^2 value (the "R Square" column) indicates how much of the total variation in the ERD, can be explained by the person mAS. In this case, mAS participates by 65.2% of total variation in the ERD,this result agree with (Musab ,2016).

Furthermore, we can used the linear relation ship between effective radiation dose and mAs show in figure (4-5).

Also for furthermore we used Model coefficients test used for determine whether mAs contributes statistically significantly to the effective radiation dose ("**Sig.**" = 0.000< 0.05) which indicates that statistically significant correlation between ERD and mAS. Furthermore, we can use the values in the "**B**" column (ERS is -0.402±0.234,while it increases 0.0004±0.0003 per one unit in mAS show in the table (4-6).

5.2. Conclusion:

This study intended to measure effective radiation dose of brain in IBN ALHAITHAM DIGNOSTIC CENTER is suitable compared to ICRP

In this study no different between effective dose of male brain and female brain according to differences in anatomical structure of brain

the effective radiation dose has proportional relation with mAs.

5.3.Recommendation :

- Clear justification of examinations is highly recommended.

- Avoid repeating of examination is important.

- Limitation of scan length.

-Further studies are highly encouraged in this field with larger samples and different CT modalities to improve the performance and minimize the radiation hazards.

-CT machines should be available at each radiology department .

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Appendix:

Data collection sheet:

Pt No	Age	Gender	CTDIvol	DLP	KVp	mAs	ERD

Table (2) Correlation Between MAs And ERD.

PT NO	Total MAS	ERD
1	7399	2.08068
2	5835	1.58109
3	2441	0.85638
4	2410	0.87633
5	2413	0.83937
6	6706	2.63235
7	6555	2.56893
8	2333	0.79233
9	5662	1.53468
10	5420	1.44123
11	7355	1.995
12	6772	2.53491
13	2481	0.85638
14	2347	0.84042
15	2441	0.85638
16	7326	1.95638
17	2189	0.7542
18	8002	5.81931

19	2246	0.78603
20	6242	2.44209
21	3884	1.46853
22	6416	2.51034
23	7680	3.04479
24	6020	2.33289
25	4460	1.19973
26	5769	2.34213
27	7044	2.88603
28	6753	4.78695
29	6075	2.36607
30	2425	0.85638
31	6930	2.72748
32	6815	2.68632
33	2482	0.90909
34	6753	4.7895
35	7305	2.88603
36	2667	0.94941
37	2457	0.83622
38	4095	1.0962
39	2286	0.79653
40	6032	1.63128
41	6032	1.63128
42	3342	1.22745
43	4222	1.61322
44	5923	1.41519
45	7445	2.806
46	4990	2.09538
47	6706	2.63235
48	2325	0.82299
49	6802	2.67372
50	6848	2.6943
51	2524	0.87633
52	2338	0.86541
53	5663	1.53468
54	2751	0.96201
55	2413	0.83937
56	6105	2.43033
57	8002	5.81931
58	2601	0.90909
59	2434	0.83916
60	2350	0.82362

Table (4.7): Measure of patient's mAs to ERD:

R	R Square	Std. Error of the Estimate
0.811	0.652	0.70655

This table provides the R and R2 values. The R value represents the simple correlation is 0.811 (the "R" Column), which indicates a strong degree of correlation between patient's ERD and their mAs. The R2 value (the "R Square" column) indicates how much of the total variation in the ERD, can be explained by the person mAs. In this case, mAs participates