بسم الله الرحمن الرحيم

Sudan University for Science and Technology

College of Graduate Studies

Evaluation of the Head CT Findings Compare to Clinical Diagnosis in Sudanese Children

تقويم نتائج التصوير المقطعي لرأس الأطفال السودانيين مقارنة مع التشخيص السريري

A Thesis Submitted, for a Partial Fulfillment of the Requirement of the M.Sc Degree in Diagnostic Radiology

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الآيـــــة

قال الله تعالى:

بسم الله الرحمن الرحيم

(وَمَنْ أَحْسَنُ قَوْلاً مِّمَّن دَعَاإِلَى الله وَعَمِلَ صَالِـحًا وَقَالَإِنَّنِي
مِنَ الْـمُسْلِمِينَ (٣٣) وَ لَا تَسْتَوِي الْحَسَنَةُ وَ لَا الْسَّيِّئَةُ ادْفَعْ
بِالَّتِي هِيَ أَحْسَنُ فَإِذَا الَّذِي بَيْنَكَ وَ بَيْنَهُ عَدَاوَةٌ كَأَنَّهُ وَلِيٌّ حَمِيمٌ
(٣٤))

(سورة فصلت:٣٣– ٣٤)

Dedication

Every Challenging work needs self efforts as well as guidance of elders especially those who were very close to our heart. My humble effort I dedicate to my sweet and loving

Parents, Brother and sister,

Whose affection, love, encouragement and prays of day and night make me able to get such success and honor.

Along with all hard working and respected: Teachers.

With whom I share the journey of Life: MY Friends.

To my colleagues and All who help and support me.

Acknowledgment

I would like to thank Allah for enabling me to complete this thesis; I thank Dr. Ikhlas Abdelaziz Hassan my supervisor of my thesis for his guidance and patience and I would like to express my gratitude to my colleagues and to the whole staff of Khartoum and Algazira states Hospitals for their great help and support. Finally I greatly thank all those who supported and help me to complete this thesis.

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List of abbreviations

CT	Computed Tomography
US	United states of America
ciTBi	Clinically-important traumatic brain injury
mGy	milliGray
CSF	Cerebrospinal fluids
CNS	Central nervous system
MS	Multiple sclerosis
MRI	Magnetic resonance imaging
mm	millimeter
CRT	Cathode Ray Tube
Kv	kilovolt
mAs	Milliamper second
IV	Intravenous
EAM	External auditory meatus
C1	First cervical vertebra
ICI	Intracranial injury
KAUH	King Abdulaziz University Hospital
NICE	National institute for health and care excellence

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Abstract

A descriptive study was performed in Sudanese hospitals and medical centers during the period from July 2016 – March 2017.

The aim of the study was to evaluate the head CT findings and clinical diagnosis in Sudanese children.

The study applied for all children patients whom examined clinically and by CT scan to diagnose head cases which were 81 patients.

The data was collected, classified, analyzed by using computerized statistics procedure (Excel).

The analysis of the results found that the male patients were dominant (55.6%) while females were (44.4%) and most effected age group was 1-5 years (35.9%). And most of the patients were outpatient (84.09%).

The most common head clinical diagnosis for children of the sample showed that (28.4%) of the patients had intracranial hemorrhage (ICH), which the trauma was indicated to it and also hydrocephalus had same percentage (28.4%). Also study showed the normal CT findings of the sample were (45.7%) while abnormal was (54.3%).

The high percentages of radiological findings for head CT did not confirm the clinical diagnosis which the compatibility of head CT findings with clinical diagnosis was (48.1%), while the incompatible was (51.9%).

The study concluded that most head CT done for children were not justification as well as there were more head CT findings not confirmed the clinical diagnosis, although the head CT may be significant in most of the cases. Hence, there is a big concern about the increasing requests for unnecessary head CT.

ملخص الدراسة

هذه الدراسة وصفية، أجريت في عدة مستشفيات و مراكز طبية بالسودان، خلال الفترة من يوليو ٢٠١٦ و حتى مارس ٢٠١٧.

هَدُفَت هذه الدراسة إلى تقييم نتائج التشخيص السريري للدماغ مقارنة مع نتائج التصوير المقطعي في الأطفال السودانيين، و طُبِّقت هذه الدراسة على كل المرضى الأطفال اللذين فحصوا سريريا وكذلك عن طريق التصوير المقطعي لتشخيص حالات الدماغ والذي بلغ عددهم ٨١ مريضا.

تمّ جمع البيانات وتصنيفها و تحليلها بواسطة برنامج التحليل الاحصائي (إكسل)، ووجدت نتائج تحليل هذه الدراسة أن المرضى الذكور بلغوا نسبة (٥٥.٦٪)، بينما كانت نسبة الإناث (٤٤.٤٪)، وأكثر الفئات العمرية إصابة هي (١-٥) سنة ويمثلون (٥٣.٩٪)، كما أن معظم الحالات كانت من العيادات الخارجية بنسبة (٨٤.٠٩٪).

أوضحت الدراسة أن التشخيص السريري الأكثر شيوعا لدى الأطفال هو النزيف داخل الجمجمة بنسبة (٢٨.٤٪)والتي تعتبر الصدمات إحدى دلائله و مؤشراته، وكذلك الاستسقاء الدماغي والذي له نفس النسبة (٢٨.٤٪)، أيضا أوضحت الدراسة أن نتائج التصوير المقطعي للحالات الطبيعية بنسبة (٤٥.٧٪) بينما الحالات الغير طبيعية بنسبة (٥٤.٣٪) .

نسبة عالية جدا من نتائج فحص التصوير المقطعي للدماغ لم تؤكد التشخيص السريري والذي كان فيه نسبة التطابق بينهم بنسبة (٤٨.١٪) بينما نسبة عدم التطابق كانت (٥١.٩٪).

خَلُصَت هذه الدراسة الى أن معظم فحوصات التصوير المقطعي التي أُجريت للأطفال كانت غير مبررة؛ و ذلك لأن كثيرا منها لم تؤكد التشخيص السريري. فبالتالي، هنالك قلق كبير بشأن كثرة طلب فحوصات التصوير المقطعي للدماغ التي لا حوجة لها.

Chapter one

Introduction

Chapter one

1.1 Introduction:

Children computed tomography (CT) utilization has increased over the last two decades. CT has brought significant changes in the diagnosis of diseases (Miglioretti, et.al, 2013).

Since the advert of CT into clinical practice in 1973 [1], there has been an exponential increase in the number of CT scanners and the frequency of CT examinations (Elkhadir,et.al, 2016).

In 2011, 85 million CTs were performed in the US, with5-11% on children. While CT has greatly improved diagnostic capabilities, its use comes with risks. The ionizing radiation doses delivered by CT are 100-500 times higher than conventional radiography and are in ranges linked to increased cancer risk (Preston, et.al. 2007).

This is especially concerning for children, who are more sensitive to radiation-induced carcinogenesis and have many remaining years of life for cancer to develop (Miglioretti, et.al, 2013).

A major drawback of CT is the use of ionizing radiation and consequently, the risks of radiation-induced side effects (Solvis, 2002) and (Berrington, et.al, 2009). Of these side effects, the induction of cancer is the most important. This is especially true in children because rapidly dividing cells are more sensitive to radiation, the tissues of children are up to 10 times more radiosensitive than those of adults. CT is frequently used in children to look for clinically-important traumatic brain injury (ciTBi). There is a body of research showing the potential deleterious effects of medical radiation exposure to children, especially radiation to the brain. Multiple clinical decision rules were developed to attempt to identify children at low risk for intracranial injury following blunt head trauma as a way to avoid unnecessary radiation. Yet, the indications for CT in these children remained controversial (Elkhadir,et.al, 2016).

A recent study on June 6, 2012 showed radiation exposure from two or three head CT scans in childhood giving a cumulative dose of around 60 mGy can triple the risk of developing brain cancer, while five to 10 such scans (cumulative dose around 50 mGy) may triple the risk of developing leukemia, according to a major study published online June 7 in Lancet (websitehttp://www.auntminnie.com/index.aspx)

This is an exploration to understand the request form of the head CT of children in the diagnostic radiology departments, Sudan. The purpose of this study is to evaluate the clinical diagnosis of head CT and CT findings.

1.2 The problem of study:

A vast gap between the clinical diagnosis and CT Findings and to asses radiology request forms.

1.3 Significance of the study

This study is important to quantify the degree to which clinical and radiological diagnosis may differ in a consecutive series of patients with Children Head CT requests.

1.4 Objectives

1.4.1 General Objective

To evaluate the Head CT Findings Compare to Clinical Diagnosis in Sudanese Children

1.4.2 Specific objectives:

This research aimed to quantify the degree to which radiological and clinical findings may differ, also to identify the demand of requesting head CT for children and to ensure the selection of the most appropriate diagnostic procedure which avoid children from the risk of unnecessary exposure and wasting the time of the patient.

1.5 Overview of study

This study consists of five chapters are: Chapter one: introduction, problem and objectives, Chapter two: theoretical background and literature review, Chapter three: materials and methods, Chapter four: the results and Chapter five: discussion, conclusions and recommendations.

References.

Appendices.

Chapter Two

Theoretical Background and Literature Review

Chapter two

Literature review

2.1. Anatomy of the brain

The brain consists of many parts that function as an integrated whole. The major parts are the cerebrum, the cerebellum, brain stem (medulla, pons and midbrain) the hypothalamus, the thalamus and the ventricular system. All this parts interconnected and work together (Scanlon, 2007).

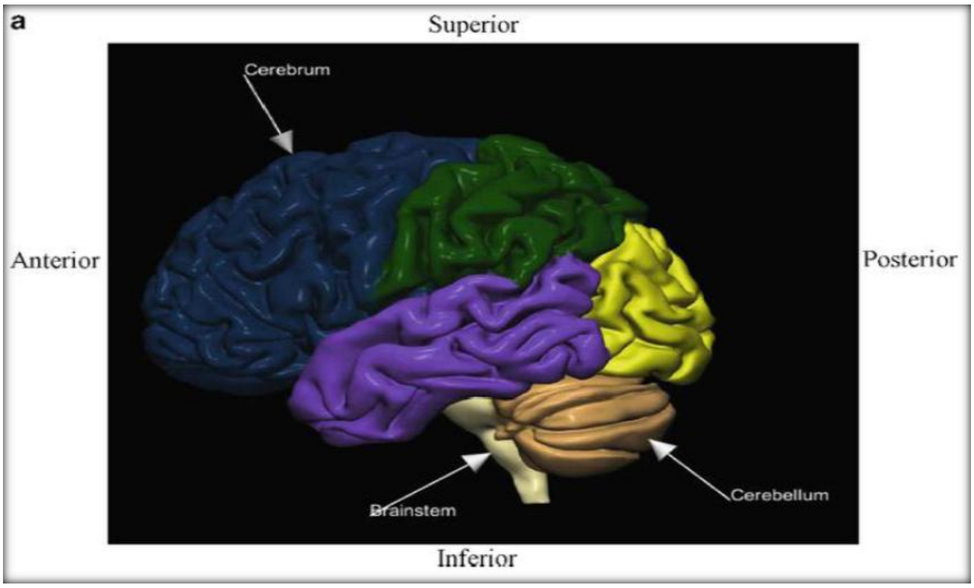


Fig (2.1) shows the major parts of the brain (Nowinski, 2011).

2.1.1 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 myelinated axons 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 (Scanlon, 2007).

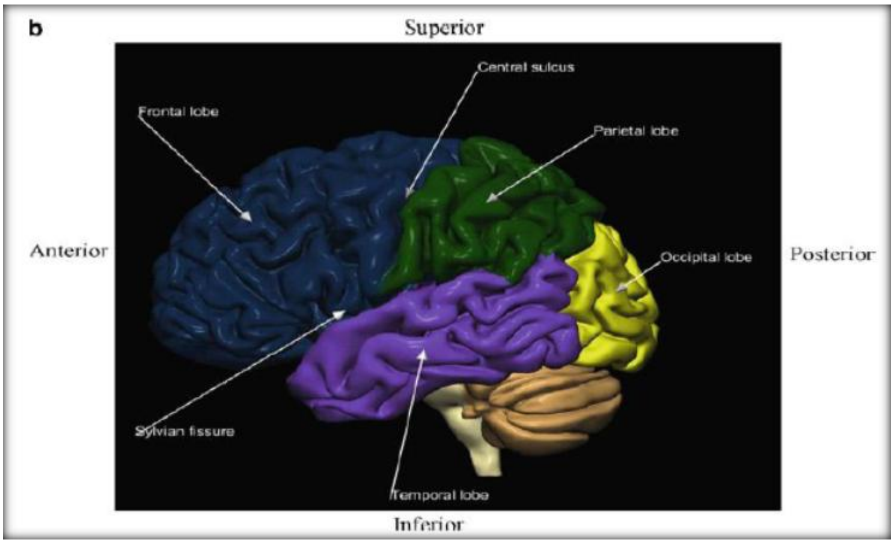


Fig (2.2) shows the brain lobes (Nowinski, 2011).

2.1.1.1 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 precentral gyrus, consists of the primary motor area and is bordered anteriorly by the precentral sulcus and posteriorly by the central sulcus.

The region of the frontal lobe located anterior to the precentral sulcus is subdivided into the superior, middle, and inferior frontal gyri. This subdivision is due to the presence, though inconsistent, of two longitudinally disposed sulci, the superior and inferior frontal sulci. The inferior frontal gyrus is demarcated by extensions of the lateral fissure into three sub-regions: 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 arched cingulate sulcus, which forms the boundary of the superior aspect of the cingulate gyrus.

The quadrangular-shaped cortical tissue anterior to the centralsulcus is a continuation of the precentral gyrus and is known as the anterior paracentral lobule (Maria and Leslie, 2006).

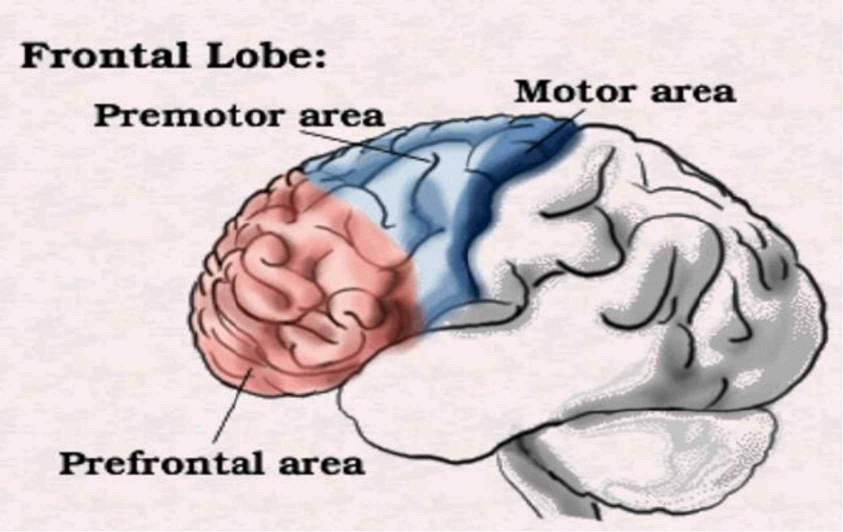


Fig (2.3) demonstrates the anatomy of the frontal lobe (website http://www.waiting.com/frontallobe.html)

2.1.1.2 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 intraparietal 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 marginal gyrus, 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.

2.1.1.3 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 temporal sulcus that is interposed between the inferior temporal gyrus and the lateral occipitotemporal gyrus (fusiform gyrus). The collateral sulcus separates the fusiform gyrus from the parahippocampal gyrus of the limbic lobe (Maria and Leslie, 2006).

2.1.1.4 Occipital 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 (calcarine cortex), and forms the primary visual cortex.

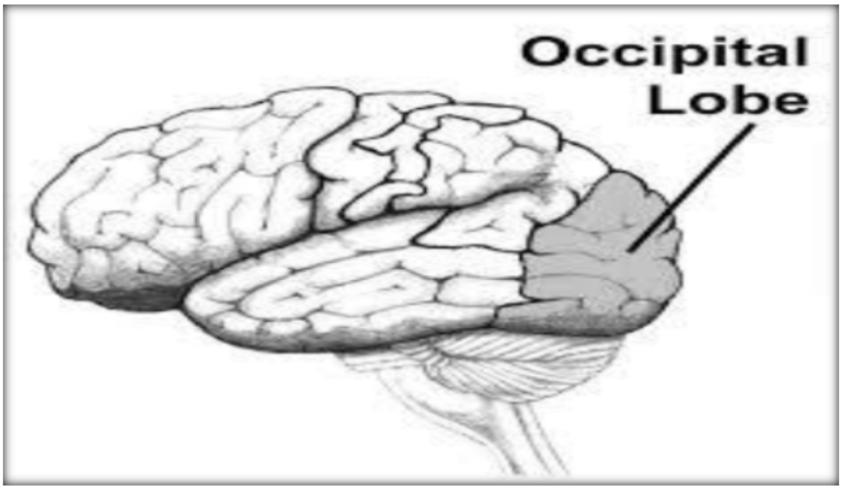


Fig (2.4) demonstrates the occipital lobe (website http://www.pinterest.com).

2.1.1.5 Limbic lobe:

The limbic lobe is a complex region and includes the cingulate gyrus, parahippocampal gyrus, hippocampal formation, subcallosal gyrus, parolfactorygyrus, and the preterminal gyrus.

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 cingulated gyrus is located above the corpus callosum and is separated from it by the callossal sulcus. As the cingulate gyrus continues posteriorly, 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 parahippocampal gyrus whose anteriormost extent is known as the uncus.

Above the parahippocampal gyrus is the hippocampal sulcus, which separates the parahippocampal gyrus from the hippocampal formation (composed of the hippocampus, subiculum, and dentate gyrus). Just beneath the rostrum of the corpus callosum is the subcallosal gyrus. The connection between the anterior commissure and the optic chiasma is the lamina terminalis and the cortical tissue anterior to the lamina terminalis is the parolfactory gyrus and preterminal gyrus.

The subcallosal, parolfactory, and preterminal gyri are referred to as the subcallosal area (Maria and Leslie, 2006).

2.1.2 Ventricles

The ventricles are four cavities within the brain: two lateral ventricles, the third ventricle, and the fourth ventricle each ventricle contains a capillary net work called a choroid plexus, which forms cerebrospinal fluid (CSF) from blood plasma. Cerebrospinal fluid is the tissue fluid of the central nervous system.

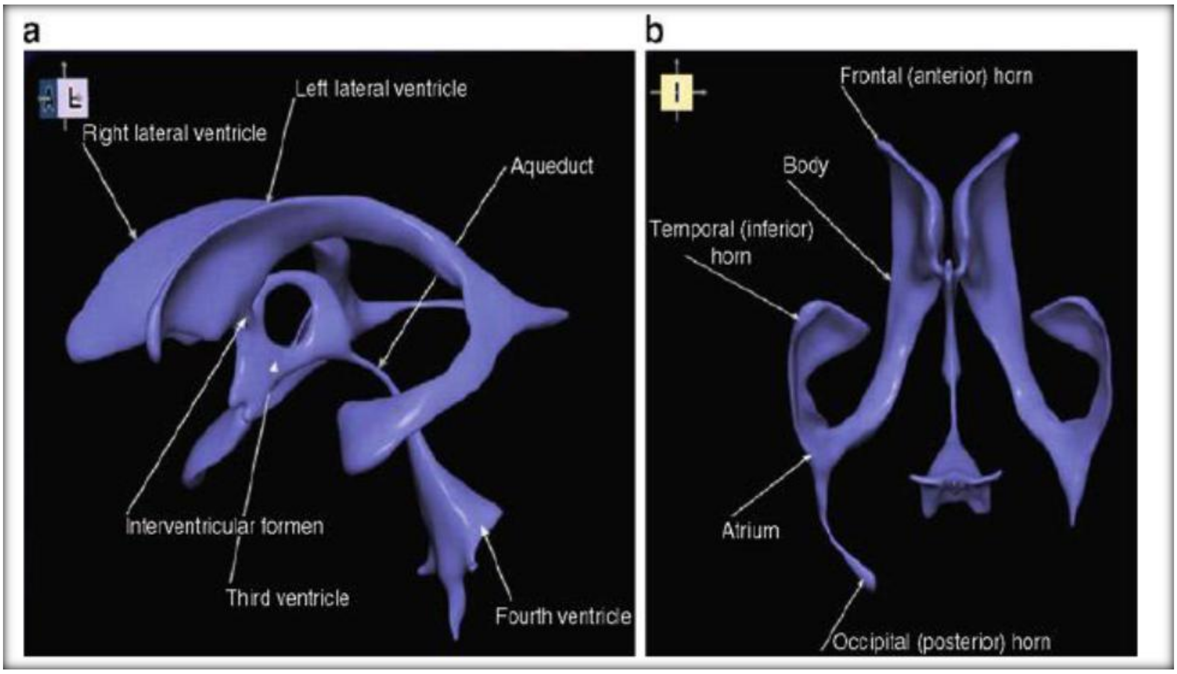


Fig (2.5) shows the ventricular system (Nowinski, 2011).

2.1.3 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 a horizontal 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 betweenthe 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 midsagittal 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 a three-layered structure, the outermost molecular layer, the middle 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 capillaries 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, emboliform, and globose nuclei.

The connections between the cortical regions 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).

2.1.4 The brain stem:

The brain stem is composed of medulla, pons and midbrain

2.1.4.1 Medulla:

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

2.1.4.2 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 a normal 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.

2.1.4.3 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 (Scanlon, 2007).

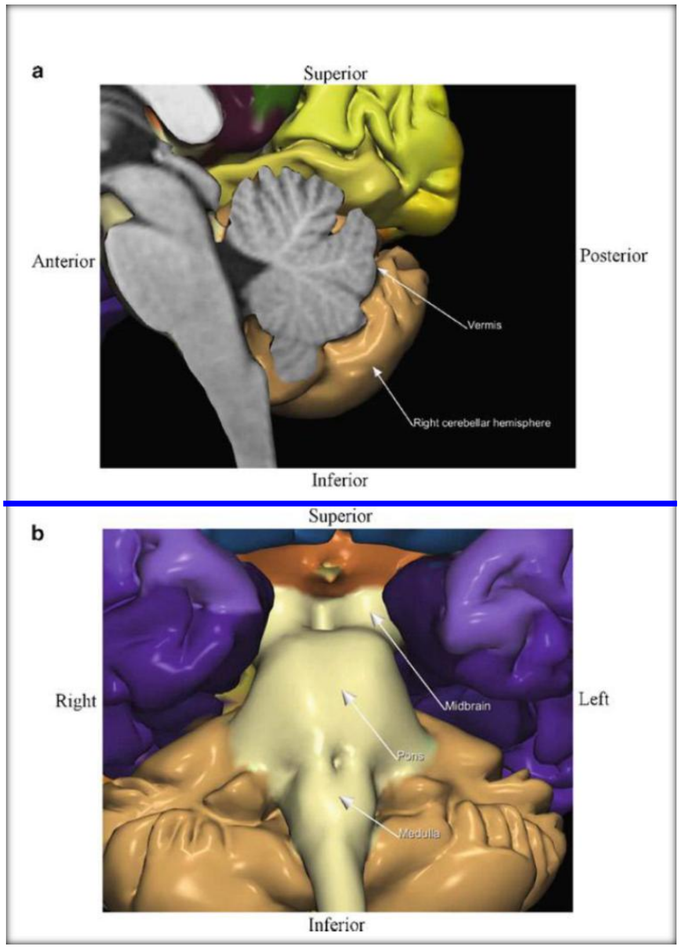


Fig (2.6) cerebellum and brain stem (Nowinski, 2011).

2.1.5 Hypothalamus

Located superior to the pituitary gland and inferior to the thalamus, the hypothalamus is a small area of the brain with many diverse functions

2.1.6 Thalamus

The thalamus is superior to the hypothalamus and inferior to the cerebrum. The third ventricle is a narrow cavity that passes through both the thalamus and hypothalamus.

2.1.7 Basal Ganglia

The basal ganglia, called ganglia even though they are nuclei, are large collections of cell bodies that are embedded deep in the white matter of the brain.

These soma include those deep nuclei of the brain and brainstem which, when damaged, produce movement disorders. Thus the basal ganglia are composed of the caudate nucleus, lenticular nucleus (putamen and globus pallidus), subthalamic nucleus of the ventral thalamus, and the substantia nigra of the mesencephalon (the caudate nucleus and the putamen together are referred to as the striatum).

These nuclei have numerous connections with various regions of the CNS; some receive input and are categorized as input nuclei, some project to other regions and are referred to as output nuclei, whereas some receive input, project to other regions of the CNS, and have local interconnections and these are known as intrinsic nuclei (Maria and Leslie, 2006).

2.2 Physiology of the brain

The brain is found in the cranial cavity. Within it are found the higher nerve centers 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).

2.2.1 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 a bundle 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 (Wiki books Contributors, 2007).

2.2.2 Cerebellum:

The cerebellum is the part of the brain that is located posterior to the medulla oblongata and pons. It coordinates skeletal muscles to produce smooth, graceful motions. 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.

2.2.3 Medulla:

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

2.2.4 Pons:

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

2.2.5The 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 hippocampus, and the cingulate Gyrus (Wiki books Contributors, 2007).

2.3Brain pathology

2.3.1 Neurodegenerative disorders:

Neurodegenerative disorders must be distinguished from normal aging. The neurodegenerative disorders are characterized by loss of functionally related groups of neurons anatomically. **Examples are as follows:** Alzheimer‘s disease, frontotemporal dementia, Parkinson‘s disease, amyotrophic lateral sclerosis, diffuse Lewy body disease (Fung, 2006).

2.3.2 Intracranial hemorrhage:

Intracranial hemorrhage (ie, the pathological accumulation of blood within the cranial valut) may occur within parenchyma or the surrounding meningeal spaces. Hemorrhage within the meninges or the associated potential spaces, including intracerebral hematoma, intraventricular hemorrhage, subarachnoid hemorrhage, subdural hematoma and epidural hematoma (El-Naggar, 2000).

2.3.3 Intracranial calcification:

Is common in certain locations there including: Suprasellar calcification, periventricular calcification and diffuse calcification, and often are of no clinical concern (El-Naggar, 2000)

2.3.4 CNS infections:

Infection of the nervous system can involve the meninges (Meningitis) or the brain substance itself (Encephalitis) and Brain abscess which is collection of pus, immune cells, and other material in the brain, usually from a bacterial or fungal infection (El-Naggar, 2000)

2.3.5 Brain tumors:

Are masses of tissues which formed by an accumulation of abnormal cells which emerge from the various cells that make up the brain and central nervous system and are named for the kind of cell in which they first form and they have locations as Infratentorial tumours and supratentorial tuomours (El-Naggar, 2000).

2.3.6 Hydrocephalus:

Hydrocephalus has two types: Congenital hydrocephalus and acquired hydrocephalus (El-Naggar, 2000).

2.3.7 Cranial lesions:

A lesion is an area of tissue that has been damaged through injury or disease within cranial such as skull fractures and cephalohematoma (El-Naggar, 2000).

2.3.8 Brain atrophy:

Is shrinking of the brain caused by the loss of its cells, called neurons. Two types of brain atrophy can occur; localized atrophy and generalized atrophy (El-Naggar, 2000).

2.3.9 Demyelinating disease:

A demyelinating disease is any condition that results in damage to the protective covering (myelin sheath) that surrounds nerve fibres in brain and spinal cord and some common forms are; multiple Sclerosis (MS) Characteristic: A chronic, often relapsing, demyelinating disease which classified as primary demyelinating disease. And inflammatory demyelinating pseudotumour (Fung, 2006).

2.4 Computed tomography (CT) investigation

2.4.1 Definition:

Computed tomography (CT) is a medical imaging method employing tomography and digital geometry processing, it use constant three – dimensional image of the inside of an object from a large series of two-dimensional x-ray images taken a round a single axis of rotation (Serum).

The primary purpose of CT is to produce a tow-dimensional representation of the linear x-ray attenuation coefficient distribution through a narrow planner cross section of the human body. The resultant image delineates various structures within the body, showing the relative anatomic relationship (Gasmo, 1992).

2.4.2 Physical Principle of CT scanning:

The physical principle of the CT includes the three processes referred to as; Data acquisition, data processing and image display (Gasmo, 1992).

2.4.2.1 Data acquisition:

Refer to systemic collection of information from the patient to produce the CT image. The two method of data acquisition are slice-by-slice data acquisition and volume data acquisition (Gasmo, 1992).

In conventional slice-by-slice data acquisition, data are collected through different beam geometries to scan the patient. Essentially, the x-ray tube rotates round the patient and collects data from the first slice. The tube stops and the patient moves into position to scan next slice. This process continues until all slices have been individually scanned.

In volume data acquisition, special beam geometry referred to as spiral or helical geometry is used to scan a volume of tissue rather than one slice at a time. In spiral or helical CT, the x-ray tube rotates around the patient and traces a spiral/ helical path scan an entire volume tissue while the patient holds a single breath. This method generates a single slice per one revolution of the x-ray tube. More recently, multi-slice spiral / helical CT has become available for faster imaging patients. It generates multiple slices per one revolution of the x-ray tube (Gasmo, 1992).

2.4.2.2 Data processing:

Essentially constitutes the mathematical principles involved in CT. Data processing is a three-step process. First, the raw data undergo some form of pre-processing, in which corrections are made and some reformatting of data occurs. This is necessary to facilitate the next step in data processing, image reconstruction. In this step, the scan data, which represent attenuation readings converted into a digital image characterized by CT number. The final step is image storage of the reconstructed digital image. This image is held in a disk memory is a short-term storage (Gasmo, 1992).

2.4.2.3 Image display:

It is final process. After the CT image has been reconstructed, it exits the computer in digital form. The must be converted to a form that is suitable for viewing and meaningful to the observer. In CT the digital reconstructed image is converted into a gray scale image for interpretation by the radiologist. Because a diagnosis is made from this image, it is important to present this image in a way that facilitates diagnosis (Gasmo, 1992).

Display device: the gray scale image is display on a cathode ray tube (CRT), or television monitor, which is an essential component of the control or viewing console. In some scanner there are two monitors, one for text information and one for images (Gasmo, 1992).

The instrumentation: a modern CT facility consists of: A scanning gantry that includes the collimated x-ray source, the detectors, the computer for data acquisition, the image reconstruction system, Motorized patient – handling table and the CT viewing console.

The major technical difference between various commercial scanners lies in the gantry design and the number and type of x-ray detectors used (Gasmo, 1992).

Figure 2.7: shows CT scanner components (Mohammed, 2016)

The Advantages of CT:

The Advantages of CT include: it has capacity to image material ranging from air to metal, it is used as a guide in taking biopsy of the lesion demonstrated by other imaging technique and CT images have high contrast resolution which can easily demonstrate the brain tissue and the ventricular system and any other brain lesion (Gasmo, 1992).

The disadvantages of CT:

The disadvantages of CT include: Long exposure time, the x-ray has serious effects in early pregnancy and it is less available (Gasmo, 1992).

2.5 The Previous studies:

Elkhadir,et.al. (2016) studied the CT Brain in Children: Evaluation of the Clinical and Radiological Findings, The purpose of the study is to evaluate the situation of requesting CT brain versus the reporting findings. A retrospective study was carried out in the Department of Radiology, KAUH between 1 January and 31 December 2012. There were 417 children scanned by CT for brain, their data were reviewed and analyzed from radiology records to form the sample of the study. The study revealed that high percentages of radiological findings for CT brain did not confirm the clinical diagnosis. The percentages of such cases which observed in the three departments of emergency, inpatient and outpatient were 68.4%, 53.6% and 49.4% respectively. This result shows that a percentage of children were given unnecessary exposure to radiation among those who received CT brain from the radiology department in KAUH. From the study, it is concluded that most brain CT done for children were not justification as well as there were more brain CT findings not confirmed the clinical diagnosis, although the brain CT may be significant in most of the cases. Hence, there is a big concern about the increasing requests for unnecessary brain CT. Therefore, the pediatricians should be more careful in requesting of brain CT unless it is indispensible.

Zeeb, et.al. (2012) studied the Paediatric CT scan usage and referrals of children to computed tomography in Germany-a cross-sectional survey of medical practice and awareness of radiation related health risks among physicians, The purpose of a cross-sectional survey among office-based physicians in Germany was the assessment of medical practice in paediatric CT referrals and to investigate physicians' knowledge of radiation doses and potential health risks of radiation exposure from CT in children, A total of 295 (36.4%) physicians responded. 59% of the doctors had not referred a child to CT in the past year, and approximately 30% referred only 1-5 children annually. The most frequent indications for a CT examination in children were trauma or a suspected cancer. 42% of the referrals were related to minor diagnoses or unspecific symptoms. The participants underestimated the radiation exposure due to CT and they overestimated the radiation exposure due to conventional X-ray examinations.

The National Institute for Health and Care Excellence (2014) studied the Triage, assessment, investigation and early management of head injury in children, young people and adults, an important clinical guideline 176 rather to pediatricians to read and follow it carefully before ordering any CT examinations to the children.

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Materials

3.1.1 Study population

The study population was composed of 81 Children patients with head examination requests presenting to the CT departments in Sudanese centers and hospitals and data of this study was collected from July 2016 to March 2017.

3.1.2 CT machine

The study was executed using multi-detector computed tomography scanner Toshiba (Aquilion 64), Neusoft (NeuViz 128) and GE and followed CT protocols were:

Table feed 10-14 mm/rotation.

Effective tube current 180-225 mAs at 100-120 kV.

Pitch = 0.6 mm Detector collimation = 0.5x 32

Average scan time = 0.7s. (Appendix A and B)

3.2 Methods

3.2.1 Routine Children Head technique used:

Without contrast and also acquired after IV contrast administration (3ml/kg of iodinated contrast media is given I.V with a maximum dose of 120ml).

3.2.1.1. Patient preparation:

The technologist explained procedure to the patient briefly before examination.

All metallic objects were removed from the area under examination, including such items as earrings, hair pins and necklaces.

If the patient was comfortable on the table, the result was less motion and therefore less degradation of image quality.

3.2.1.2. Patient Position:

Patient should be supine, head first into the gantry, with the head in the head-holder whenever possible.

Center the table height such that the external auditory meatus (EAM) is at the center of the gantry.

3.2.1.3. Scan Range:

Top of C1 lamina through top of calvarium.

3.2.1.4. Scanning protocol:

Scanning protocol was established to include information such as pt position, pre-scan localization (scout view), scan range, slice thickness, spacing and MA values (Appendix B).

This was intended to assist the technologist performed the CT examination and generally helped increase the efficiency of the examination.

The axial plane used for brain imaging. The plane of the scans was based on the anthropologic baseline, which joins the infra-orbital point anteriorly to the posterior border of the external auditory meatus (EAM), better cross-sectional images of the orbits, cella turica temporal lobes, ventricular system and brain stem were obtained than a more steeply angled plane. Slice thickness of 10 mm was used, although often many site used 2-1 mm slice to improve spatial resolution (American Association of physicists in Medicine, 2015).

3.2.2 Data collection and analysis

A special data collection sheet was designed by the author. The inclusion criteria of the study variables that were age, gender, clinical diagnosis finding, CT findings and diagnosis evaluation and location of examination (Appendix A).

And analyzed by using Excel program, the results were presented in form of tables and graphs.

3.2.3 Image interpretation:

The images were interpreted by three qualified radiologist.

3.3 Ethical considerations

The Ethical considerations which followed in this thesis were; no identification or individual details will be published and no information or patient details will be disclosed or used for reasons other than the study.

Chapter Four

Results

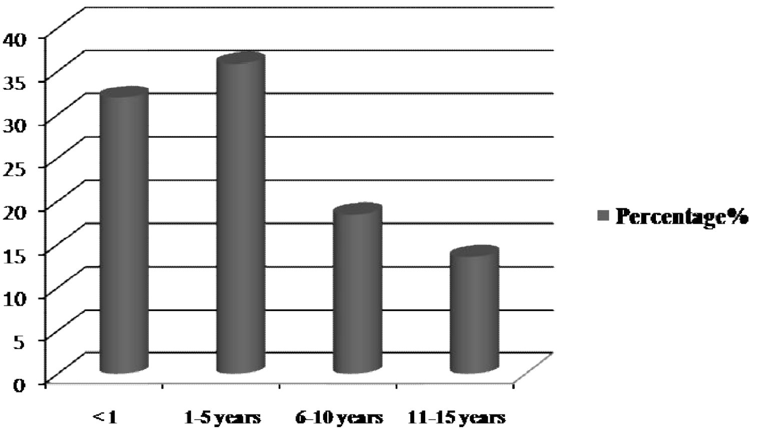
Chapter Four

Results

81 children patients with head examination requests. All 81 patients scanned by the CT scanner, the results were presented by the following tables and figures:

Table (4.1): shows the distribution of age groups and percentages.

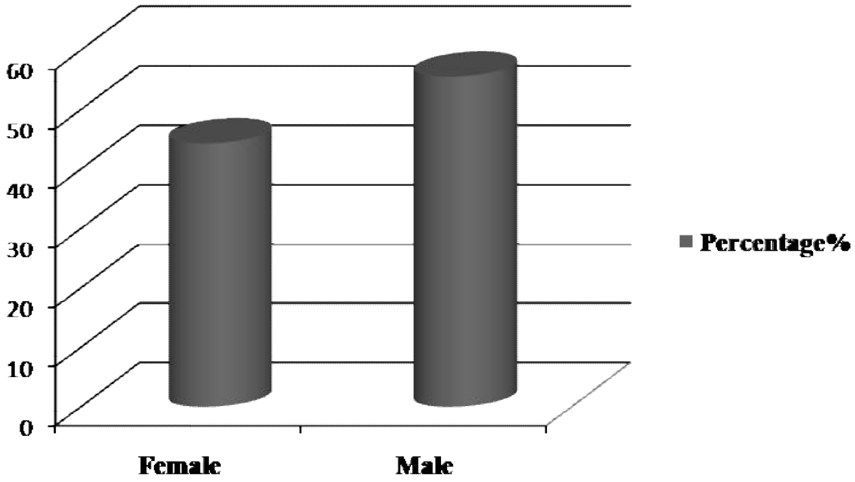
Age group (years)	frequency	Percentage%
< 1	26	32
1- 5	29	35.9
6- 10	15	18.5
11- 15	11	13.6
Total	**81**	**100**



Graph. (4.1): shows the percentages distribution of age groups.

Table. (4.2) shows the gender of patients and percentages.

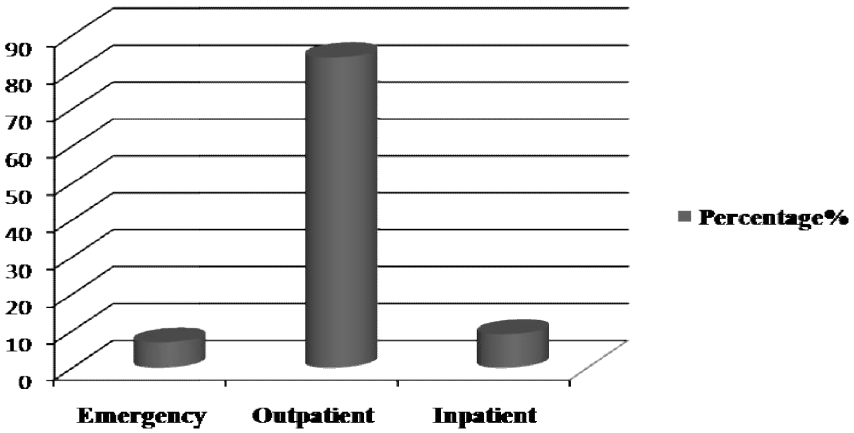
Gender	**Frequency**	**Percentage%**
Female	36	44.4
Male	45	55.6
Total	**81**	**100**



Graph. (4.2) shows percentages of patients gender.

Table. (4.3) shows children location (points to where the patients referred from) distribution and percentages**.**

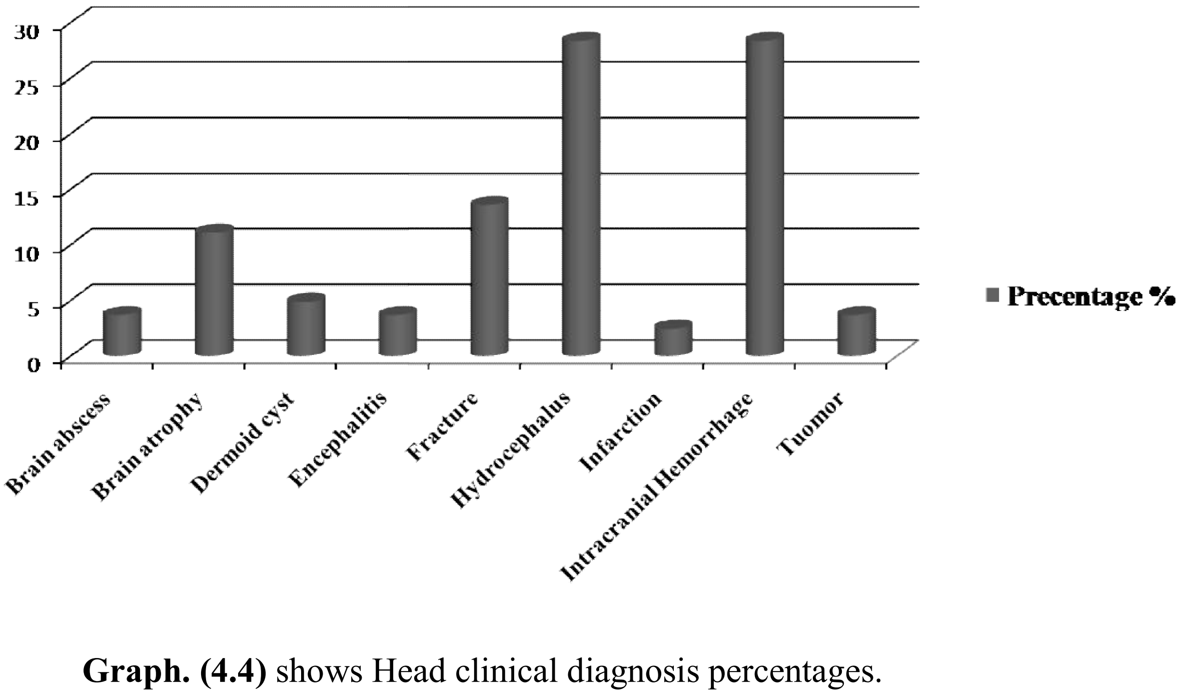
Children location	**Frequency**	**Percentage%**
Emergency	10	6.82
Outpatient	66	84.09
Inpatient	5	9.09
Total	**81**	**100**



Graph. (4.3) shows percentages of the children location (points to where the patients referred from).

Table. (4.4) shows Head clinical diagnosis and percentages.

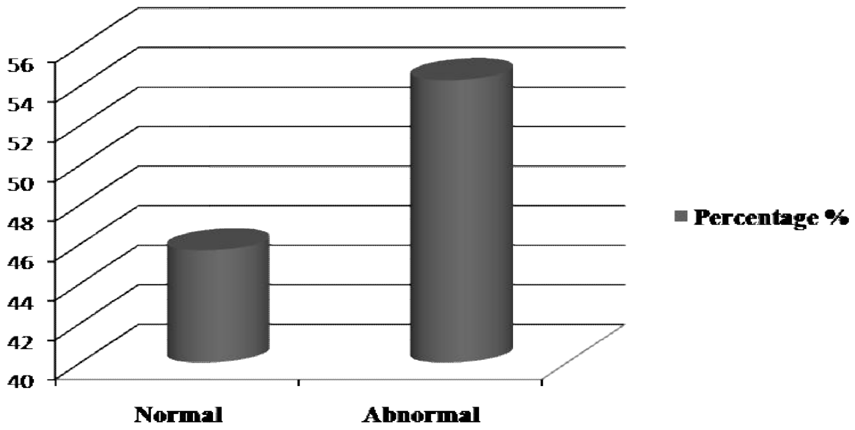
Clinical diagnosis	Frequency	Percentage%
Brain abscess	3	3.7
Brain atrophy	9	11.1
Dermoid cyst	4	4.9
Encephalitis	3	3.7
Fracture	11	13.6
Hydrocephalus	23	28.4
Infarction	2	2.5
Intracranial Hemorrhage	23	28.4
Tumor	3	3.7
Total	**81**	**100**



Graph. (4.4) shows Head clinical diagnosis percentages.

Table. (4.5)shows the comparing between normal and abnormal CT findings and percentages.

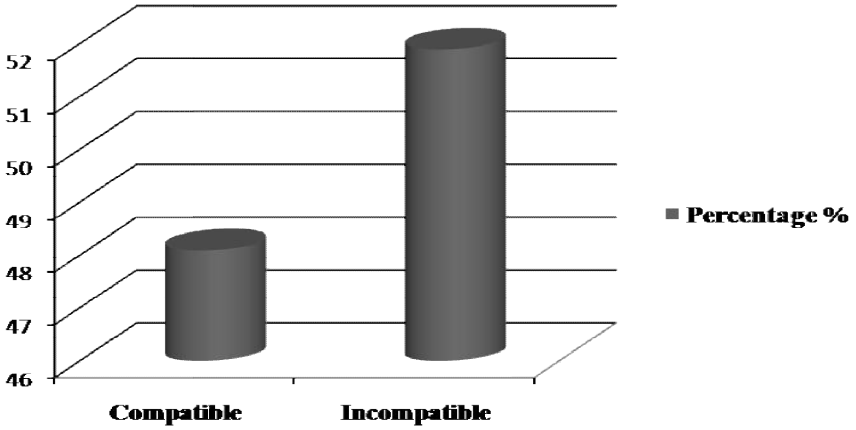
CT findings	**Frequency**	**Percentage %**
Normal	37	45.7
Abnormal	44	54.3
Total	**81**	**100**



Graph. (4.5) shows the comparing between Normal and abnormal CT findings percentages.

Table. (4.6) shows the Compatible of head CT Findings with clinical Diagnosis and percentages.

Compatibility	**Frequency**	**Percentage %**
Compatible	39	48.1
Incompatible	42	51.9
Total	**81**	**100**



Graph. (4.6) shows the compatible of children CT Findings with Clinical Diagnosis and percentages.

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion

81 children patients were investigated by CT scan and clinical diagnosis in Sudanese hospitals and medical centers. The study was designed to compare the clinical diagnosis and CT findings in patients with Head conditions. Regarding to the Age distribution the study found that most effected age group were 1-5 years as presented in table (4.1), there were 29 out of 81 cases (35.9%),This study agrees with records of the (Elkhadir. et.al,2016). With respect to gender distribution, of the 81 cases, 45were males forming an incidence (55.6%) and 36 were females (44.4%) as presented in table (4.2), Also This study agrees with records of the(Elkhadir. et.al,2016). And according to the children Location distribution (points to where the patients referred from), the majority of the patients were from outpatient there were 66 patients from 81 patients (84.09%) as presented in table (4.3),this study is not in agreement with records of the (Elkhadir. et.al,2016) , which the majority of the patients were from inpatient (43.8%).

Most head clinical diagnosis for children of the sample showed that (28.4%) of the patients had intracranial hemorrhage (ICH), which the trauma was indicated and also hydrocephalus had same percentage (28.4%) presented in table (4.4), and this is in agreement with records of the (Elkhadir. et.al, 2016), which was (21.58%); and (Zeeb, et.al, 2012) in his study in Germany demonstrated the most frequent indications for a CT examination in children were trauma (57%). Related to the Triage, assessment, investigation and early management of head injury in children recently the National Institute for Health and Care Excellence (NICE) Issued(January 2014) an important clinical guideline 176 rather to pediatricians to read and follow it carefully before ordering any CT examinations to the children. When I comparing between normal and abnormal CT findings from the results the majority of patients were abnormal (54.3%), while normal CT findings (45.7%), which presented in table (4.5). Finally from 81 patients with clinical diagnosis and CT findings were 39 of them correctly diagnosed (48.1%) and 42 patients were misdiagnosed (51.9%).

My study has some limitation, because this was smaller sample size in patients made it difficult to assess the variables associated with CT use in children. To sum up, head CT scans in children dramatically increased to confirm or negate the clinical diagnosis.

1.2 Conclusion

This study concluded that head CT utilization must be associated with justification for scan in children. It is important that pediatricians and other doctors should not order head CT unless it is indispensable.

It is no doubt true that health professional’s work together to minimize the radiation dose to children. But it is recommended that it is very important for pediatricians, radiologist and x-ray technologist to put their minds on the three unique considerations in children:

- Children are considerably more sensitive to radiation than adults, as demonstrated in epidemiologic studies of exposed populations;
- Children have a longer life expectancy than adults, resulting in a larger window of opportunity for expressing radiation damage.
- Children may receive a higher radiation dose than necessary if CT settings are not adjusted for their smaller body size (Website http://www.cancer.gov/cancertopics/causes/radiation/radiation-risks-pediatric-CT)

5.3 Recommendations

The researcher recommends that clinicians and the pediatricians (specially) should be more careful in requesting of head CT by write a detailed clinical history through a properly filled request form unless it is indispensible and also have knowledge of children CT protocols.

Data should be compared with the final diagnosis to evaluate the role of CT in finding disease, so it is important to increase the number of patient for more findings and good communication between the reporting radiologist and technologists is important.

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Appendices

Appendix A

Data Collection Sheet

Hospital Name:..

No	Sex (M/F)	Pt. Location (O/I/E)	Age	diagnosis Clinical (reason for examination)	CT Findings	Name and Model of CT scanner	Others
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

- **Protocols of CT brain examination:**

Protocol	Detector collimation	KVp	Effective mAs	Slice	Rotation time	Scan time	Pitch
Brain sequence-child							

Appendix B

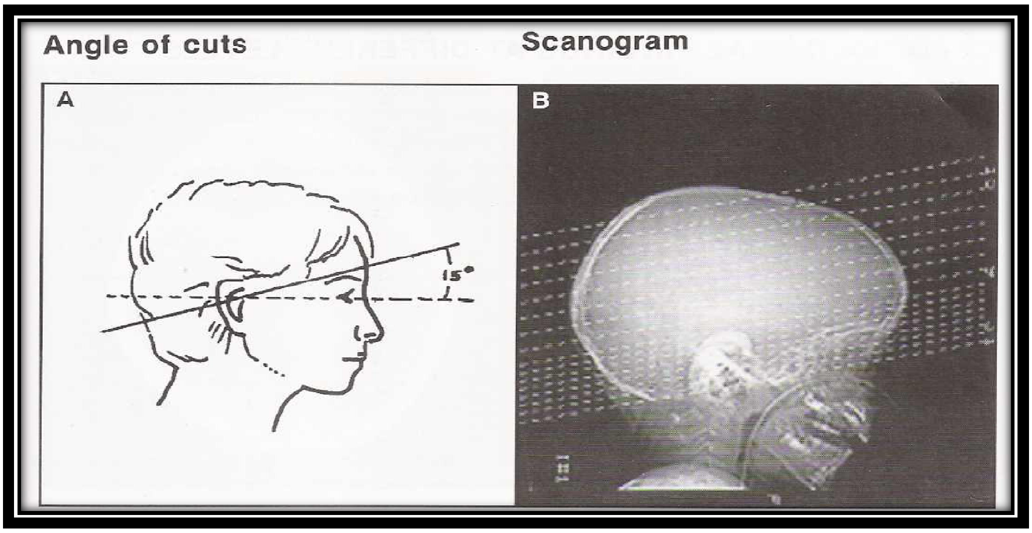

Figure (B1): shows scanogram (scout view) and angle of cuts in children head CT

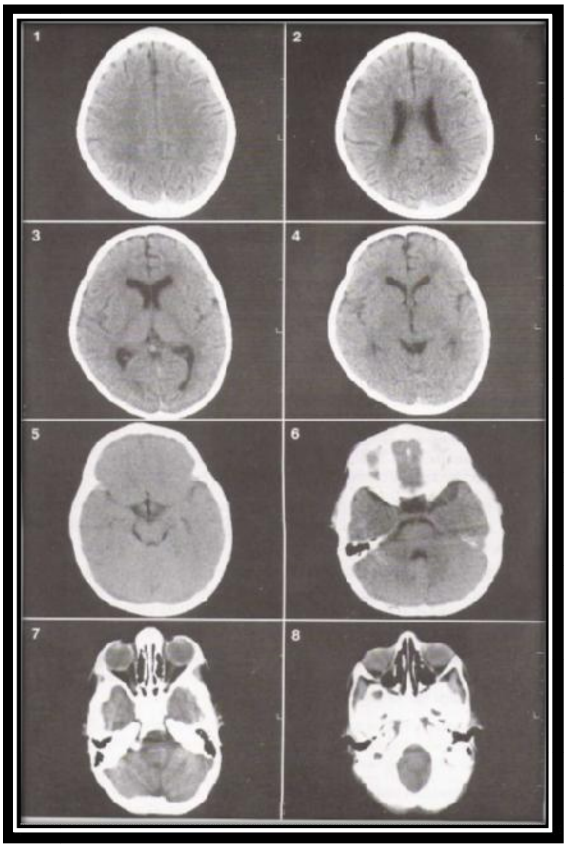

Figure (B2): shows a series of sections of normal plain CT scan of children (from 1-8)

Appendix C

Toshiba Aquilion™ 64 MDCT scanner. Monitor, Gantry and Table

Figure (C1): shows the control panel and monitor of CT machine

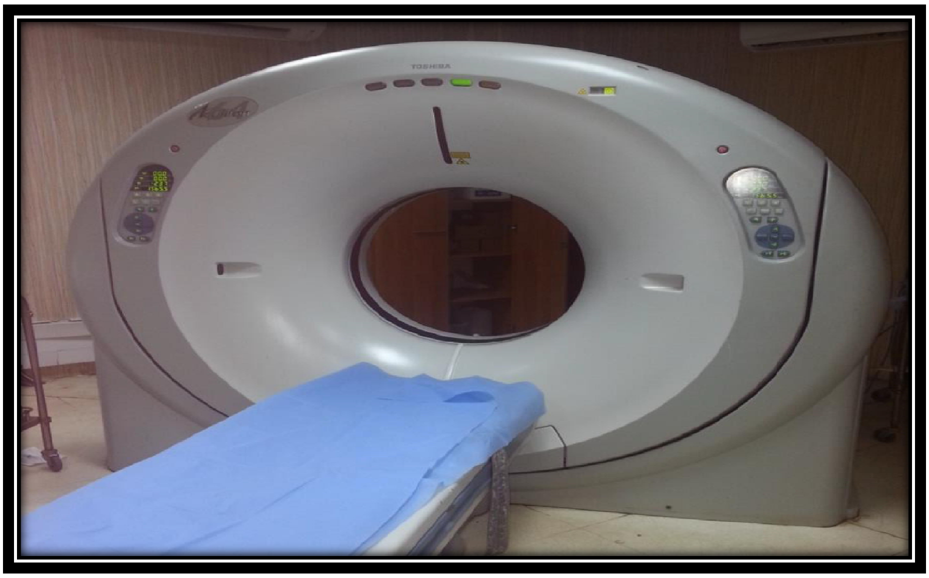

Figure (C2): shows Gantry and Table of CT machine