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Sudan University of Science and Technology

College of Graduate Studies and Scientific Research

Study of Brain Infarction by Using CT and MRI

دراسة احتشاء المخ باستخدام الاشعة المقطعية والرنين المغنطيسي

A Thesis Submitted for Partial Fulfillment of the Requirements of MSc Degree in Radiological Imaging Diagnosis

By

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الآية

قَالَ تَعَالَىٰ: ﴿ أَوَلَيْسَ ٱلَّذِى خَلَقَ ٱلسَّمَٰوَٰتِ وَٱلْأَرْضَ بِقَٰدِرٍ عَلَىٰٓ أَن يَخْلُقَ مِثْلَهُم ۚ بَلَىٰ وَهُوَ ٱلْخَلَّٰقُ ٱلْعَلِيمُ ﴿٨١﴾ إِنَّمَآ أَمْرُهُۥٓ إِذَآ أَرَادَ شَيْـًٔا أَن يَقُولَ لَهُۥ كُن فَيَكُونُ ﴿٨٢﴾ فَسُبْحَٰنَ ٱلَّذِى بِيَدِهِۦ مَلَكُوتُ كُلِّ شَىْءٍ وَإِلَيْهِ تُرْجَعُونَ ﴿٨٣﴾ ﴾

صدق الله العظيم

سورة يـــس ٨١ - ٨٣

Dedication

To

My parent

To

My family

To

My Teachers

To

My friends

To

My Colleagues

I Dedicate this Research

Acknowledgments

First for most, I would like to express May deepest gratitude to Dr. Hussein Ahmed Hassan for this support and guidance. Without this help this work could not have been accomplished. I also would like to thank Doctors hospital, National ribat hospital, Yastabshiroon medical center.

Deep thanks to my friends and finally, I, would like to sincerely thank May family for their consistent mental support.

Abstract

This was cross sectional description study done to study of cerebral infarction by using CT and MRI. The study was done in Doctors Hospital, National Ribat Hospital, and Yastabshiroon Medical Center during the period from November 2016 to January 2017.

The data was collected by data collection sheet specially design for this study from 100 patients suffering from cerebral infarction 50 patient diagnosed – through CT and 50 patient diagnosed by MRI . Then analyzed by statistical package for the social science (SPSS).

The study found that in both group more than halve of patient were male (56% in CT group, 54% in MRI group)respectively. Cerebral infarction occurs more commonly in age group (60-79 years, 40-59 years) in both groups. the study found that most type of infarction is acute , followed by chronic and then sub acute ، and most common site of infarction was frontal and inter cerebral and intra ventricular, and most common of size of infarction 11-60 mm in both group , the study found that cerebral infarction can be diagnosis either through CT and MRI.

الخلاصه

الهدف من البحث دراسه احتشاء المخ باستخدام التصوير بالاشعة المقطعية والرنين المغنطيسي . هذه الدراسه عملت في ثلاثة مستشفيات مختلفة مستشفي الرباط الوطني ،مستشفي الاطباء ومستشفي يستبشرون الطبي في الفترة من نوفمبر 2016 الي يناير 2017.

تم جمع البيانات عن طريق ورقة جمع البيانات وصممت خصيصاً لهذه الدراسة من مائة مريض يعانون من احتشاء المخ بواقع خمسين مريض تم تشخيصهم من خلال التصوير بالاشعة المقطعية و 50 مريض من تم تشخيصهم عن طريق التصوير بالرنين المغنطيسي .تم تحليل البيانات باستخدام نظام الحزمة الاحصائية للعلوم الاجتماعية (اس بي اس اس).

ووجدت الدراسة ان في كل مجموعه اكثرمن نصف المرضي كانوا من الذكور (54–56 %) علي التوالي .احتشاء المخ ظهر اكثر شيوعاً في المرضي الذين عمرهم بين (40–80 سنه) في كلتا المجموعتين . ايضا من حيث النوع وجدنا اكثر الانواع من حيث الترتيب الحاد ثم المزمن واخيراً دون الحاد . ومن حيث موقع الاحتشاء وجدنا الفص الامامي وداخل السربلل علي التوالي . من حيث حجم الاحتشاء وجدنا الحجم الاكثر شيوعاً (11–60 مليمتر) . ووجدت الدراسة اناحتشاء المخ يمكن ان يكون التشخيص اما عن طريق التصوير بالاشعة المقطعية والتصوير بالرنين المغنطيسي.

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List of abbreviations

CT	Computer Tomography
MRI	Magnetic Resonance Image
RF	radio frequency
CSF	cerebrospinal fluid
PET	positron emission tomography
T	Tesla
MHz	megahertz
FID	free induction decay signal
NMV	Net Magnetization Vector
B0	Magnetic field
FFT	Fast Fourier transform
SNR	Single to noise ratio
FOV	Field of view
DWI	Diffusion weighted image
PWI	Protein weighted image
SWE	Susceptibility weighted imaging
MRA	Magnetic resonance angiography

Chapter One

Chapter one

1-1 Introduction

The stroke is the third common cause of death in developed countries. The age – adjusted annual death rate from strokes is 116 per 100.000 populations in the UK; it is higher in afro – Caribbean population than Caucasian. Stroke is uncommon below the age of 40 years and is more common in males. The death rate following stroke is 25 %. The incidence of stroke is decreasing in the age range 40-60 years as hypertension is recognized and treated. However, particularly in the elderly population, stroke remains a major cause of morbidity and mortality (Von Kummer, 1994).

Major cerebral infarction from thromboembolism typically produces a stroke. Some small infarction may cause TIAS, whole others are silent. The clinical picture is thus very variable and depends on the site and extent of the infarction. Diagnosis on clinical grounds of the precise vascular territory involved is often inaccurate. Nevertheless, the general site of major cerebral infarction may be inferred from the pattern of the physical signs (e.g. cortex, internal capsule, brain stem). CT was originally used for the head and changed for all time the investigation of brain pathology. Prior to that detailed radiological assessment of the brain required uncomfortable and potentially dangerous technique such as air encephalography. Cerebral angiography the former is now obsolete, the later required for less now, due to presence of CT and MRI (Kummer, 1994)

Computed tomography in order to overcome the problem of x-ray diagnosis previously described , a new tomography procedure has been developed with which the images are not obtained directly but must first calculated by means of a computer (Kummer, 1994)

In recent years new generations of CT scanner have appeared with shorter examination times and higher resolution. In 1973 lauterbar published a technique by which data obtained from a magnetic resonance imaging (MRI) experiment could be used to calculate images from two water field tube. In 1977 HINSHOW published MRI images of the hand and in 1980 MR scans appeared showing brain pathology. MRI considered in its most basic from unit consists of a magnet, a radio frequency (RF) transmitter, and an image display system. In order to create an MR image, a patient is placed inside large bore magnet energy, in the form of RF energy, is directed into the patient. some of the excess energy transmitted into the patient radiates back out and is detected by a n antenna which transmits this signal to an RF signal , and this information in turn is processed in a computer to determine the point in the body from which given signal originated . The computer can thus create a grid work or matrix of signals coming from the body that in turn can be projected on a video screen to yield a cross-sectional image of the body. The MRI system is pathology oriented system. (Verlage,1992)

1-2 problem of study :

- CT and MRI are modalities of choice when in clinical question is cerebral infarction , CT using ionizing radiation but short scan time and available , MRI expensive , long scan time , not available and not scan for cramps , epilepsy patient and pediatricexcept sedation may be used , which a modalities to use when having patient with strokes .

1-3 Hypothesis

- The CT advance than MRI to diagnosis cerebral infarction

- MRI the best modalities to investigate and prognosis cerebral infarction

1-4 objectives

1-4-1general objective

Study of brain infarction by using CT and MRI

1-4-2 specific objective

- To compare the infarction to gender
- To compare the infarction to age
- To compare the infarction to type of infarction
- To compare the infarction to size of infarction
- To compare the infarction to site of infarction

Chapter Two

Chapter two

Theoretical background

2-1 Anatomy of brain

The central nervous system consists of the brain and the spinal cord. The peripheral nervous system consists of the extensions of neural structures beyond the central nervous system and includes somatic and autonomic divisions. The brain is composed of 3 main structural divisions: the cerebrum, the brainstem, and the cerebellum (see the images 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)

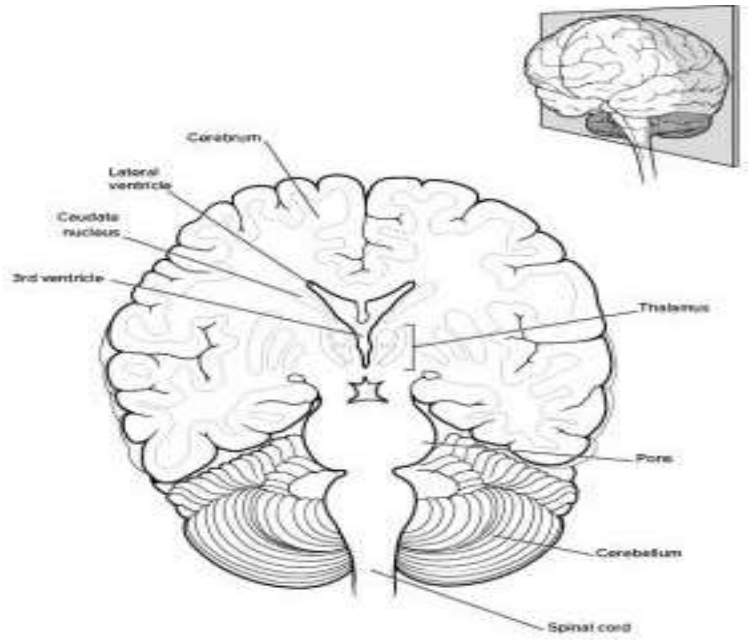

Fig 2-1 Brain, coronal view.

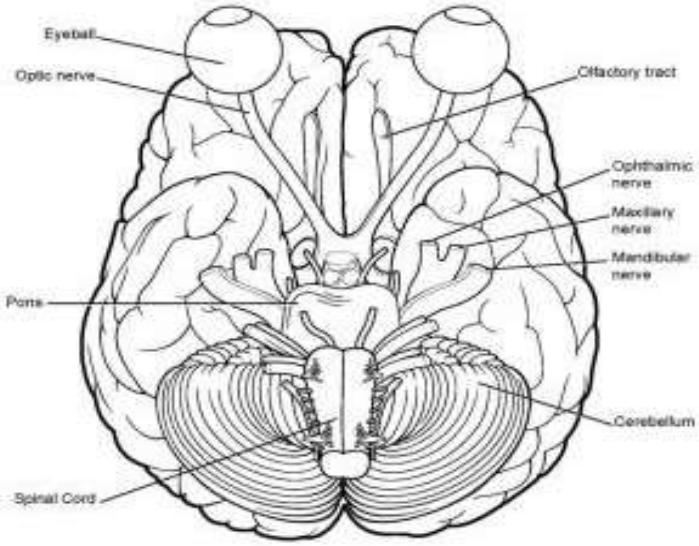

Fig 2-2 Brain, inferior view.

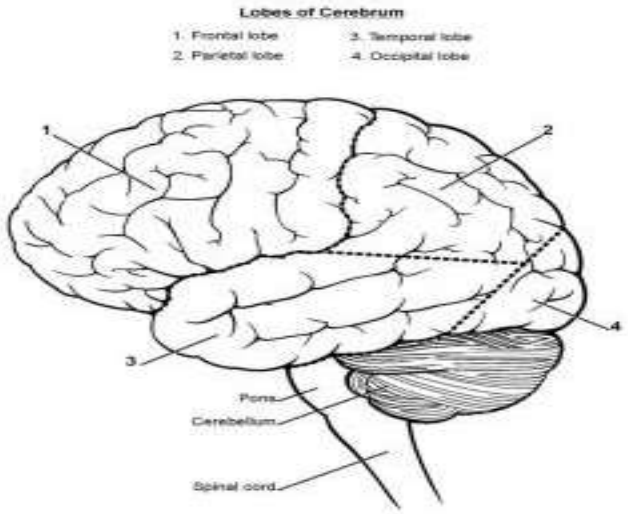

Fig 2-3Brain, lateral view.

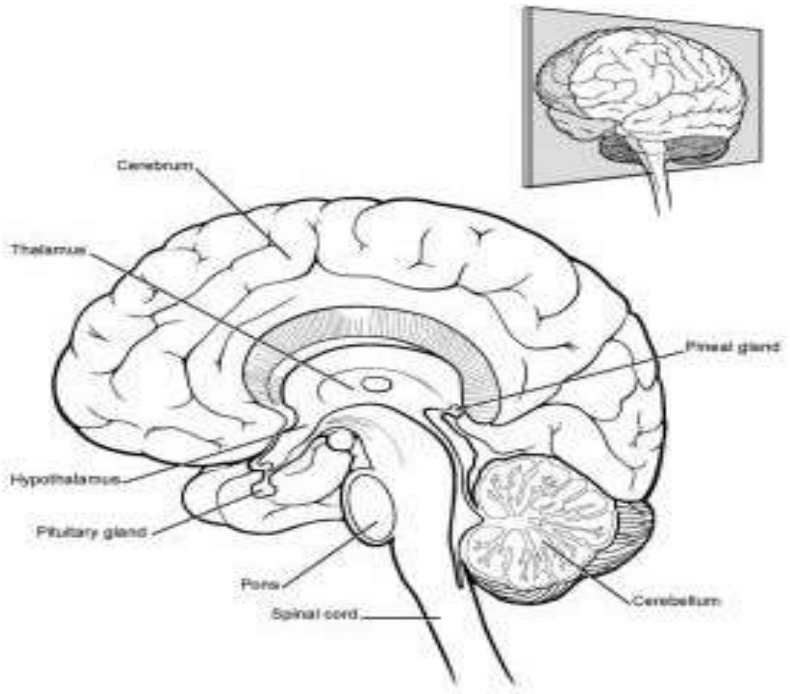

Fig 2-4 Brain, midsagittal view.

2-1-1 Cerebrum

The cerebrum is the largest component of the brain. It is divided into right and left hemispheres. The corpus callosum is the collection of white matter fibers that joins these hemispheres. Each of the cerebral hemispheres is further divided into 4 lobes: the frontal lobe, the parietal lobe, the temporal lobe, and the occipital lobe. The medial temporal lobe structures are considered by some to be part of the so-called limbic lobe. Briefly, the frontal lobe is distinguished from the parietal lobe posteriorly by the central sulcus (see the image below). The frontal lobe and parietal lobes are divided inferiorly from the temporal lobe by the lateral sulcus. The parietal lobe is distinguished from the occipital lobe by the parieto-occipital sulcus on the medial surface. (Nolte,1993)

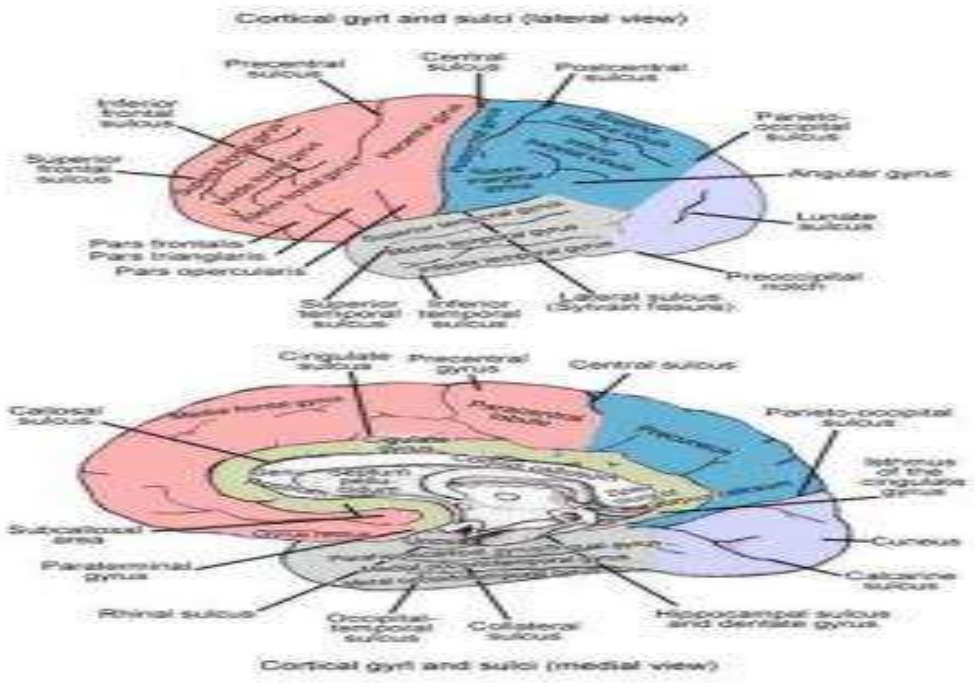

Fig2-5 Lateral and medial surfaces of cerebrum, showing major sulci and gyri.

The cerebrum is further divided into the telencephalon and diencephalon. The telencephalon consists of the cortex, the subcortical fibers, and the basal nuclei. The diencephalon mainly consists of the thalamus and hypothalamus. The telencephalon of the cerebrum is disproportionately well-developed in humans as compared with other mammals. (Nolte,1993)

2-1-2 Cortex and subcortical 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. (Nolte,1993)

2-1-3 Limbic system

The limbic system is a grouping of cortical and subcortical 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. The limbic system is not defined by strict anatomic boundaries but incorporates several important structures. The limbic structures conventionally include the amygdala, the hippocampus, the fornix, the mammillary bodies, the cingulate gyrus, and the Para hippocampal gyrus. The functional connections within the limbic system are best summarized by the Papez circuit. From the hippocampus, signals are relayed via the fornix to the mammillary bodies and via the mammillothalamic tract to the anterior nucleus of the thalamus. The thalamocingulate radiation then projects to the cingulate gyrus and back to the hippocampus to complete the circuit. The hippocampus serves as a primary output structure of the limbic system. Unlike the 6-layered neocortex, the hippocampus only has 3 layers and is termed the archicortex. The hippocampus is felt to be a structure that is crucial to formation of memory--more specifically, a type of memory called declarative or explicit memory. Declarative memory is essentially the ability to recall life events of the past such as what meal was eaten for breakfast or where the car is parked. Over time, however, certain declarative memories from the distant past can be independently recalled without the hippocampal structures. The hippocampus likely allows long-term memory encoding in the cortex and allows short-term memory retrieval. In laboratory studies of animals and humans, the hippocampus has been shown to also have a cellular memory termed "long-term potentiation.

The amygdala is a collection of nuclei that lies within the uncus. It receives multiple modes of sensory information as inputs. The outputs from the amygdala travel through the striaterminalis and the ventral amygdalofugal pathway. Output structures include the hypothalamus, as well as the thalamus, hippocampus, brainstem, and cortex. The amygdala appears to be involved in mediating the emotional aspects of memory, especially the subjective aspects of fear responses. (Nolte,1993)

2-1-4 Basal nuclei (ganglia)

The basal nuclei (formerly referred to as the basal ganglia) comprise the caudate nucleus, putamen, globuspallidus, sub thalamic nucleus, and substantial nigra. Pairs of these structures bear different names. The putamen and globuspallidus combined form the lentiform nuclei. The putamen and caudate nucleus combined form the striatum. The striatum derives its name from the striped appearance given by the gray matter connections bridging across the internal capsule. The basal nucleus is closely integrated with the motor cortex, premotor cortex, and motor nuclei of the thalamus and plays a crucial role in modulation of movements. The primary input to the basal nuclei is from the primary motor cortex and premotor cortex (Brodmann areas 4 and 6) and consists primarily of the pyramidal cells in cortical layer V. These excitatory projections lead primarily to the striatum. The striatum also receives input from the dopaminergic cells of the substantianigra. In turn, the striatum sends inhibitory projections to the globuspallidusexterna and interna. The globuspallidus external sends inhibitory projections to the sub thalamic nucleus, which sends excitatory projections to the globuspallidus internal. The globuspallidus internal in turn projects to the ventral anterior and ventral lateral nuclei of the thalamus. Certain movement disorders can be traced to pathologies in the basal nuclei, the most

notable being Parkinson disease, which is related to deficiencies of dopaminergic cells of the substantianigra. Huntington disease is a heritable disorder that involves degeneration of the striatum and leads to progressive jerky, or choreiform, movement. (Loukas,2011)

2-1-5 Thalamus

Positioned between the brainstem and the telencephalon, the diencephalon is composed of the thalamus, the epithalamus, the sub thalamus, 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. The thalamus consistof multiple nuclei that arebriefly described here (see the image below) (Nolte,1993**)**

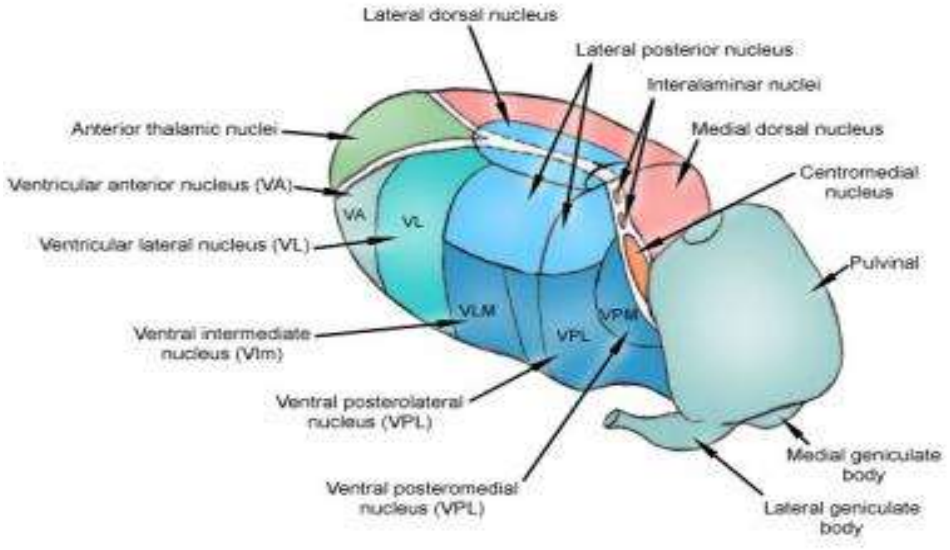

fig (2-6) Major nuclei of thalamus.

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. The anterior thalamic nuclei are functionally associated with the limbic system and share reciprocal connections with the cingulate gyrus and the mammillary bodies. The medial nuclei project to the frontal association cortex and premotor cortex, with reciprocal connectivity. The ventrolateral nuclei can be further divided into the ventral anterior (VA), ventral lateral (VL), ventral posterolateral (VPL), and ventral posteromedial (VPM) nuclei. The VA and VL nuclei share input from the globuspallidus and projections to the motor cortex. The VPL and VPM serve as sensory relays in the body and face, respectively. The lateral nuclei are divided into lateral dorsal and lateral posterior nuclei, with projections to the cingulate gyrus and parietal cortex, respectively. Other thalamic structures not included in the anatomic divisions above include the medial and lateral geniculate bodies, which process auditory and visual information, respectively. The pulvinar connects reciprocally with the parietal and occipital association cortex. Intralaminar nuclei within the internal medullary lamina obtain input from the brainstem, cerebellum, and other thalamic nuclei and project to basal nuclei structures and other thalamic nuclei. Amongst the intralaminar nuclei, the centromedian nucleus is a part of the reticular activating system, which plays a role in maintaining cortical arousal. (Nolte,1993)

2-1-5-1 Epithalamus The epithalamus is made up of the habenula, the habenular commissure, the posterior commissure, and the pineal gland. (Nolte, 1993)

2-1-5-2 Sub thalamus Located between the midbrain and the thalamus, the sub thalamus contains the subthalamic nucleus, the red nucleus, and the substantianigra. Sub thalamic structures are closely integrated with the basal nuclei and play a role in modulation of movement. (Nolte, 1993)

2-1-5-3 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 supraoptic, and Para ventricular 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 . (Nolte,1993)

2-1-6 Cortex

The neocortex is the most phylogenetically developed structure of the human brain as compared with the brains of other species. The complex pattern of folding allows an increased cortical surface to occupy a smaller cranial volume. The pattern of folding that forms the sulcal and gyral patterns remains highly preserved across individuals. This enables a nomenclature for the cortical

anatomy. The left and right cerebral hemispheres are separated by the longitudinal cerebral fissure. The principal connection between the 2 hemispheres is the corpus callosum. Each cortical hemisphere can be divided into 4 lobes: frontal, temporal, parietal, and occipital. The frontal lobe can be distinguished from the temporal lobe by the lateral sulcus (Sylvian fissure). The frontal lobe can be distinguished from the parietal lobe by the central sulcus (Rolandic fissure). The parieto-occipital sulcus, which is visible on the medial aspect of the hemisphere, divides the parietal and occipital lobes. Within the lateral sulcus is another cortical surface referred to as the insula. The frontal lobe can then be further divided into the superior, middle, and inferior frontal gyri, which are divided by the superior and inferior frontal sulci, respectively. The inferior frontal gyrus forms the frontal operculum, which overlies the lateral sulcus. The frontal operculum can be divided into 3 triangular gyri: the pars orbitalis, the pars triangularis, and the pars opercularis, in order from anterior to posterior. The precentralgyrus is the gyrus immediately anterior to the central sulcus. Similarly, the temporal lobe is divided into the superior, middle, and inferior temporal gyri, which are separated by the superior and inferior temporal sulci. On the inferior surface of the temporal lobe just lateral to the midbrain the parahippocampalgyrus can be identified, with the collateral sulcus lying lateral. Between the parahippocampalgyrus and the inferior temporal gyrus lies the occipitotemporalgyrus, also known as the fusiform gyrus. Within the parietal lobe, the superior temporal sulcus is capped by the angular gyrus. Just above this, the lateral sulcus is capped by the supramarginalgyrus. Just below the angular gyrus, the lateral occipital gyrus caps the inferior temporal sulcus. (Nolte,1993)

2-1-7 Brainstem and Cranial Nerves

Evolutionarily, the brainstem is the most ancient part of the brain. Structurally, it can be divided into the medulla oblongata, pons, and midbrain. These three structures are briefly described below. Cross-sectional anatomy of the brainstem is rather complex, given the multiple traversing pathways and cranial nerve nuclei (see the image below). (Loukas,2011)

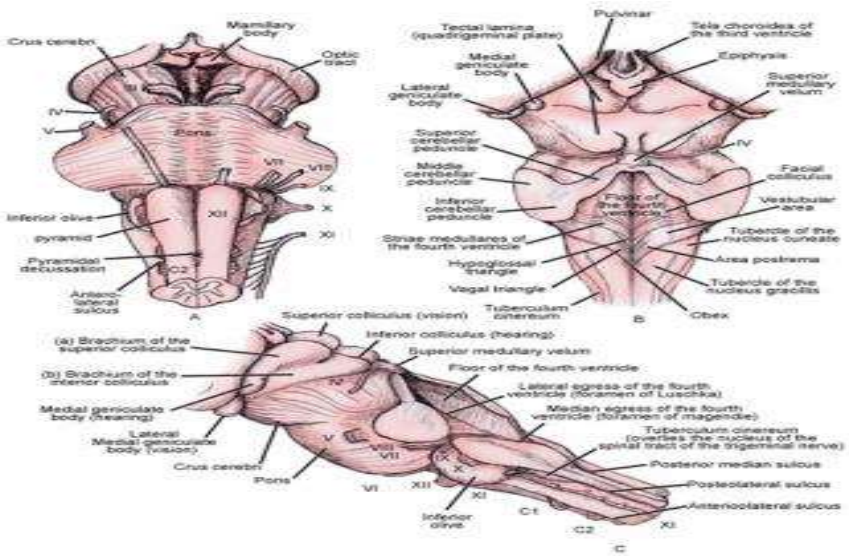

Fig (2-7) Three views of brainstem.

2-1-8 Medulla oblongata

The medulla oblongata, or simply medulla, is continuous with and superior to the cervical spinal cord. There are several external anatomic features of the medulla that can be visible grossly. Ventrally, the pyramids and pyramidal decussation is visualized just below the pons. These are the descending corticospinal tracts. Just lateral to the pyramids, the rootlets of the hypoglossal nerve can be seen as they exit the brainstem. Lateral to the rootlets of the hypoglossal nerve is the inferior olive. Dorsolateral to the inferior olive, the rootlets of the 9th and 10th cranial nerves (glossopharyngeal and vagus) exit.

Dorsally, 2 pairs of protrusions are visible, which are the gracile tubercles medially and the cuneate tubercles just lateral to those. These represent the nuclei where sensory information from the dorsal columns is relayed onto thalamic projection neurons. Just superior to these protrusions is the floor of the fourth ventricle, which bears several characteristic impressions. The vagal trigone is the dorsal nucleus of the vagus nerve (cranial nerve X) and lies inferiorly, just below the hypoglossal trigone. (Loukas,2011)

2-1-9 Pons

Superior to the medulla lies the pons, the ventral surface of which has a characteristic band of horizontal fibers. These fibers are the pontocerebellar fibers that are in turn projections from the corticopontine fibers. They cross to enter the contralateral middle cerebellar peduncle and thus enter the cerebellum. On either side of the midline, there are bulges that are produced by the descending corticospinal tracts. At the pontomedullary junction, the 6th cranial nerve (abducens) can be seen exiting the brainstem. Laterally, but anterior to the middle cerebellar peduncle, the fifth cranial nerve (trigeminal) is seen exiting the brainstem. Below the middle cerebellar peduncle, the seventh and eighth cranial nerves (facial and vestibulocochlear) can be seen exiting. Dorsally, the pons forms the floor of the fourth ventricle. (Loukas,2011)

2-1-10 Midbrain

The midbrain, also termed the mesencephalon, is the superiormost aspect of the brainstem. Ventrally, the midbrain appears as 2 bundles that diverge rostrally as the cerebral peduncles. Between the cerebral peduncles, the third cranial nerve (oculomotor) can be seen exiting. The fourth cranial nerve (trochlear) exits dorsally and is unique in this regard. It then courses anteriorly against the cerebral peduncles. The posterior aspect of the midbrain has 2 pairs of

characteristic protrusions, the superior and inferior colliculi. The superior colliculi are involved in mediating the vestibulo-ocular reflex, whereas the inferior colliculi are involved in sound localization. (Loukas,2011)

2-1-11 Cranial nerves

There are 12 pairs of cranial nerves that function mainly to convey motor signals to and sensory information from the head and neck. The lower cranial nerves have somewhat more complex visceral functions that are not strictly limited to the head and neck. The cranial nerves are as follows:

- The olfactory nerve relays information from the nerves of the olfactory epithelium to mesial temporal lobe and frontal lobe structures
- The optic nerve relays visual information from the retina; the right and left optic nerves then join at the optic chiasm, where they give rise to the optic tracts, which convey visual information to the thalamus and brainstem and, ultimately, the visual cortex; optic gliomas can arise from the optic nerve
- The oculomotor nerve is principally involved in the control of eye movements through its innervation of the superior rectus, the medial rectus, the inferior rectus, and the inferior oblique muscles
- The trochlear nerve innervates the superior oblique muscle and is purely a motor nerve
- The trigeminal nerve is both a motor and sensory nerve and has 3 divisions, V_1 (the ophthalmic division), V_2 (the maxillary division), and V_3 (the mandibular division); it is involved in conveying sensory information from the face and also in controlling the muscles of mastication; vascular compression of the branches of the trigeminal nerve near its entry into the brainstem has been associated with some types of facial pain, including trigeminal neuralgia

- The abducens nerve innervates the lateral rectus nerve, allowing lateral eye movements
- The facial nerve is principally involved in innervation of the muscles of facial expression and also plays a role in tearing, salivation, and taste; Bell's palsy is a relatively common facial nerve palsy
- The vestibulocochlear nerve is a purely sensory nerve that conveys auditory information from the cochlea to the brainstem via the cochlear branch; the vestibular branch conveys proprioceptive information about head position and movement from the inner ear to the brainstem; acoustic neuromas are typically benign tumors that can arise from the vestibular portion of this nerve
- The glossopharyngeal nerve is involved in taste and salivation, as well as sensation in the oropharynx; the afferent limb of the gag reflex is mediated by the glossopharyngeal nerve
- The vagus nerve conveys visceral sensation to the brainstem and also controls some visceral functions, such as heart rate and gastrointestinal motility
- The accessory nerve has contributions from a spinal component and innervates neck muscles involved in head turning
- The hypoglossal nerve is a motor nerve that innervates muscles of the tongue (Nolte,1993)

2-1-12 Cerebellum

The cerebellum occupies the posterior fossa, dorsal to the pons and medulla. It is involved primarily in modulating motor control to enable precisely coordinated body movements. Similar to the cerebrum, which has gyri and sulci, the cerebellum has finer folia and fissures that increase the surface area.The cerebellum consists of 2 hemispheres, connected by a midline structure called the vermis. In contrast to the neocortex of the cerebrum, the cerebellar cortex has

3 layers: molecular, Purkinje, and granular. There are 4 deep cerebellar nuclei: the fastigial, globose, emboliform, and dentate nuclei, in sequence from medial to lateral. The afferent and efferent pathways to and from the cerebellum exist within the 3 cerebellar peduncles.

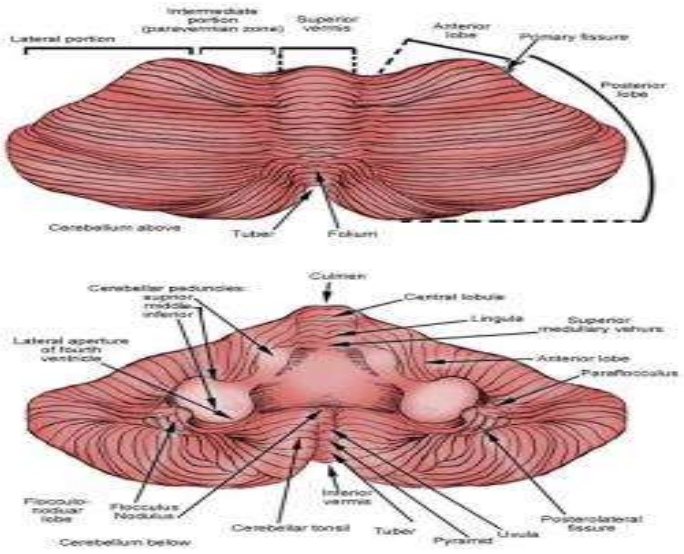

Fig 2-8 Top and anterior views of cerebellum.

In children, the cerebellum is a common location for tumors such as juvenile pilocyticastrocytomas and medulloblastomas. In adults, the posterior fossa is a very common location for metastatic tumors but also a common location for tumors such as hemangioblastomas. Another pathology of the posterior fossa can occur when the cerebellar tonsils descend below the foramen magnum; this is termed a Chiari I malformation. (Nolte,1993)

2-1-13 Meninges

The meninges consist of 3 tissue layers that cover the brain and spinal cord: the pia, arachnoid, and the Dura mater (see the image below). The pia along with the arachnoid are referred to as the leptomeninges, whereas the Dura is referred to as the pachymeninx.

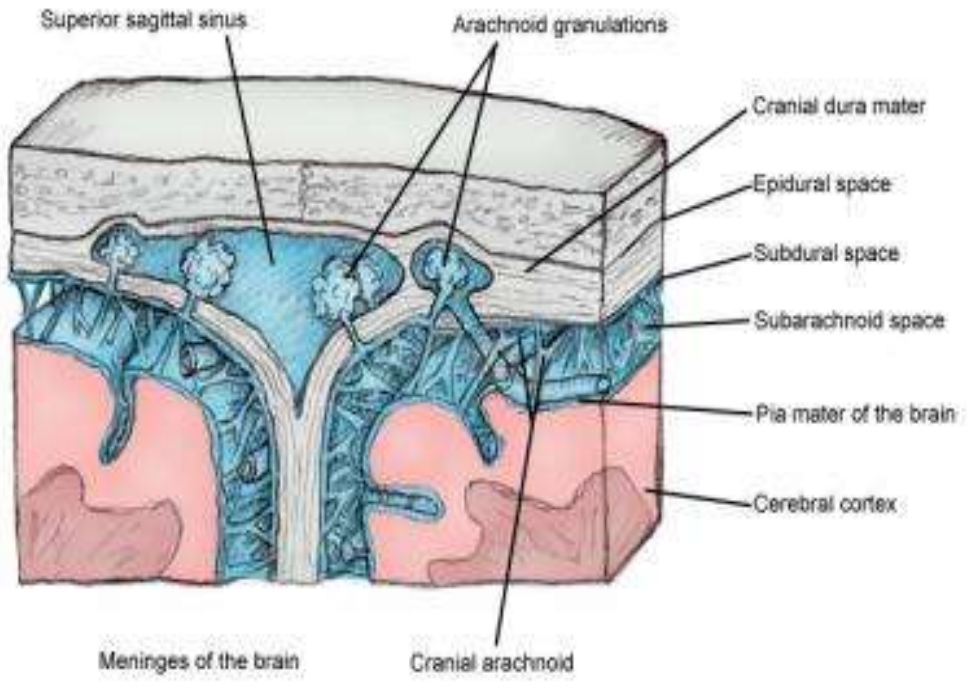

Fig 2-9 Cross-sectional view of meninges and dural venous sinus.

The innermost of the 3 layers is the pia mater, which tightly covers the brain itself, conforming to its grooves and folds. This layer is rich with blood vessels that descend into the brain. Outside the pia mater, which tightly contours the brain, is the arachnoid mater. The arachnoid mater is a thin web like layer. Between the pia mater and the arachnoid mater is a space called the subarachnoid space, which contains cerebrospinal fluid (CSF). This space is where the major arteries supplying blood to the brain lie. If a blood vessel ruptures in this space, it can cause a subarachnoid hemorrhage. The arachnoid cap cells can give rise to meningiomas, a usually benign tumor.The outermost meningeal layer is the Dura mater, which lines the interior of the skull. The Dura mater is composed of 2 individual layers, the meningeal Dura and the periosteal Dura. For the most part, these layers are fused; venous sinuses can be found in areas of separation. The tentorium cerebelli is a Dura mater fold that separates

the cerebellum from the cerebrum. The falxcerebra is a fold that separates the left and right cerebral hemispheres.Between the arachnoid mater and the Dura mater is the subdural space. If bleeding occurs in the space underneath the Dura mater, it is called a subdural hematoma. If bleeding occurs outside the Dura but underneath the skull, this is called an epidural hematoma.(Nolte,1993)

2-1-14 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 (see the image below). Within the cerebral hemispheres are the lateral ventricles, which are connected to each other and to the third ventricle through a pathway called the interventricular 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.

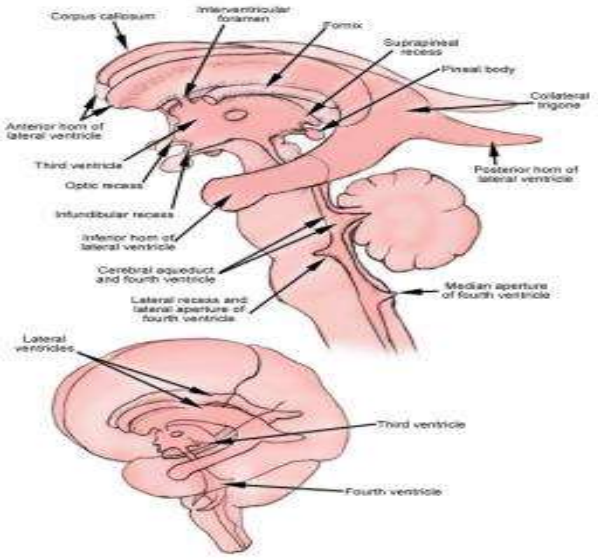

Fig 2-10 Ventricular system, which circulates cerebrospinal fluid through brain.

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. 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. (Nolte,1993)

2-1-15 Blood Vessels

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 an important collateral circulation at the base of the brain termed the cerebral arterial circle (of Willis). These vessels lie within the subarachnoid space and are a common location for cerebral aneurysms to form. Venous return to the heart occurs through a combination of deep cerebral veins and superficial cortical veins. The veins then contribute to larger venous sinuses, which lie within the dura and ultimately drain through the internal jugular veins to the brachiocephalic veins and then into the superior vena cava. (Nolte,1993)

2-1-16 Microscopic Anatomy

The cellular structure of the brain is composed primarily of neurons and their support cells, which are broadly termed glial cells. The 3 principal types of glial cells are astrocytes, oligodendrocytes, and microglia. These glial cells can give rise to glial tumors, such as astrocytomas, oligodendrogliomas, and glioblastomas, which are among the most common primary brain tumors.When examined histologically, the neurons of the cortical gray matter demonstrate a laminar pattern. The neocortex contains 6 distinct layers, in contrast to the evolutionarily older paleocortex and archicortex, which typically contain 3 layers. The specificcytoarchitectural patterns of the cortex are not uniform throughout the cerebral cortex, and their variation was mapped by the German physician KorbinianBradman and presented in 1909. The so-called Bradman areas represent cytoarchitectural differences across different brain regions, and

the numbering scheme developed by Bradman is still used to refer to distinct areas of the cortex. (Loukas,2011)

2-1-16 -1 Layers of neocortex

- The molecular layer is the outermost layer of the cortex, which lies adjacent to the pial surface
- The external granular layer is a dense layer of primarily inhibitory granule cells; this layer serves mainly to establish intracortical connections
- The external pyramidal layer contains smaller neurons than its deeper counterpart; this layer provides projections to association fibers and commissural fibers.
- The internal granular layer is the principal input layer of the cortex, with input derived largely from the thalamus
- The internal pyramidal layer is typically the largest layer within the cortex, containing large pyramidal cells; it is one of the principal output layers of the cortex, projecting to subcortical and spinal pathways; in the motor cortex, cells of this layer are termed Betz cells
- The fusiform layer contains cells that form association and projection fibers (Loukas,2011)

2-1-16-2 White matter

White matter tracts connect both nearby and distal brain structures and can be distinguished according to the types of connections they mediate. Projection fibers connect structures over the longest distances, such as the corticospinal projections from the motor cortex to the anterior horn cells of the spinal cord. Association fibers connect structures within the same hemisphere, such as the arcuate fasciculus, which connects the temporoparietal receptive speech areas with the frontal speech areas. Commissural fibers connect homologous

structures in the left and right hemispheres, the most notable example being the corpus callosum. Diffusion tensor imaging has emerged recently as a magnetic resonance imaging tool that provides exceptionally detailed white matter tractography in both normal and pathologic anatomy. (Loukas,2011)

2-1-16-3 Glial cells

The glial cells provide supportive and regulatory functions for neurons, and in fact glial cells outnumber neurons. Three principal types of glial cells exist: microglia, astrocytes, and oligodendrocytes. Microglia have a function in the brain similar to that of the immune system. Astrocytes play a role in creating the blood-brain barrier, which allows certain substances to selectively pass from the capillary system. They are also responsible for reactive scar formation in the brain. Oligodendrocytes form myelin, which serves to electrically insulate the axons of nerve cells, allowing increased rates of conduction. Abnormal proliferation of oligodendrocytes and astrocytes can lead to primary brain tumors called oligodendrogliomas and astrocytomas. Collectively, these belong to a family of tumors called gliomas, and the most aggressive type is termed a glioblastoma multiform. (Loukas,2011)

2-1-17 Functional Neuroanatomical

Our current understanding of functional localization in the cortex (see the image below) is derived from several sources, which include insights from patients with lesions involving specific areas of the cortex, awake mapping of the cortex during brain surgery, and functional imaging studies such as functional magnetic resonance imaging (MRI) and positron emission tomography (PET) in healthy volunteers.

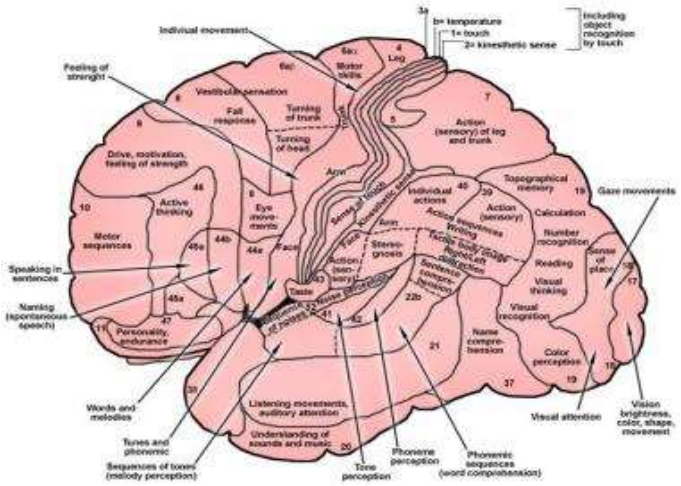

Fig 2-11 Functional localization within cerebral cortex.

Some of the earliest contributions to modern language mapping can be traced to the work of neurologist Paul Broca, who studied the language deficits in patients with stroke. Broca's area, as it is termed, is a region of the frontal operculum, which also overlaps with Bradman area 44 and 45. Three overlapping names describe this region, which is responsible for speech production. Selective damage to this region leads to difficulty speaking but typically with preserved comprehension.In contrast, Wernicke's area refers to the posterior aspect of the superior temporal gyrus, which overlaps with Bradman area 22. This region is generally responsible for speech comprehension, and selective injury to it can lead to impaired understanding with preserved speech production. Additionally, language function is hemispherically dominant. This means that Broca's and Wernicke's aphasia typically result from damage to the hemisphere that is dominant for language. In right-handed individuals, the left hemisphere is nearly always dominant for language. However, among left-handed individuals, the left hemisphere is dominant for speech in only 70%. Bilateral representation occurs in 15% of left-handed people, and right-hemisphere language representation occurs in 15% of left-handed people. The primary motor and sensory cortex

have been mapped extensively through intraoperative stimulation in awake patients. Early work performed by neurosurgeon Wilder Penfield in Montreal led to the conceptualization of the homunculus, which is the somatotopicrepresentation of the body in both the primary motor and primary sensory cortex (see the image below).

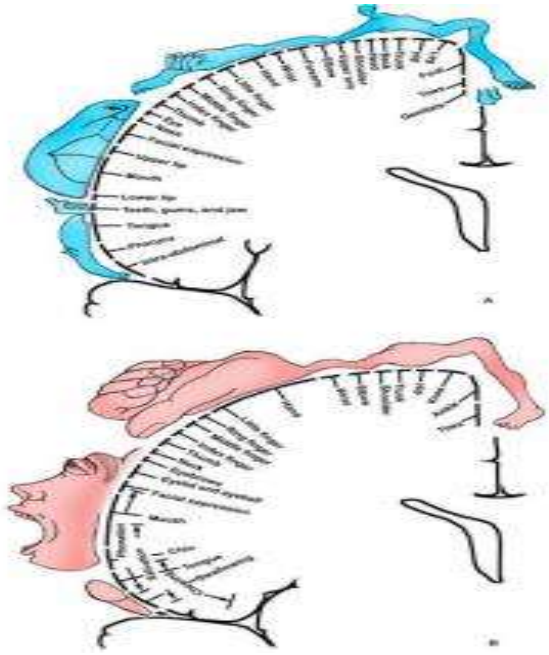

Fig 2-12 Functional localization within cerebral cortex.

The primary motor cortex corresponds with the precentralgyrus, or Bradman area 4. Intraoperative stimulation of the motor cortex in awake patients leads to contralateral muscle contraction in a single muscle or discrete group of muscles. The premotor cortex, which corresponds to Bradman area 6, is also occupied with movement, but typically more complex movements are elicited by stimulation here.The primary sensory cortex corresponds with the post central gyrus, or Bradman areas 1-3. The homunculus obtained from awake mapping corresponds to that of the motor cortex. Stimulation in awake patients during surgery typically leads to the subjective sensation of tingling of the

corresponding body part on the opposite side of the body. Caudally, the superior parietal lobule, Bradman areas 5 and 7, represents the secondary sensory cortex, which is felt to sub serve multimodal sensory information. The primary visual cortex corresponds to Bradman area 17 and occupies the occipital pole. It is also termed the striate cortex. The visual cortex is retinotopically organized. Surrounding the primary visual cortex is the visual association cortex, or Bradman areas 18 and 19.The primary auditory cortex lies on the superior bank of the superior temporal gyrus and corresponds to Bradman area 41. Like the primary motor, primary sensory, and visual cortices, the primary auditory cortex is ton topically organized. The auditory association cortex, or Bradman area 42, surrounds the primary auditory cortex. (Loukas,2011)

2-2 Brain Physiology

2-2-1 Cells of the nervous system

The brain and nervous system are made of nerve cells called neurons. Neurons send electrochemical signals to one another, forming the basis of the brain's complex, essential functions: to form memories and thoughts, to produce actions, 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 non-neuronal cells, called glia, in the brain as there are neurons, if not more. (Crossman,2000)

2-2-2 Neuroplasticity

The brain is a remarkably adaptive organ. Neurons and the connections between them are continually changing, which allow us to acquire new skills, retain memories, and recover from brain injury. Neuroplasticity refers to the brain and

nervous system's ability to re-model in response to new information. Being plastic, the brain can change as a result of behaviour, emotions, external stimuliand injury. One mechanism through which this occurs issynaptic plasticity, which occurs at synapses and is crucial for forming new memories. Another is the birth of new neurons, which is known as neurogenesis. (Crossman,2000)

2-2-3 Memory

Memory is what makes us who we are—it is the process by which we store and recall experiences, facts, and information. How does memory work? How does the brain store memories, and *where* is the information stored? *Learn more about the neuroscience behind memory*. (Crossman,2000)

2-3 Computer Tomography (CT)

2-3-1 Definition

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

2-3-2 Physical principles of CT scanning

The primary purpose of CT is to produce a two dimensional representation of the linear x-ray attenuation coefficient distribution through a narrow planner cross section of the human body.The resolution image delineates various structures within the body, showing the relative anatomic relationship. The physical principle of the CT includes the three processes referred to as: data acquisition, data processing and image display.(Goldman, 2008).

2-3-3 Data acquisition:

Refer to the systemic collection of information from the patient to produce the CT image. The two methods of data acquisition are slice- by- slice data acquisition and volume data acquisition. In conventional slice- by- slice data acquisition, data are collected through different beam geometrics 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 the next slice. This process continues until all slices have been individually scanned. More recently, multi-slice spiral/ helical CT has become available for faster imaging patient. It generates multiple slices per one revolution of the x-ray tube. (Goldman, 2008).

2-3-4 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 preprocessing, in which correction 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 numbers. The final step is image storage of the reconstructed digital image. This image is held in a disk memory is a short- term storage.(Goldman, 2008).

2-3-5 Image display:

It is the final process. After the CT image has been reconstructed, it exits the computer in digital form. This 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. (Goldman, 2008)

2-3-6 Display device*:*

The gray scale image is displayed 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.(Goldman, 2008)

2-3-7 Technique and protocol:

This study using automatic system for early detection of liver diseases from Computed tomography (CT) images

2-3-8 Position & imaging procedure:

The technologist begins by positioning you on the CT examination table ,Usually lying flat on your back .Straps and pillows may be used to help you maintain the correct position and to help you remain still during the exam, The table will move slowly through the machine as the actual CT scanning is performed. Depending on the type of CT scan, the machine may make several passes. You may be asked to hold your breath during the scanning. CT examination of the abdomen includes transaxial images from just above the dome of the diaphragm to the upper margin of the sacroiliac joints with 5 mm or less slice thickness .(Goldman, 2008)A dual or (tri-phase) scanning protocol may also be prescribed, enabling imaging for arterial and portal venous phases of the liver using one contrast injection. Post contrast image data are acquired first caudally (arterial phase) and after a 15 second delay, in reverse, cranially (portal phase). (Goldman,2008)

2-3-9 The instrumentation a modem 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, the CT viewing console.The major technical difference between various commercial scanners lies in the gantry design and the number and the type of x-ray detectors used. (Goldman, 2008).

2-3-10 Advantages of CT:

CT has a capacity to image material ranging from air to metal, CT is used as a guide in taking biopsy of the lesions demonstrated by other imaging technique, and CT image has high contrast resolution which can easily demonstrate the liver tissue and any other liver lesions. (Goldman, 2008).

2-3-11 Disadvantages of CT:-

Long exposure time-The x-ray has serious effects in early pregnancy- It is less available(Goldman, 2008).

2-4 Magnetic Resonance Imaging (MRI)

2-4-1 History :

Nikola Tesla discovered the Rotating Magnetic Field in 1882 in Budapest, Hungary. This was a fundamental discovery in physics.

In 1956, the "Tesla Unit" was proclaimed in the Rathaus of Munich, Germany by the International Electro-technical Commission-Committee of Action. All MRI machines are calibrated in "Tesla Units". The strength of a magnetic field is measured in Tesla or Gauss Units. The stronger the magnetic field, the stronger the amount of radio signals which can be elicited from the body's atoms and therefore the higher the quality of MRI images.

1 Tesla = 10,000 Gauss

Low-Field MRI= Under .2 Tesla (2,000 Gauss)

Mid-Field MRI= .2 to 0.6 Tesla (2,000 Gauss to 6,000 Gauss)

High-Field MRI= 1.0 to 1.5 Tesla (10,000 Gauss to 15,000 Gauss)

In 1937, Columbia University Professor Isidor I. Rabi working in the Pupin Physic Laboratory in Columbia University, New York City, observed the quantum phenomenon dubbed nuclear magnetic resonance (NMR). He recognized that the atomic nuclei show their presence by absorbing or emitting radio waves when exposed to a sufficiently strong magnetic field.Professor Isidor I. Rabi received the Nobel Prize for his work. He is one of 28 Nobel Laureates from the Pupin Physics Laboratory in New York City. Raymond Damadian, a physician and experimenter working at Brooklyn's Downstate Medical Center discovered that hydrogen signal in cancerous tissue is different from that of healthy tissue because tumors contain more water. More water means more hydrogen atoms. When the MRI machine was switched off, the bath of radio waves from cancerous tissue will linger longer then those from the healthy tissue. In 1973, Paul Lauterbur, a chemist and an NMR pioneer at the State University of New York, Stony Brook, produced the first NMR image.Mike Goldsmith, one of the graduate students cobbled a wearable antenna coil to monitor the hydrogen broadcast detected by the coil. On July 3, 1977, nearly five hours after the start of the first MRI test, the first human scan was made as the first MRI prototype.(Carolyn,2011)

2-4-2 The basic principles of magnetic resonance imaging (MRI)

Form the foundation for further understanding of this complex subject. It is important that these ideas are fully grasped before moving on to areas that are more complicated. There are essentially two ways of explaining the fundamentals of MRI: classically and via quantum physics. Any discussion

requires both, so we have attempted to integrate the two versions. Within this chapter, the propertiesof atoms and their interactions with magnetic fields, excitation and relaxation are discussed. (Carolyn,2011)

2-4-3 Atomic structur

All things are made of atoms , including the human body. Atoms are very small. Half a million lined up together are narrower than a human hair. Atoms are organized in molecules , which are two or more atoms arranged together. The most abundant atom in the body is hydrogen . This is most commonly found in molecules of water (where two hydrogen atoms are arranged with one oxygen atom, H 2 O) and fat (where hydrogen atoms are arranged with carbon and oxygen atoms; the number of each depends on the type of fat). The atom consists of a central nucleus and orbiting electrons .The nucleus is very small, one millionth of a billionth of the total volume of an atom, but it contains all the atom ' s mass. This mass comes mainly from particles called nucleons , which are subdivided into protons and neutrons . Atoms are characterized in two ways. The atomic number is the sum of the protons in the nucleus. This number gives an atom its chemical identity. The mass number is the sum of the protons and neutrons in the nucleus. The number of neutrons and protons in a nucleus are usually balanced so that the mass number is an even number. In some atoms, however, there are slightly more or fewer neutrons than protons. Atoms of elements with the same number of protons but a different number of neutrons are called isotopes . Nuclei with an odd mass number (a different number of protons to neutrons) are important in MRI . Electrons are particles that spin around the nucleus. Traditionally this is thought of as being analogous to planets orbiting around the sun. In reality, electrons exist around the nucleus in a cloud; the outermost dimension of the cloud is the edge of the atom. The position of an electron in the cloud is not predictable as it depends on the energy of an

individual electron at any moment in time (physicists call this Heisenberg ' s Uncertainty Principle). The number of electrons, however, is usually the same as the number of protons in the nucleus. Protons have a positive electrical charge, neutrons have no net charge and electrons are negatively charged. So atoms are electrically stable if the number of negatively charged electrons equals the number of positively charged protons. This balance is sometimes altered by applying external energy to knock out electrons from the atom. This causes a deficit in the number of electrons compared with protons and causes electrical instability. Atoms in which this has occurred are called ions . (Carolyn,2011)

2-4-5 Motion in the atom

Three types of motion are present within the atom.These are:

- electrons spinning on their own axis
- electrons orbiting the nucleus
- the nucleus itself spinning about its own axis.

The principles of MRI rely on the spinning motion of specific nuclei present in biological tissues. This spin derives from the individual spins of protons and neutrons within the nucleus. Pairs of subatomic particles automatically spin in opposite directions but at the same rate as their partners. In nuclei that have an even mass number, i.e. the number of protons equals the number of neutrons, half spin in one direction and half in the other. The nucleus itself has no net spin. However, in nuclei with odd mass numbers, i.e. where the number of neutrons is slightly more or less than the number of protons, spin directions are not equal and opposite, so the nucleus itself has a net spin or angular momentum . These are known as MR active nuclei. (Carolyn,2011)

2-4-6 Alignment

In the absence of an applied magnetic field, the magnetic moments of the hydrogen nuclei are randomly orientated. However, when placed in a strong static external magnetic field (Carolyn,2011)

2-4-7 Precession

Each hydrogen nucleus is spinning on its axis as in Figure 1.6 . The influence of B 0 produces an additional spin or wobble of the magnetic moments of hydrogen around B 0 . This secondary spin is called precession and causes the magnetic moments to follow a circular path around B 0 . This path is called the precessional path and the speed at which they wobble around B 0 is called the precessionalfrequency . The unit of precessional frequency is megahertz (MHz) where 1 Hz is one cycle or rotation per second and 1 MHz is one million cycles or rotations per second.(Carolyn,2011)

2-4-8 The Larmor equation

The value of the precessional frequency is governed by the Larmorequati on. The Larmor equation

states that:

$\omega 0 = \mathbf{B0} \cdot \lambda$

where:

$\omega 0$: is the precessional frequency

B 0 : is the magnetic field strength of the magnet

λ : is the gyromagnetic ratio.

The gyromagnetic ratio expresses the relationship between the angular momentum and the magnetic moment of each MR active nucleus. It is constant and is expressed as the precessional frequency of a specific MR active nucleus at 1 T. The unit of the gyromagnetic ratio is therefore MHz/T. The gyromagnetic ratio of hydrogen is 42.57 MHz/T. Other MR active nuclei have different

gyromagnetic ratios, so have different precessional frequencies at the same field strength. In addition, hydrogen has a different precessional frequency at different field strengths (Carolyn,2011)

2-4-9 The MR signal

As a result of resonance, in phase or coherent magnetization precesses at the Larmor frequency in the transverse plane. Faraday ' s law of electromagnetic induction states that if a receiver coil or any conductive loop is placed in the area of a moving magnetic field, i.e. the magnetization precessing in the transverse plane, a voltage is induced in this receiver coil. The MR signal is produced when coherent (in phase) magnetization cuts across the coil. Therefore the coherent moving transverse magnetization produces magnetic field fluctuations inside the coil that induce an electrical voltage in the coil. This voltage constitutes the MR signal. The frequency of the signal is the same as the Larmor frequency – the magnitude of the signal depends on the amount of magnetization present in the transverse plane (Carolyn,2011)

2-4-10 The free induction decay signal (FID)

When the RF pulse is switched off , the NMV is again influenced by B 0 and it tries to realign with it. To do so, the hydrogen nuclei must lose the energy given to them by the RF pulse. The process by which hydrogen loses this energy is called relaxation. As relaxation occurs, the NMV returns to realign with B0 because some of the high - energy nuclei return to the low - energy population and align their magnetic moments in the spin - up direction.

- The amount of magnetization in the longitudinal plane gradually increases – this is called recovery .
- At the same time , but independently , the amount of magnetization in the transverse plane gradually decreases – this is called decay.

As the magnitude of transverse magnetization decreases, so does the magnitude of the voltage induced in the receiver coil. The induction of reduced signal is called the free induction decay (FID) signal. (Carolyn,2011)

2-4-11 Relaxation

During relaxation hydrogen nuclei give up absorbed RF energy and the NMV returns to B 0 . At the same time, but independently, the magnetic moments of hydrogen lose coherency due to dephasing. Relaxation results in recovery of magnetization in the longitudinal plane and decay of magnetization in the transverse plane.

- T he recovery of longitudinal magnetization is caused by a process termed T1 recovery.
- T he decay of transverse magnetization is caused by a process termed T2 decay. (Carolyn,2011)

2-4-12 T1 recovery

T1 recovery is caused by the nuclei giving up their energy to the surrounding environment or lattice, and it is termed spin lattice relaxation . Energy released to the surrounding lattice causes the magnetic moments of nuclei to recover their longitudinal magnetization (magnetization in the longitudinal plane). The rate of recovery is an exponential process, with a recovery time constant called the T1 relaxation time . This is the time it takes 63% of the longitudinal magnetization to recover in the tissue. (Carolyn,2011)

2-4-13 T2 decay

magnetization to be lost (37% remains).(Carolyn,2011)

T2 decay is caused by the magnetic fields of neighbouring nuclei interacting with each other. It is termed spin - spin relaxation and results in decay or loss of

coherent transverse magnetization (magnetization in the transverse plane). The rate of decay is also an exponential process, so that the T2 relaxation time of a tissue is its time constant of decay. It is the time it takes 63% of the transverse

2-4-14 Data Collection and image formation

The application of all the gradients selects an individual slice and produces a frequency shift along one axis of the slice, and a phase shift along the other. The system can now locate an individual signal within the image by measuring the number of times the magnetic moments cross the receiver coil (frequency) and their position around their precessional path (phase). This information now has to be translated on to the image. When data of each signal position are collected, the information is stored as data points in the array processor of the system computer. The data points are stored in K space. (Carolyn,2011)

2-4-15 K space description

16 illustrates K space for *one slice* . K space is rectangular in shape and has two axes perpendicular to each other. The frequency axis of K space is horizontal and is centered in the middle of several horizontal lines. The phase axis of K space is vertical and is centered in the middle of K space perpendicular to the frequency axis. K space is a spatial frequency domain, i.e. where information about the frequency of a signal and where it comes from in the patient is stored. In other words, it is where information of frequencies in space or distance is stored. In this context frequency is defined as phase change over distance. (Carolyn,2011)

2-4-16 Fast Fourier transform (FFT)

The mathematics of FFT are well beyond the scope of this book but are described in its basic context here. An MR image consists of a matrix of pixels, the number of which is determined by the number of lines filled in K space

(phase matrix) and the number of data points in each line (frequency matrix). As a result of FFT, each pixel is allocated a color on a grayscale corresponding to the amplitude of specific frequencies coming from the same spatial location as represented by that pixel. Each data point contains phase and frequency information from the whole slice at a particularti me during readout. In other words, frequency amplitudes are represented in the ti me domain. The FFT process mathematically converts this to frequency amplitudes in the frequency domain. This is necessary because gradients spatially locate signal according to their frequency, not their time. (Carolyn,2011)

2-4-17 Types of acquisition

There are basically three ways of acquiring data:

- sequential
- two- dimensional volumetric
- three- dimensional volumetric.

Sequential acquisitions acquire all the data from slice 1 and then go on to acquire all the data from slice 2 (all the lines in K space are filled for slice 1 and then all the lines of K space are filled for slice 2, etc.). The slices are therefore displayed as they are acquired (not unlike computerized tomography scanning).Two - dimensional (2D) volumetric acquisitions fill one line of K space for slice 1, and then go on to fill the same line of K space for slice 2, etc. When this line has been filled for all the slices, the next line of K space is filled for slice 1, 2, 3, etc. This is the most common type of data acquisition. (Carolyn,2011)

2-4-18 Type of coil

The type of coil used affects the amount of signal received and therefore the SNR. Coil types are discussed in Chapter 9 . Quadrature coils increase SNR

because two coils are used to receive signal. Phased array coils increase SNR even more as the data from several coils are added together. Surface coils placed close to the area under examination also increase the SNR. The use of the appropriate receiver coil plays an extremely important role in optimizing SNR. In general, the size of the receiver coil should be chosen such that the volume of tissue imaged optimally fills the sensitive volume of the coil. Large coils, however, increase the likelihood of aliasing, because tissue outside the FOV is more likely to produce signal. The position of the coil is also very important for maximizing SNR. To induce maximum signal, the coil must be positioned in the transverse plane perpendicular to B 0 . Angling the coil, as sometimes happens when using surface coils, results in a reduction of SNR, (Carolyn,2011)

2-4-19 Benefits of an MRI scan

MRI scans are an important tool that doctors use to investigate the cause of your symptoms. They can help confirm the presence or absence of a disease or injury. However, the diagnosis of a condition usually requires more than a single examination or test. An MRI scan should always be used to supplement — not replace — your doctor's history-taking and examination. (Carolyn,2011)

2-4-20 Disadvantages of an MRI scan

- Risks from metal objects .MRI scans are considered to be a safe procedure providing you do not have any implants or objects on you that must not go in the scanner.The powerful magnetic fields generated by the MRI scanner will attract metal objects, often with great force. For this reason, you'll be instructed to remove all metallic belongings, such as watches, keys and jewellery. The magnetic field of the MRI scanner can also pull on any metal-containing object in your body, such as medicine pumps and aneurysm clips. In other cases, (older-style) medical implants may heat up during the scan as a result of the

technology (radiofrequency energy) that is used for the procedure. MRI scans can cause heart pacemakers, defibrillation devices and cochlear implants to malfunction. Every MRI facility will have a comprehensive screening procedure that, when carefully followed, will ensure that MRI is only used on people for whom it is safe. Many newer medical implants are now manufactured to be MRI-compatible, so once the doctors know the exact nature of your implant they'll be able to tell you if it's safe for you to have an MRI. If you do have an implant that could make an MRI unsafe, the radiologist may recommend you have a different type of scan.

- Pregnancy risks MRI is safer for the unborn child (fetus) than imaging with X-rays or CT scans. However, MRI scans can cause slight warming of the body, so as a precaution most clinics avoid MRI scanning during the first 3 months of pregnancy, unless the scan is considered essential. Beyond that, MRI scans are usually considered safe in pregnancy and are occasionally used to check on the baby's development, although non-urgent scans are generally delayed until after the baby is delivered. In some situations other scans, such as an ultrasound, may be used instead of MRI
- Gadolinium-based contrast dyes are usually avoided in pregnancy.
- Risks associated with contrast media Unlike contrast agents used in X-rays, the contrast dye used in MRI scans (gadolinium chelate) does not contain iodine and rarely causes allergic reactions (such as rashes, hives, nausea, flushing, and dizziness). Severe reactions, such as difficulty breathing and swelling of the lips and mouth, are even rarer, occurring in only about 1 in 10,000 people given gadolinium. Nevertheless, it's essential you tell the doctor and radiology practice about any previous allergic reactions you've had, especially if you've had a previous reaction to contrast media. You should also tell the radiology practice before the procedure about all medicines you are taking. In very rare cases — in

people with poor kidney function — gadolinium chelate injections can cause a serious condition called nephrogenic systemic fibrosis, which involves the build-up of fibrous tissue in the skin, joints, muscles and internal organs. If there is any chance you may have kidney problems, your doctor may organise a blood test before the scan to assess whether the gadolinium contrast dye is safe to use. (Carolyn,2011)

2-5 pervious studies

Taltisumak (2002) studied the performance of the 100 centers world wide , this study concluded that MRI is increasingly replacing CT in the imaging of hyper acute stroke patients ; however , MRI is superior when therapeutic intervention are considered and should definitely be preferred in clinical trials . most located in north America and western Europe , are currently capable of and experienced in performed DWI and PWI in hyper acute stroke patients – and the number of these centers is increasing rapidly – in the rest of the world CT is generally the only imaging modality available . it is most likely that CT and MRI will coexist for decades , and the imaging method for patients acute neurological deficits will be decided according to local conditions and patient characteristics . patients will benefit from development research of both imaging technique .

Chapter Three

Chapter three

Material and Method

3-1 Material:

3-1-1 Study Groups

The samples will be collected using different CT machines by using questionnaire; the data used in this study was collected from three hospitals in Khartoum state: Doctors hospital, National ribat hospital, Yastabshiroon medical center, the data collected from November 2016 to January 2017.

3-1-2 CT and MRI machine

Three CT and MRI machines were used to collect data during this study

Table 3-1 CT machine

Hospital	Manufacture	Model	Installation	Detect type
Doctors hospital	New soft 64	Aquition 64	2015	64 slice
National ribat hospital	New soft 128	Aquition 128	2014	128 slice
Yastabshiroon medical center	Toshiba 16	Aquition 16	2010	16 slice

3-2 MRI machine

Hospital	Manufacture	Model	Installation	Magnetic field
Doctors hospital	Philps 1.5	Aquition 1.5	2013	1.5 tesla
National ribat hospital	New soft 0.35	Aquition 0.35	2014	0.35 tesla
Yastabshiroon medical center	Siemens 0.5	Aquition 0.5	2011	0.5 tesla

3-2 Methods

3-2-1 CT and MRI protocol

3-2-1-1 CT protocol

The complete CT protocol, which includes non-enhanced CT, perfusion CT, and CT angiography, can be performed as a signal examination with separate contrast material boluses.

3-2-1-1-1Non-enhanced CT

Non-enhanced scanning must be performed as soon as possible after stroke code has been activated, Non-enhanced has two role:

- Highly sensitivity for depiction of hemorrhagic lesion , and key role of Non-enhanced is the detection of hemorrhage or other possible mimics of stroke (e.g. neoplasm , areteriovenous malformation) that could be the cause of the neurologic deficit
- The detection of ischemic signs of established infarction , the main CT finding is a cortical – subcortical hypo attenuating area within a vascular territory

3-2-1-1-2 Perfusion CT

Perfusion CT is performed by monitoring only the first pass of an iodinated contrast agent bolus through the cerebral circulation. This principle is used to generate time – attenuation curves for arterial ROI, a venous ROI, and each pixel. Perfusion CT can help distinguish the penumbra from infarcted tissue in acute stroke patients

3-2-1-1-3 CT Angiography

The main role of CT angiography is to reveal the status of large cervical and intracranial arteries and thereby help define the occlusion site , depict arterial dissection , grade collateral blood flow , and characterize atherosclerotic disease . this information helps accurately predict the extent and location of the final infarction and is very useful in providing guidance for interventional neuroradiologist prior to intra-arterial thrombolysis if available .

3-2-2 MRI protocol

3-2-2-1 T1 Weighted

- Plane : sagittal (or volumetric 3D)
- Sequence : fast – spin echo (T1 FSE) or gradient (T1 MPRAGE)
- Purpose : an anatomical
- Evaluation : cortical laminar necrosis or pseudolaminer necrosis as ribbon of intrinsic high T1 signal , usually after 2 weeks (although it can be seen easilar T2)

3-2-2-2 T2 weighted

- Plane : axial

- Sequence : T2 FSE
- Purpose :
- Loss of normal signal void in large arteries may be visible immediated
- After 6-12 hours infarcted tissue becomes high signal T2
- Sulcal effacement and mass effect develop and become maximal in the first few days

3-2-2-3 FLAIR

- Plane : axial
- Sequence : FLAIR
- Purpose :
- after 6-12 hours infarcted tissue become high signal T2
- Sulcal effacement and mass effect develop and become maximal in the first few days

3-2-2-4 Diffusion – weighted imaging (DWI)

- Plane : axial
- Sequence:DWI : B=0 , B=1000 and ADC . Purpose :
- Early identification of ischemic stroke : diffusion restriction may be seen within minutes following the onset of ischemia
- Correlates well with infarct core
- Differentiation of acute from chronic stroke

3-2-2-5 Susceptibility weighted imaging (SWE)

- Plane: axial
- Sequence: susceptibility weighted imaging (ideal) or T2
- Purpose : high sensitive in the detection of hemorrhage

3-2-2-6 MRA

3-3 image interpreting

All images of cerebral CT and MRI taken by specialists hold masters degree and divide images as follow

- according to age: A (1-19 years) B (20-39 years) C (40–59 years)D (60-79 years) E (80-99 years)
- according to gender : A (male) B (female)
- according to size : A (1-10 cm) B (11-20 cm) C (21-30 cm) D (31-40cm) E (41-50cm) G (51-60cm)
- according to site of infarction : A (frontal lobe) B (paraital lobe) C (temporal lobe) D (cerebellum) E (intraventricular) F (thalamic) G (basal ganglia)
- according to type of infarction :
- Acute infarction (1 day – 1 week) the involved area is soft and edematous and there is a blurring of anatomical detail.
- Sub acute infarction (1 week – 1 month) there is obvious tissue destruction and liquefactive necrosis of the involved brain.
- Chronic infarction (> 1 month) the damage tissue has been phagocytized and there is cavitation with surrounding gliosis.

Chapter Four

Chapter four

Result

This study adapts analytic cross sectional design to determine the role CT and MRI to diagnosis cerebral infarction in the sudanese patients at the period November to January.

Table 4-1 According to gender CT group

Gender	Frequency	Percent
Male	28	56%
Female	22	44%
Total	50	100%

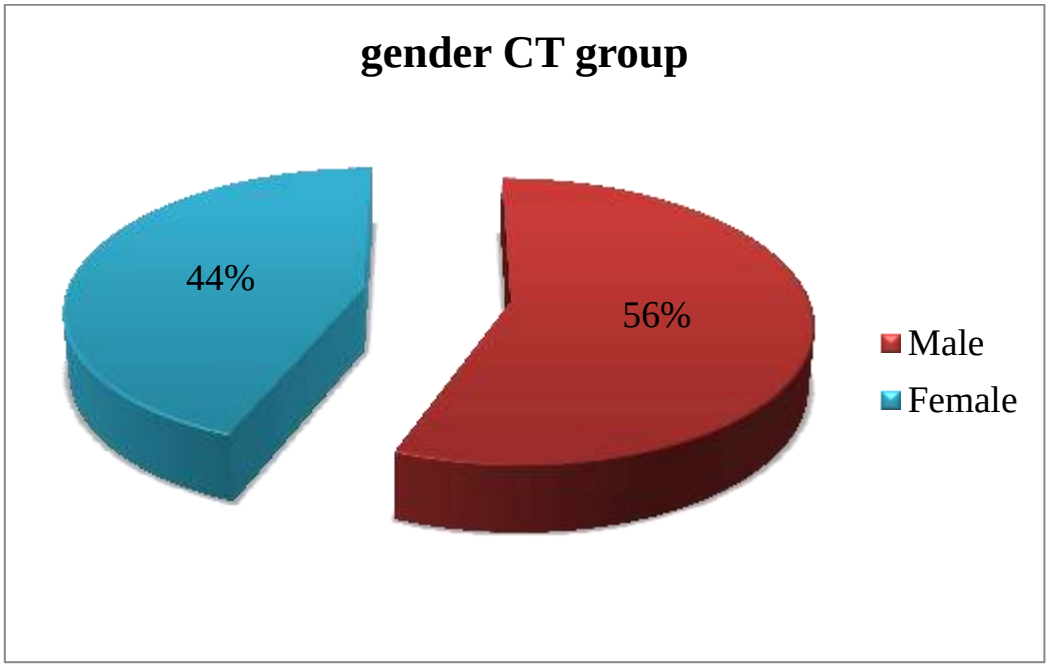

Fig 4-1 according to gender CT group

Table 4-2 According to gender MRI group

Gender	Frequency	Percent
Male	27	54%
Female	23	46%
Total	50	100%

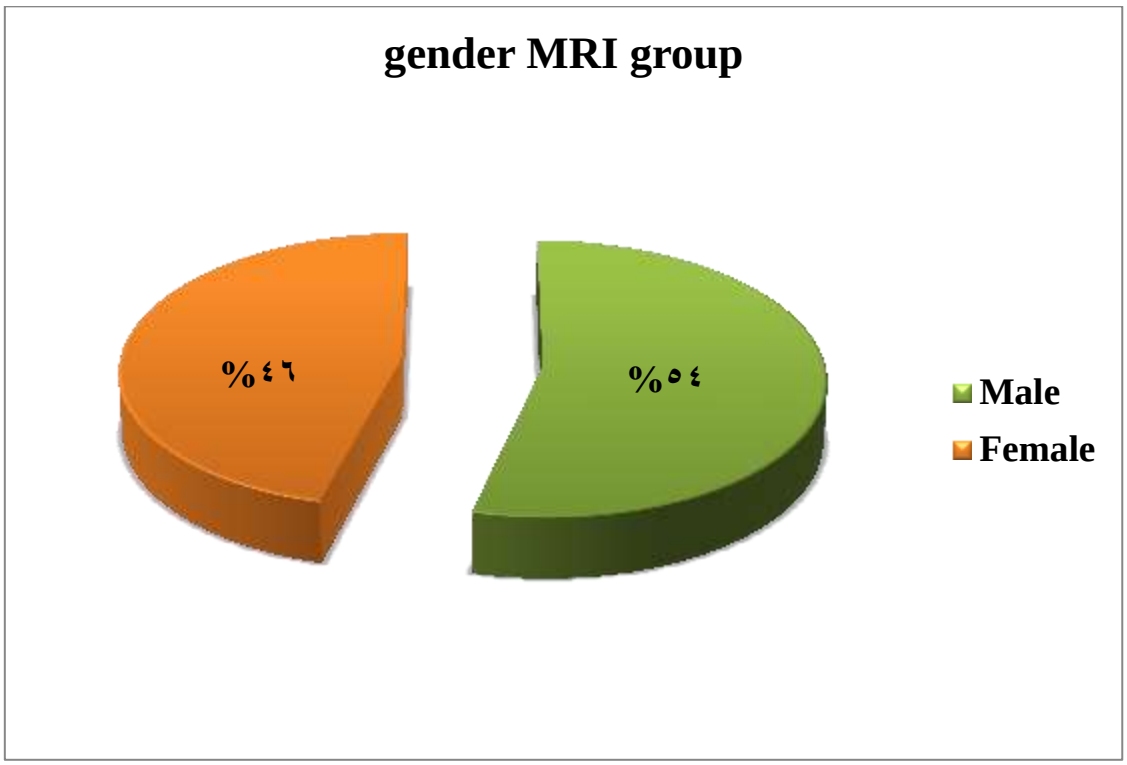

Fig 4-2 according to gender MRI group

Table 4-3 According to age CT group

Age	Frequency	Percent
0 – 19 years	0	0%
20 – 39 years	4	8%
40 – 59 years	18	36%
60 – 79 years	25	50%
80 – 99 years	3	6%
Total	50	100%

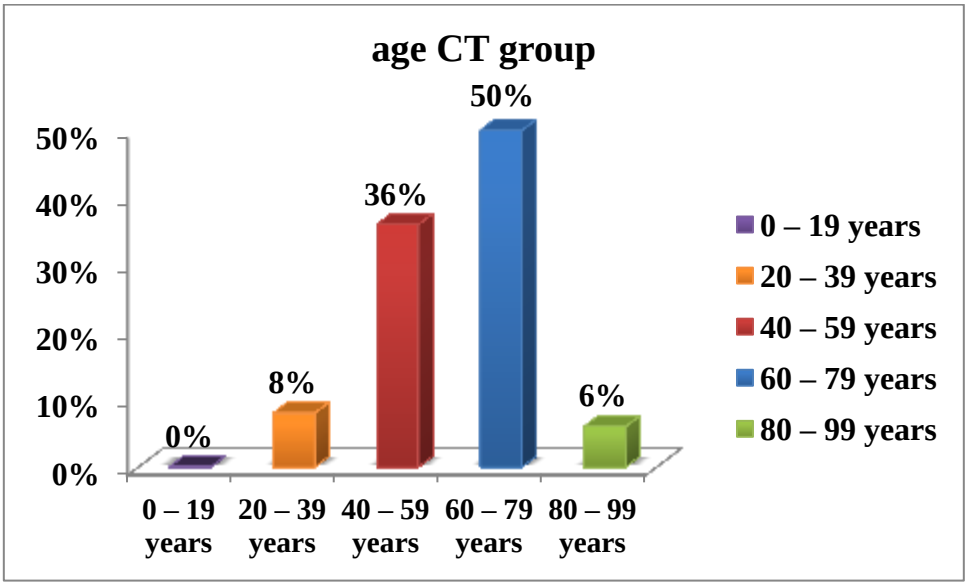

Figure 4-3 according to age CT group

Table 4-4 According to age MRI group

Age	Frequency	Percent
0 – 19 years	0	0%
20 – 39 years	8	16%
40 – 59 years	20	40%
60 – 79 years	20	40%
80 – 99 years	2	4%
Total	50	100%

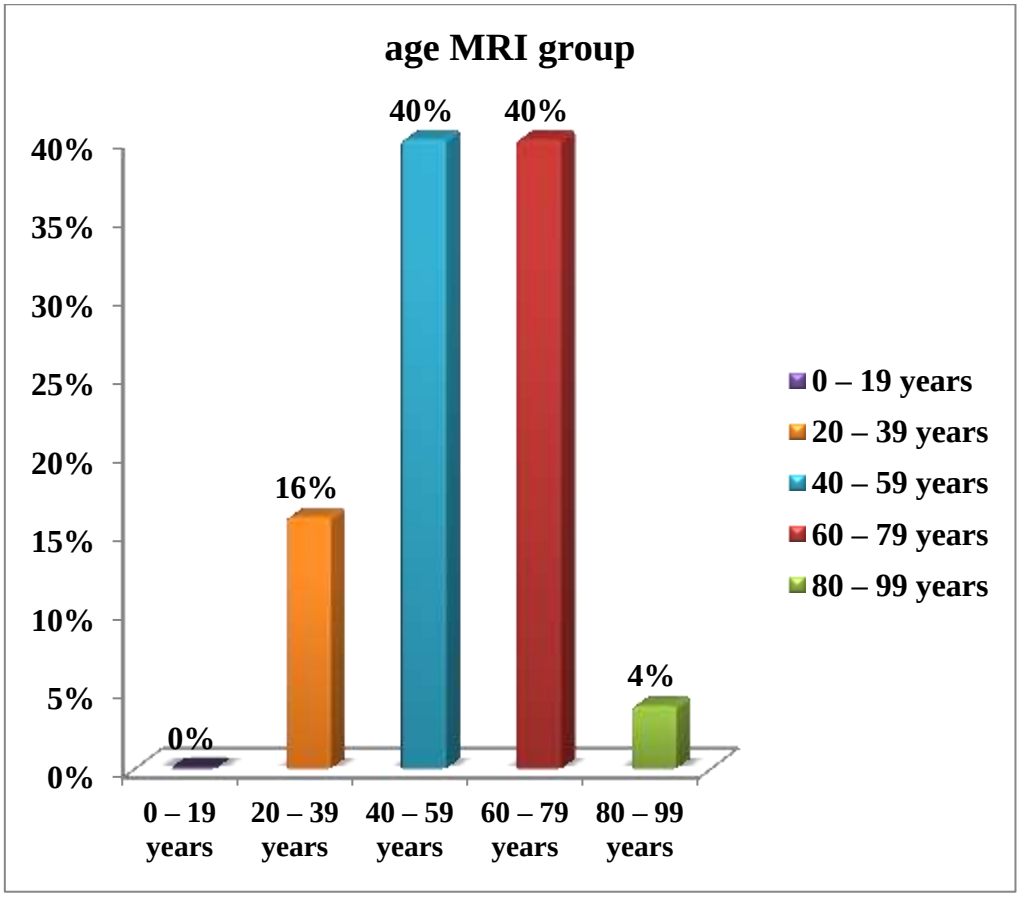

Fig 4-4according to MRI group

Table 4-5 According to size CT group

Size	Frequency	Percent
0 – 10 mm	0	0%
11 – 20 mm	2	4%
21 – 30 mm	13	26%
31 – 40 mm	23	46%
41 – 50 mm	10	20%
51 – 60 mm	2	4%
61 – 71 mm	0	0%
Total	50	100%

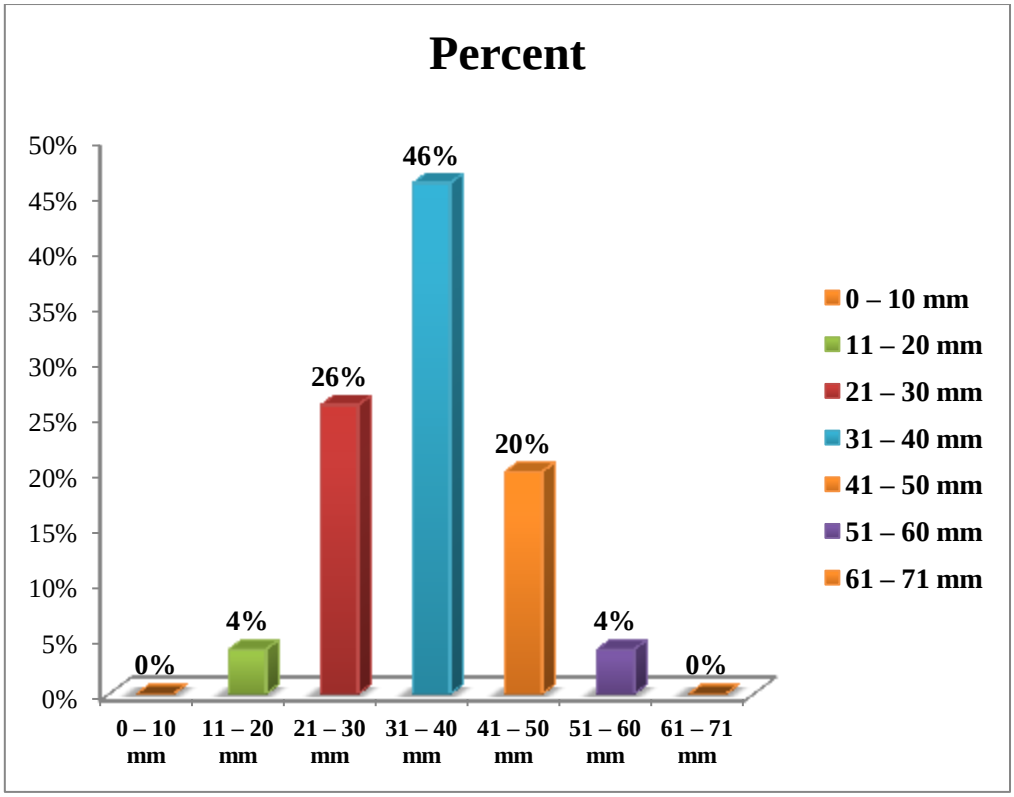

Fig 4-5 according to size CT group

Table 4-6 According to size MRI group

Size	Frequency	Percent
0 – 10 mm	0	0%
11 – 20 mm	5	10%
21 – 30 mm	9	18%
31 – 40 mm	20	40%
41 – 50 mm	16	32%
51 – 60 mm	0	0%
61 – 71 mm	0	0%
Total	50	100%

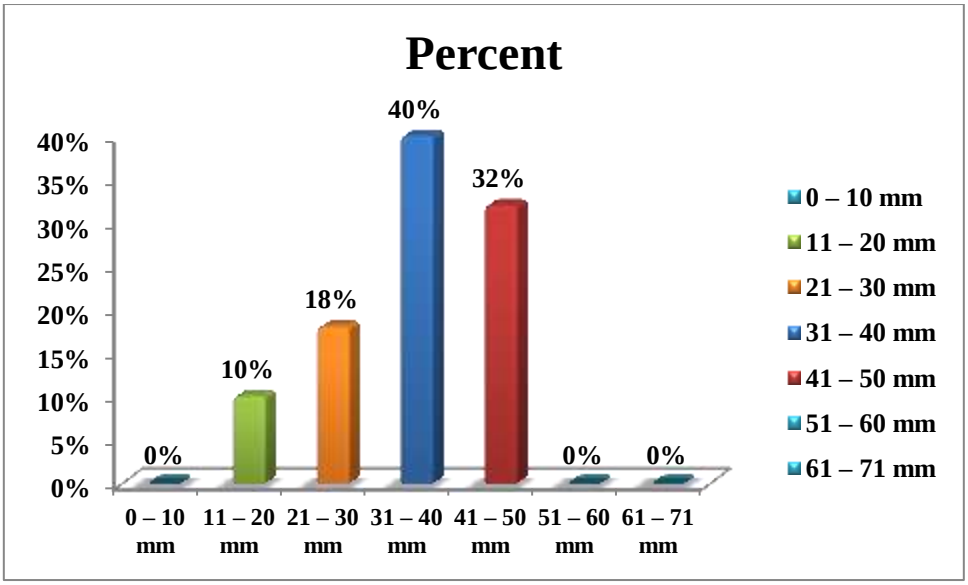

Fig 4-6 According to size MRI group

Table 4-7 According to type of infarction CT group

Type of infarction	Frequency	Percent
A cute	23	46%
Sub-acute	5	10%
Chronic	22	44%
Total	50	100%

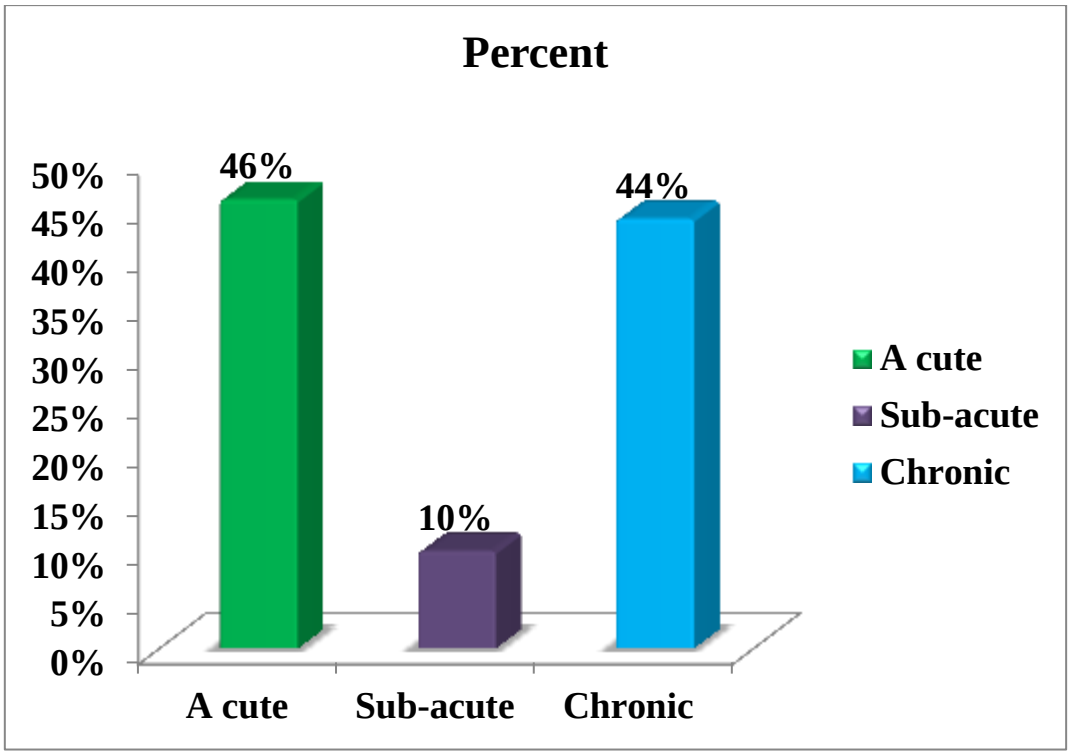

Fig 4-7 According to type of infarction CT group

Table 4-8 According to type of infarction MRI group

Type of infarction	Frequency	Percent
A cute	21	42%
Sub-acute	5	10%
Chronic	24	48%
Total	50	100%

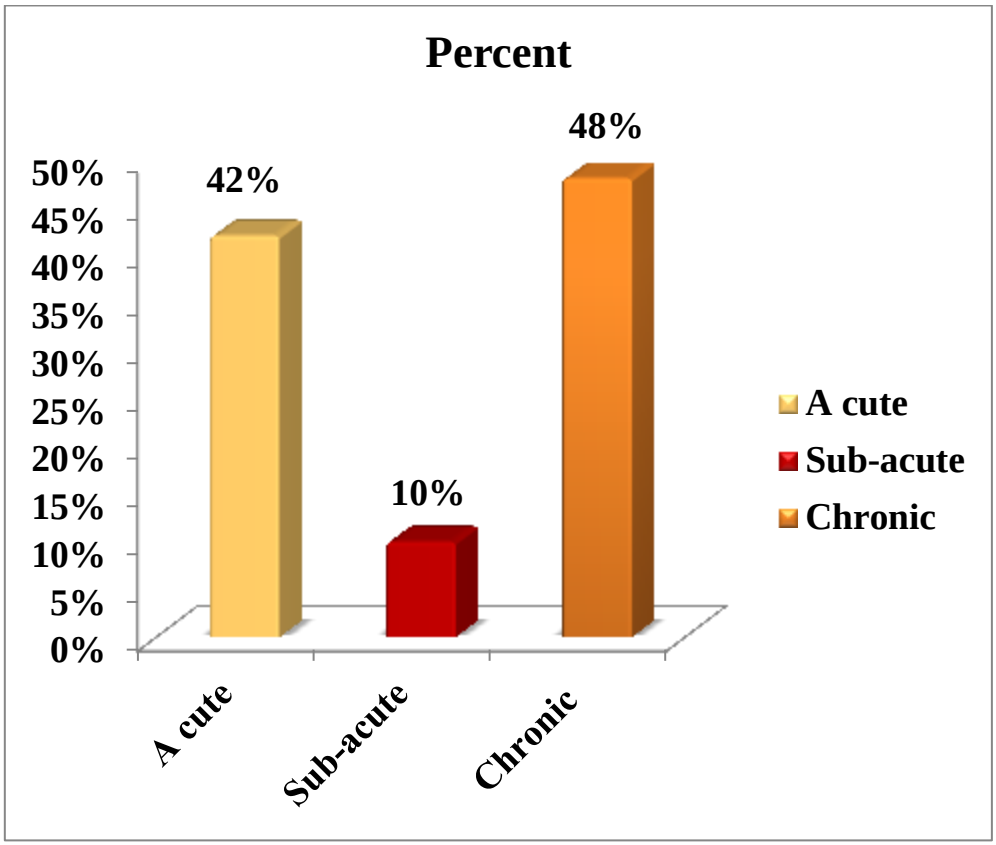

Fig 4-8 According to type of infarction MRI group

Table 4-9 According to site of infarction CT group

	Frequency	Percent
Frontal lobe	12	24%
Paraital lobe	8	16%
Temporal lobe	9	18%
Inter cerebral	10	20%
Basal gingili	5	10%
Intra ventricular	3	6%
Thalamic	2	4%
Cerebellum	1	2%
Total	50	100%

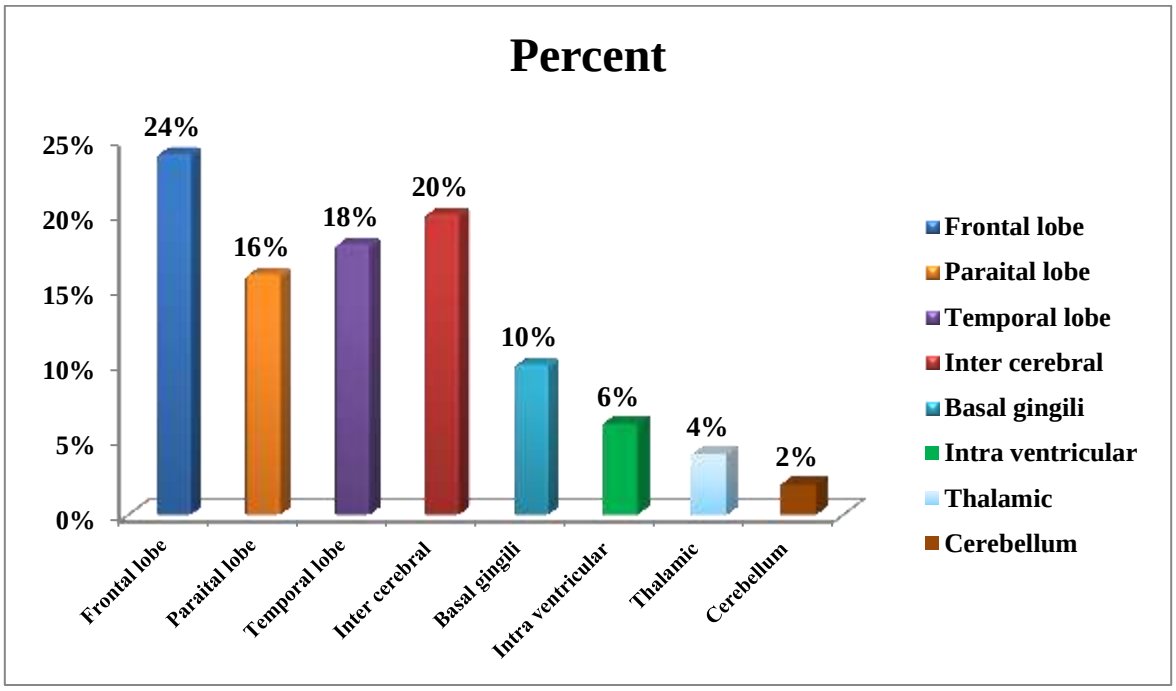

Fig 4-9 According to site of infarction CT group

Table 4-10 According to site of infarction MRI group

	Frequency	Percent
Frontal lobe	5	10%
Paraital lobe	4	8%
Temporal lobe	2	4%
Inter cerebral	15	30%
Basal gingili	5	10%
Intra ventricular	8	16%
Thalamic	4	8%
Cerebellum	7	14%
Total	50	100%

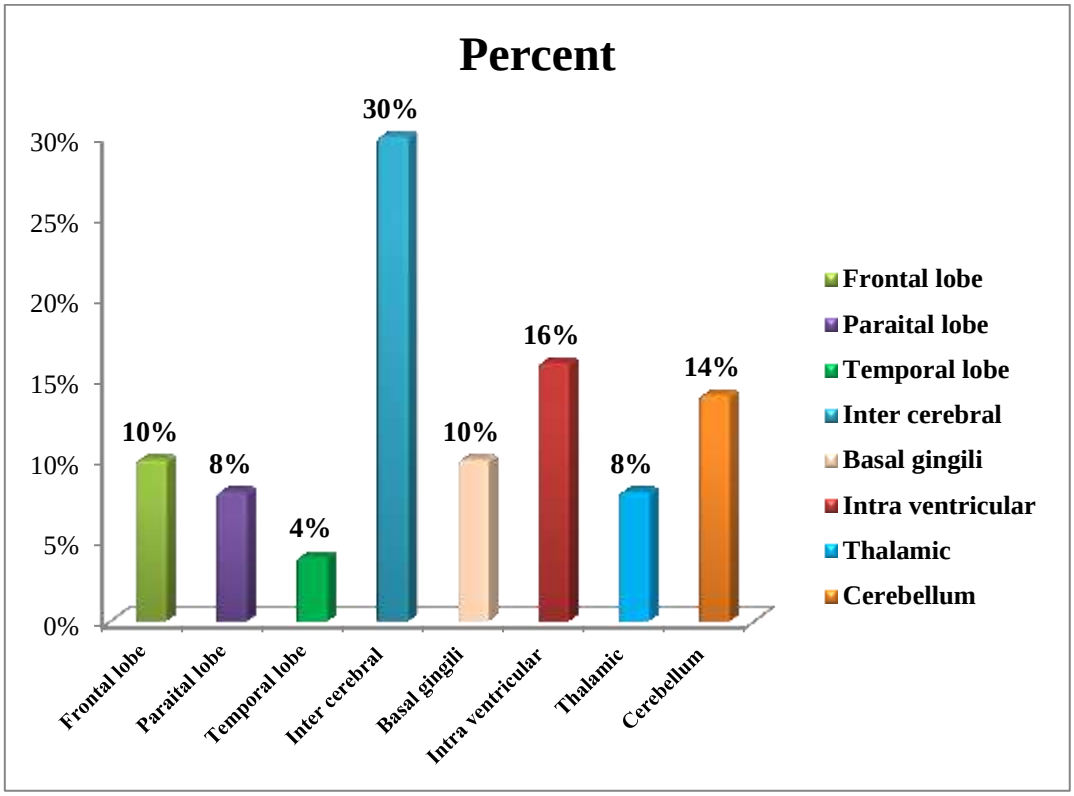

Figure 4-10 According to site of infarction MRI group

Chapter Five

Chapter five

Discussion, conclusion and recommendation

5-1 Discussion

This research evaluated role of CT and MRI in diagnosis cerebral infarction in Sudanese patients in the Khartoum state of 100 patients, 50 patients have used CT brain image and 50 patients have used MRI brain image in three different hospitals, images were obtained from the beginning signs of cerebral infarction, we divide image to see which is better for cerebral infarction CT or MRI as follows:

- According to gender in CT group we found the proportion in men 56 % and we found the proportion in women 44 %, according to gender in MRI group we found the proportion in men 54 % and we found the proportion in women 46 %.
- According to age in CT group we found the percentage of men aged between (0–19 years) 0% (20-39years) 8% (40-59years) 36% (60-79years) 50% (80–99years) 6% , according to age in MRI group we found percentage of women aged between (0–19 years) 0% (20-39years) 16% (40-59years) 40% (60-79years) 40% (80–99years) 4% .
- According to size of infarction in CT group we found the percentage of men sized per mm between (0–10 mm) 0% (11-20 mm) 4% (21-30 mm) 26% (31-40 mm) 46% (41–50 mm) 20%(51-60mm) 4% (61-70mm) 0% (71-80mm) , according to size of infarction in MRI group we found the percentage of women sized per mm between (0–10 mm) 0% (11-20 mm) 10% (21-30 mm) 18% (31-40 mm) 40% (41–50 mm) 32% (51-60mm) 0% (61-70mm) 0% (71-80mm)

- According to type of infarction in CT group we found the proportion in acute (46%) sub acute (10%) chronic (44 %), according to type of infarction in MRI group we found the proportion in acute (42%) sub acute (10%) chronic (48 %).
- According to location of infarction in CT group we found the proportion in (Frontal lobe) 24% (Paraital lobe) 16% (Temporal lobe) 18% (inter cerebral) 20% (Basal gingili) 10% (Intra ventricular) 6% (Thalamic) 4 % (Cerebellum) 2% , according to location of infarction In MRI group we found the proportion in (Frontal lobe) 10% (Paraital lobe) 8% (Temporal lobe) 4% (inter cerebral) 30% (Basal gingili) 10% (Intra ventricular) 16% (Thalamic) 8 % (Cerebellum) 4%
- In pervious study Taltisumak (2002) studied that result MRI is increasingly replacing CT in the imaging of hyper acute stroke patients, it is most likely that CT and MRI will coexist for decades, but study in Sudanese patients to compared between CT and MRI to detection cerebral infarction by used result as percentage.

5-2 Conclusion

The goal of imaging in a patient with cerebral infarction to exclude hemorrhage, and differentiate between irreversibly affected brain tissue and reversible impaired tissue and identify stenosis or occlusion of major extra and intracranial arteries.

CT has the advantage of being available 24 hours a day is the gold standard for hemorrhage, hemorrhage on MRI can be quite confusing , on CT of infarct are seen within 3-6 hrs. and virtually all are seen in 24 hours, on PD/T2wi and FLAIR as seen as high sub acute infarction after 24 hours because demonstrating hyper intensity in the territory of the middle cerebral artery.

DWI is the most sensitive sequence for stroke imaging , the sensitive to restriction of Brownian motion of extracellular water due to imbalance caused by cytotoxic edema.

CTP (CT Perfusion) was performed which demonstrated a perfusion defect, and CTA (CT angiography) was subsequently performed and dissection of the arteries

In this research we discussed the relationship of cerebral infarction with gender and we found men more simple percentage compared with women by using 100 random sample

And also we discussed the relationship of cerebral infarction with age and we found aged between 60-79 years more injured by slightly higher with aged 40-59 years by using 100 random sample

And also we discussed the relationship of cerebral infarction with size and we found most reluctance infarction frequency was 31-40 mm by slightly higher with sized 41-50 mm by using 100 random sample

And also we discussed the relationship of cerebral infarction with type infarction and we found in CT group acute infarction slightly higher than chronic infarction but in MRI group detect the chronic infarction slightly higher than acute infarction.

And also we discussed the relationship of cerebral infarction with site of infarction in CT group we found location on frontal lobe by slightly higher with intercerebral but in MRI group we found location on intercerebral by slightly higher than intraventricular

5-3 Recommendation

- In pervious studies showed that women are more susceptible to cerebral infarction than men but in this research we found that men more than women do it random sample compared to the number of samples that worked in previous research or country controls
- We found in this research and pervious studies that most patient view of cerebral infarction who exceeds the age of 45 years is because they are less movement compared with other patients.
- Dose the cerebral infarction catalysts to occur such as age, genetic factors and mental pressure ….etc.

For future studies

1. How can we reduce the incidence of cerebral infarction.
2. What are the symptoms and health problems resulting from cerebral infarction disease
3. What is motor disabilities or function expected
4. Is there a technique other than CT and MRI to her ability to detect cerebral infarction

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Appendices

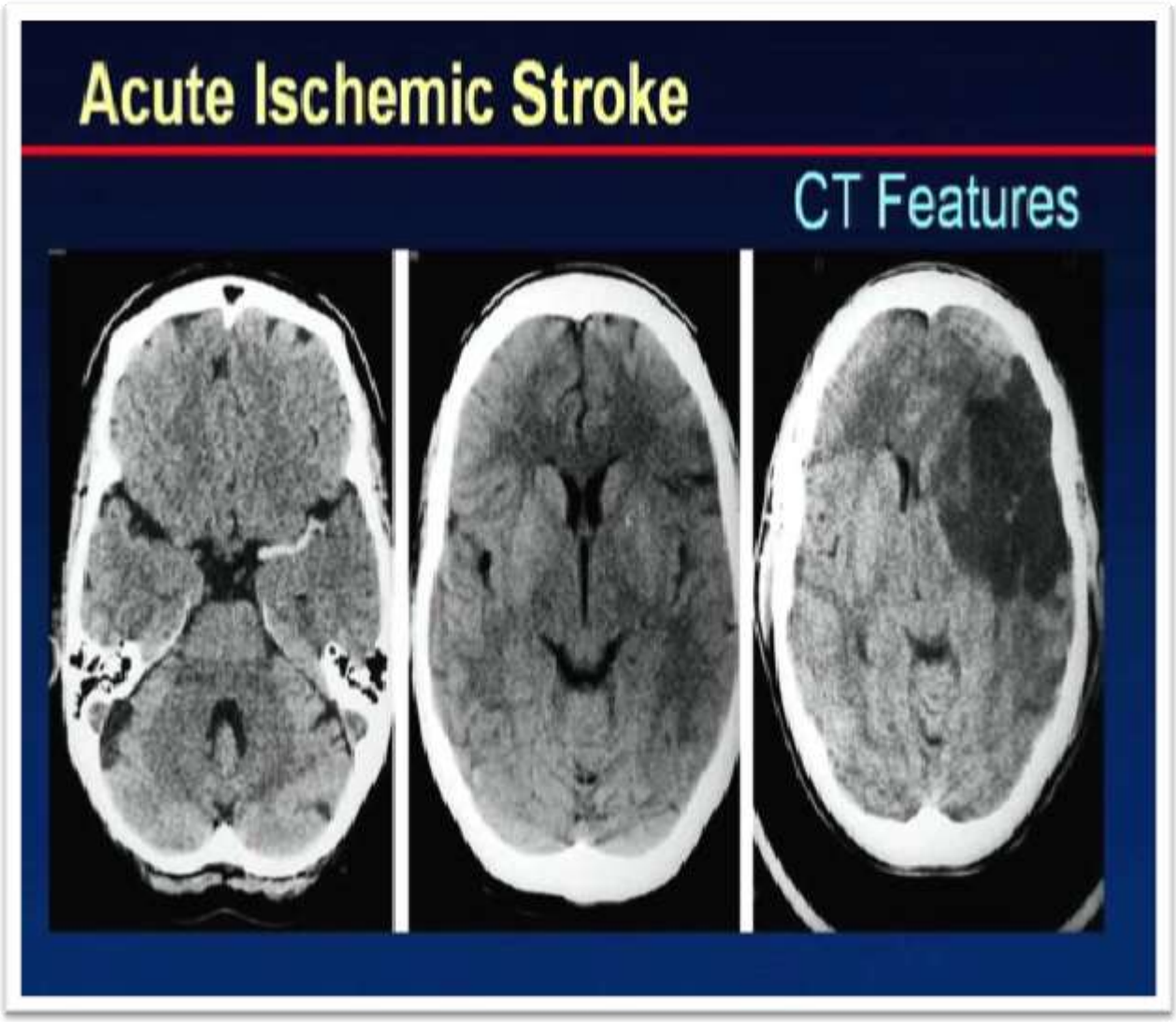

Image (1) CT acute cerebral infarction

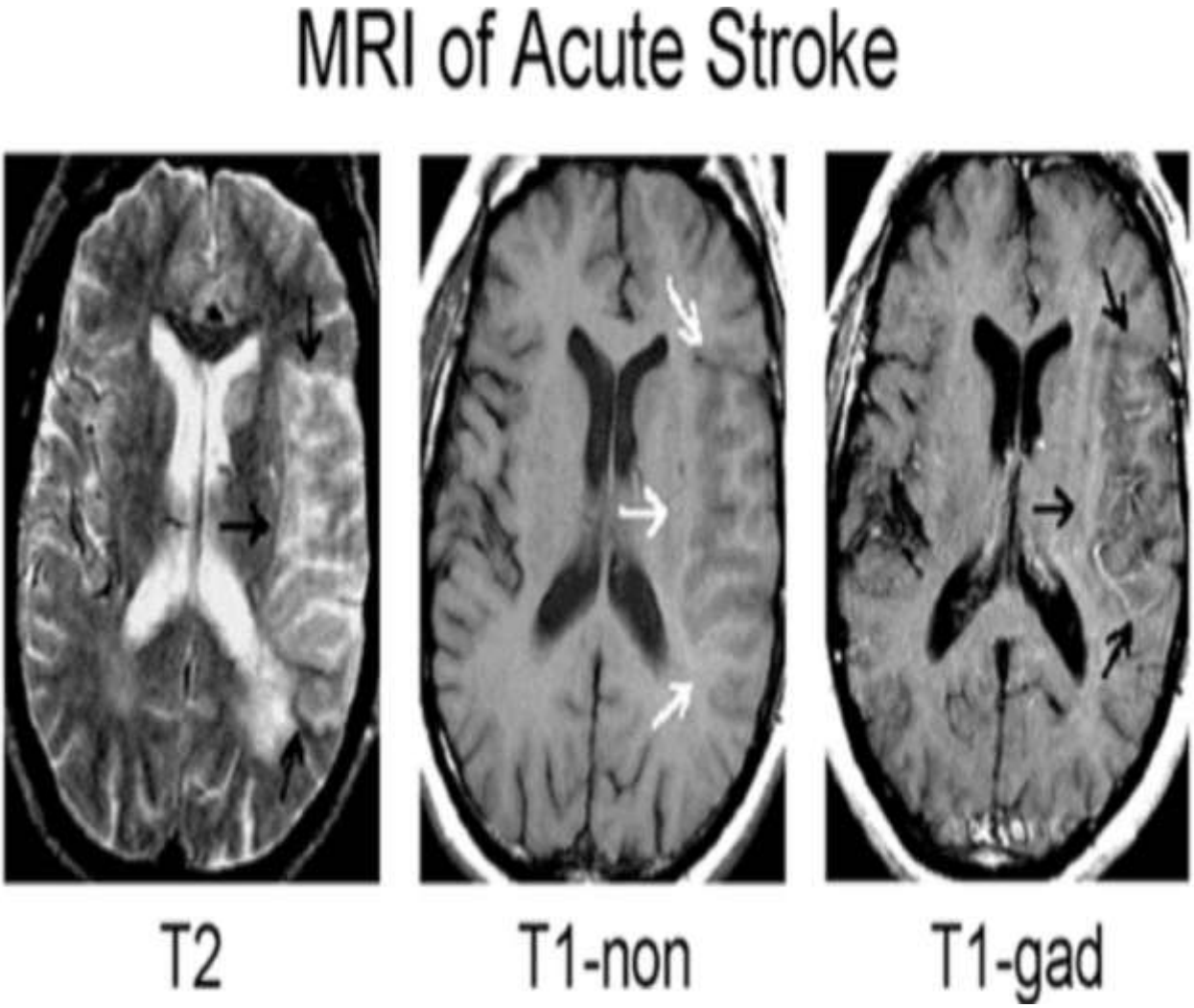

Image (2) MRI acute cerebral infarction

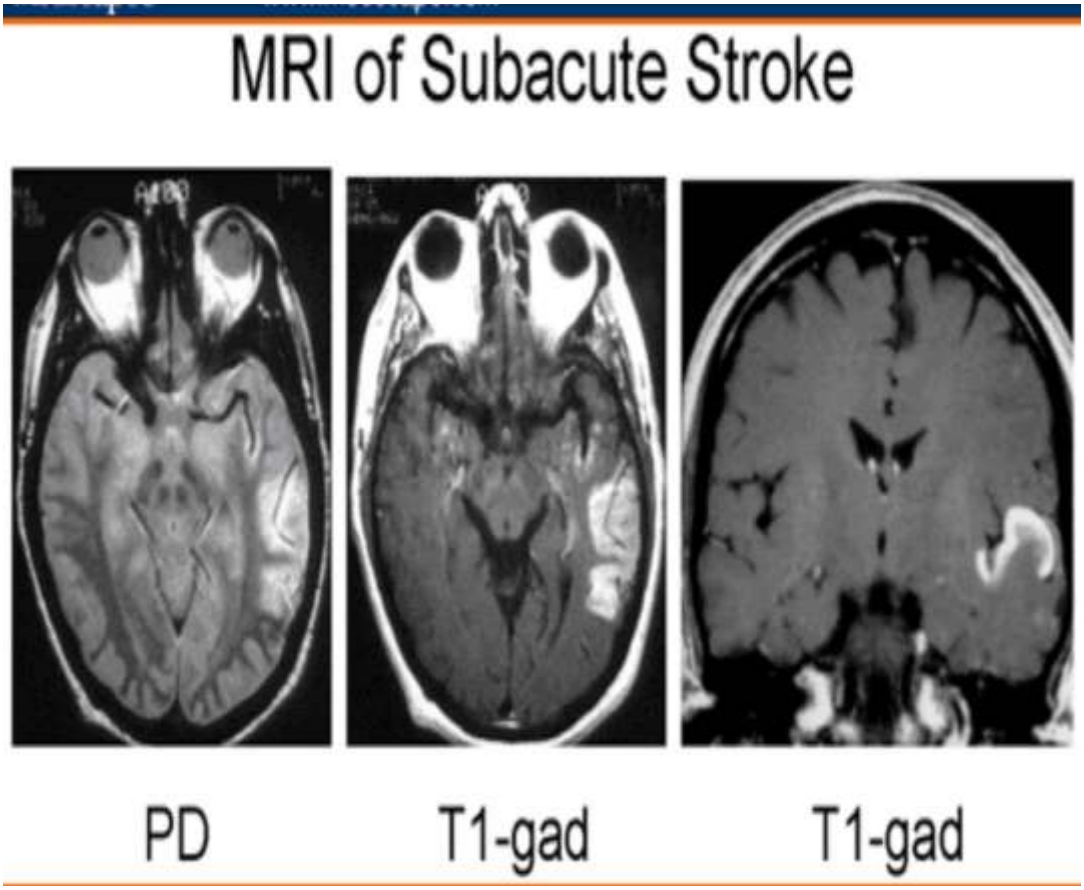

Image (3) MRI subacute infarction

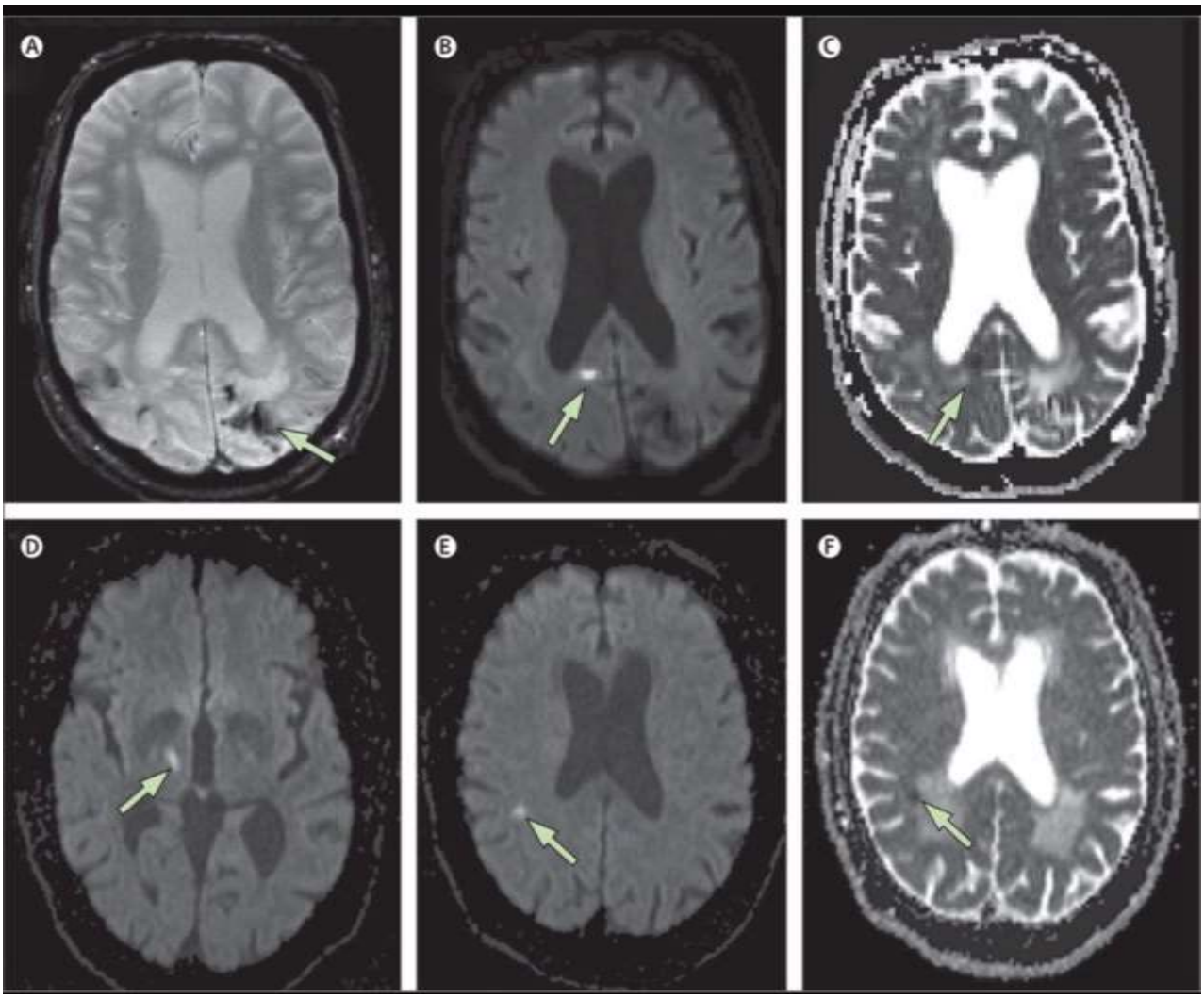

Image (4) MRI acute infarction

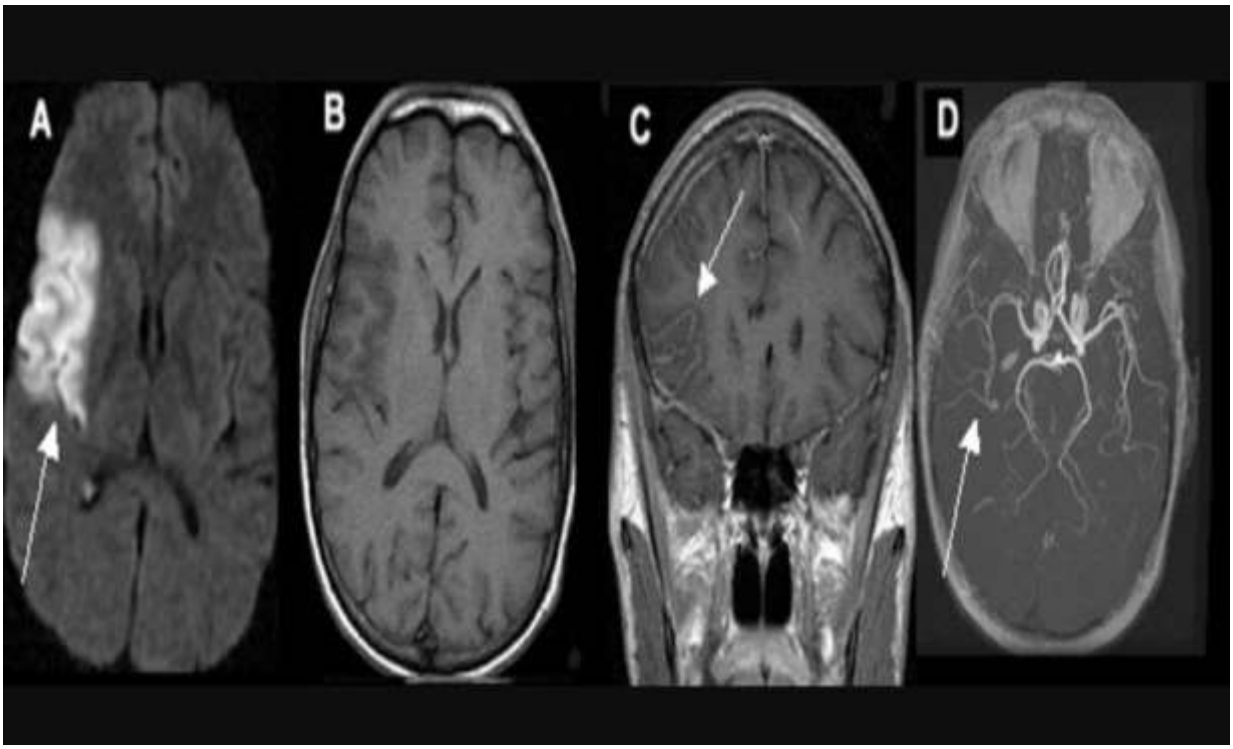

Image (5) MRI chronic infarction