Chapter One

Introduction

1.1 Anatomical Review:

The brain is the part of the central nervous system (CNS) that lies within the cranial vault, the encephalon. Its hemispheric surface is convoluted(i.e., gyrencephalic) and has gyri and sulci (Snell, 2012).

The brain divided into four major areas: the cerebrum, the diencephalon, the brainstem, and the cerebellum **(**Figure 2.1**)**

Cerebrum: The cerebrum is the largest part of the brain. It is divided into two halves called cerebral hemispheres. A thick bundle of nerve fibers called the corpus callosum connects the two hemispheres. The grooves on the surface of the cerebrum are called sulci. The “bumps” of brain matter between the sulci are called gyri, or convolutions. A deep groove called the longitudinal fissure runs between the two longitudinal hemispheres.

Cortex. The outermost layer of the cerebrum is called the cerebral cortex. It is composed of gray matter and therefore contains neuron cell bodies and dendrites. This layer contains nearly 75% of all neurons in the entire nervous system. Beneath the cerebral cortex is white matter. Besides interpreting sensory information and initiating body movements, the cortex also stores memories and creates emotions.(Snell, 2012).

Gray matter:

The gray matter of the cerebrum (or cerebral hemispheres) is deposited as a mantle on the exterior and covers the white matter lying in the interior of the hemispheres. For this reason, it is called the cortical gray matter, or cortex. The cortex (2 - 4 mm thick) consists of millions upon millions of neurons are arranged in six layers. The layers differ from each other in the size, shape, distribution, and density of population of the cell bodies and in the arrangement of the cell processes (Schottelius and Schottelius, 1978)

At many places the gray matter dips down into the brain so that folds are formed which give the hemispheres viewed from above much the appearance of the Kernel of an English walnut by this means the amount of cortical gray matter is much increased. In general, the higher animals have a more convoluted cortex than do the lower animals. The grooves are known as fissures, or sulci (singular sulcus), and the folds, as convolutions, or gyri. We may call attention to three fissures: the lateral (sylvian) fissure, the central fissure, and the longitudinal fissure, separating the two hemispheres. The cerebral cortex is divided into four major divisions: the frontal, the parietal, the occipital, and the temporal lobes. Each lobe has two or more convolutions (Schottelius and Schottelius, 1978).

White matter:

The nerve fibers, constituting the white matter of the interior of the hemispheres, are processes either of the cortical cells or of cells located in the central gray matter of the brainstem. These may be divided into three classes: projection fibers, association fibers, and commissural fibers. Projection fibers: are those that carry impulses afferently from the brainstem to the cortex and efferently from the cortex to the lower parts of the central nervous system. Association fibers: are those that originate in cortical cells and that carry impulses to other areas on the same side of the cortex. Commissural fibers: connect the two cerebral hemispheres. The corpus callosum is composed of such fibers. By this and other commissures the parts of one hemisphere are connected with corresponding parts in the other hemisphere (Schottelius and Schottelius, 1978) as shown in Figure (3).

Ventricles. Ventricles are interconnected cavities within the brain. They are filled with CSF. Recall that this fluid is also found in the subarachnoid space of the meninges and the central canal of the spinal cord. Therefore, CSF is located within the brain and spinal cord and also around the brain and spinal cord. This fluid protects and cushions the central nervous system (Figure 2.2).

Diencephalon: The diencephalon is located between the cerebral hemispheres and is superior to the brainstem. The diencephalon includes the thalamus and hypothalamus. The thalamus serves as a relay station for sensory information that heads to the cerebral cortex for interpretation.

The hypothalamus maintains balance by regulating many vital activities such as heart rate, blood pressure, and breathing rate.

Brainstem: The brainstem is a structure that connects the cerebrum to the spinal cord. The three parts of the brainstem are the midbrain, the pons, and the medulla oblongata. The midbrain lies just beneath the diencephalon. It controls both visual and auditory reflexes.

The pons is a rounded bulge on the underside of thebrain stem situated between the midbrain and the medullaoblongata. It contains nerve tracts to connect the cerebrumto the cerebellum. The pons also regulates breathing.

The medulla oblongata is the most inferior portion ofthe brain stem and is directly connected to the spinal cord.It controls many vital activities such as heart rate, bloodpressure, and breathing. It also controls reflexes associatedwith coughing, sneezing, and vomiting.

Cerebellum: The cerebellum is inferior to the occipital lobes of the cerebrum and posterior to the pons and medulla oblongata. It coordinates complex skeletal muscle contractions that are needed for body movements. For example, when you walk, many muscles have to contract

and relax at appropriate times. Your cerebellum coordinates these activities. The cerebellum also coordinates fine movements such as threading a needle, playing an instrument, and writing (Kathryn and Terri, 2008).

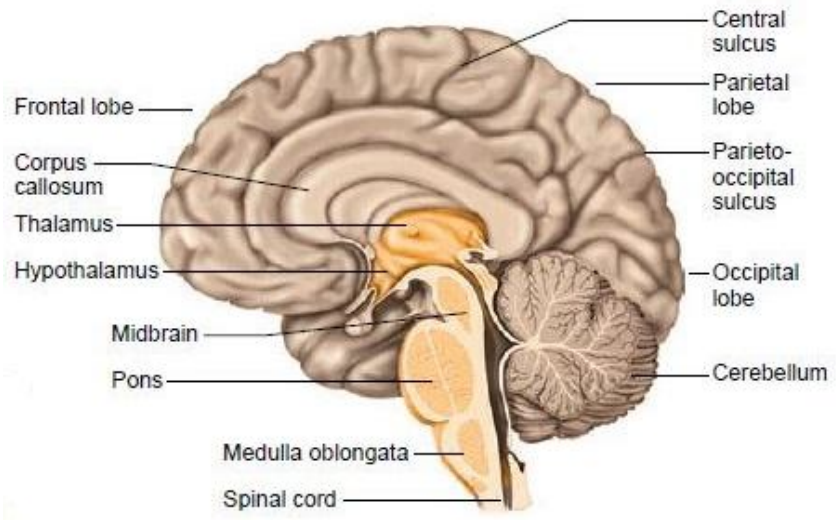


Fig. 1.1: The Sagittal section view of the brain (Kathryn and Terri, 2008)

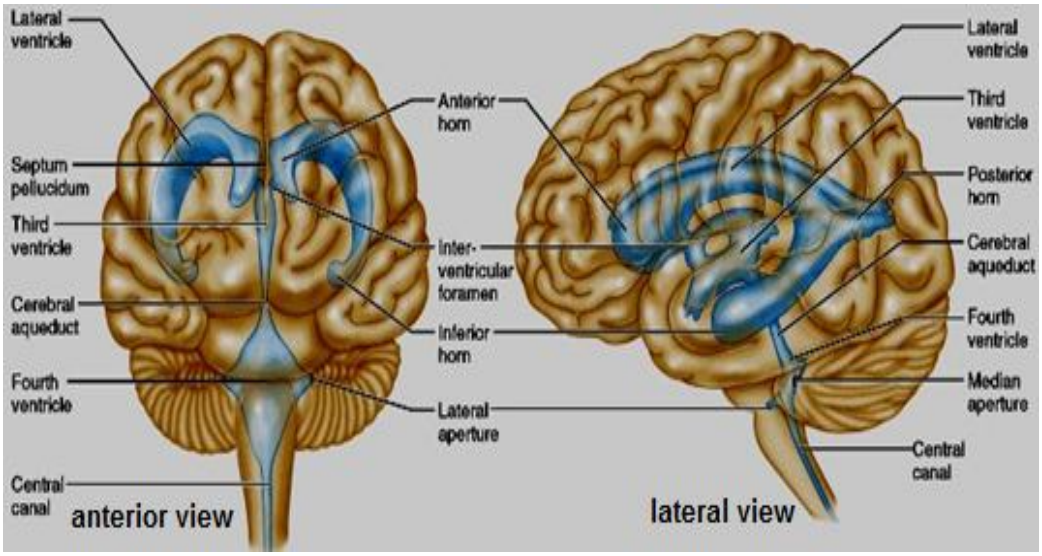


Fig 1.2 The ventricular system of the brain (Snell, 2012).

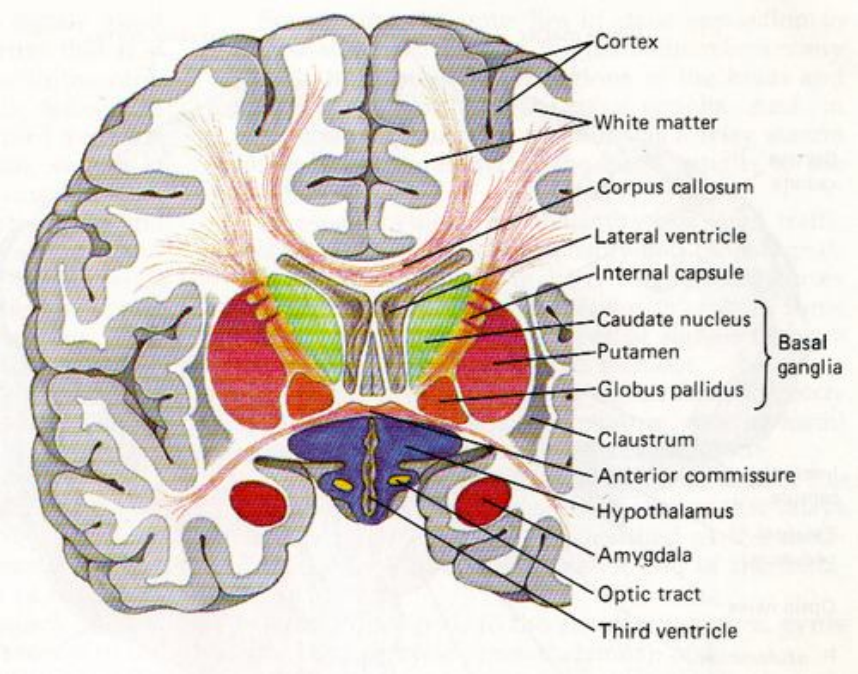


Fig. 1.3: Some internal structures of the brain and highlighting the white and gray matter(Snell, 2012).

Midbrain:

The midbrain is the narrow part of the brain that passes through the tentorial notch and connects the forebrain to the hindbrain.

The midbrain comprises two lateral halves, called the cerebral peduncles; each of these is divided into an anterior part, the crus cerebri, and a posterior part, the tegmentum, by a pigmented band of gray matter, the substancia-nigra. The narrow cavity of the midbrain is the cerebral

aqueduct, which connects the third and fourth ventricles. The tectum is the part of the midbrain posterior to the cerebral aqueduct; it has four small surface swellings, namely, the two superior and two inferior colliculi. The colliculi are deeply placed between the cerebellum and the cerebral hemispheres. The pineal body is small glandular structure that lies between the superior colliculi. It is attached by a stalk to the region of the posterior wall of the third ventricle. A small recess of the ventricles, called the pineal recess, extends into the base of the stalk. The pineal commonly calcifies in middle age, and thus it can be visualized on radiographs (Snell, 2012)

Hindbrain:

The pons is situated on the anterior surface of the cerebellum below the midbrain and above the medulla oblongata. It is composed mainly of nerve fibers, which connect the two halves of the cerebellum. It also contains ascending and descending fibers connecting the forebrain, the midbrain, and the spinal cord. Some of the nerve cells within the pons serve as relay stations, while others form cranial nerve nuclei.

The medulla oblongata is conical in shape and connects the pons above to the spinal cord below. A median fissure is present on the anterior surface of the medulla, and on each side of this is a swelling, called the pyramid. The pyramids are composed of bundles of nerve fibers that originate in large nerve cells in the precentralgyrus of the cerebral cortex. The

pyramids taper below, and here the majority of the descending fibers cross over to the opposite side, forming the decussating of the pyramids.

Posterior to the pyramids are the olives, which are oval elevations, produced by the underlying olivary nuclei. Behind the olives are the inferior cerebral peduncles, which connect the medulla to the cerebellum.

On the posterior surface of the inferior part of the medulla oblongata are the gracile and cuneate tubercles, produced by the medially placed underlying nucleus gracilis and the laterally placed underlying nucleus cuneatus.

The cerebellum lies within the posterior cranial fossa beneath the tentorium cerebelli. It is situated posterior to the pons and the medulla oblongata. It consists of two hemispheres connected by a median portion, the vermis. The cerebellum is connected to the midbrain by the superior cerebellar peduncles, to the pons by the middle cerebellar peduncles, and to the medulla by the inferior cerebral peduncles. The surface layer of each cerebellar hemisphere, called the cortex, is composed of gray matter. The cerebellar cortex is thrown into folds, or folia, separated by closely set transverse fissures. Certain masses of gray matter are found in the interior of the cerebellum, embedded in the white matter; the largest of these is known as dentate nucleus. The cerebellum plays an important role in the control of muscle tone and the coordination of muscle movement on the same side of the body. The cavity of the hindbrain is

the fourth ventricle. This is bounded in front by the pons and the medulla oblongata, and behind by the superior and inferior medullary vela and the cerebellum. The fourth ventricle is connected above to the third ventricle by the cerebral aqueduct, and below it is continuous with the central canal of the spinal cord. It communicates with the subarachnoid space through three opening in the lower part of the roof, a median and two lateral openings (Snell, 2012).

Dural venous sinuses:

The dural venous sinuses are venous channels located intracranially between the two layers of dura mater (endosteal layer and meningeal layer). They can be conceptualised as trapped epidural veins. Unlike other veins in the body they run alone, not parallel to arteries. Furthermore, they are valveless, allowing for bidirectional blood flow in intracranial veins. It is also important to note that the draining territories of intracranial veins are different from those of major cerebral arteries.(Standring S, 2011).

Superior sagittal sinus:

The **superior sagittal sinus** is the largest dural venous sinus. As the name suggests, it runs in a sagittal plane from the anterior aspect of the falxcerebri to its termination at the confluence of sinuses at the occipital protuberance, where it usually proceeds rightward and into the

right transverse sinus. It receives venous blood from the cortical veins through the cerebral hemispheres (Drake et al, 2008).

Inferior sagittal and straight sinuses:

The inferior sagittal sinus is in the inferior margin of the falxcerebri. It receives a few cerebral veins and veins from the falxcerebri, and ends posteriorly at the anterior edge of the tentorium cerebella, where it is joined by the great cerebral vein and together with great cerebral vein forms the straight sinus. The straight sinus continues posteriorly along the junction of the falxcerebri and the tentorium cerebelli and ends in the confluence of sinuses, usually bending to the left to empty into the left transverse sinus (Drake et al. 2005).

The straight sinus usually receives blood from the inferior sagittal sinus, cerebral veins from the posterior part of the cerebral hemispheres, the great cerebral vein draining deep areas of the cerebral hemispheres, superior cerebellar veins, and veins from the falxcerebri. Confluence of sinuses, transverse and sigmoid sinuses:

The superior sagittal and straight sinuses, and the occipital sinus (in the falxcerebelli) empty into the confluence of sinuses, which is a dilated space at the internal occipital protuberance and is drained by the right and left transverse sinuses. The paired transverse sinuses extend in horizontal directions from the confluence of sinuses where the tentorium cerebella joins the lateral and posterior walls of the cranial cavity. The right

transverse sinus usually receives blood from the superior sagittal sinus and the left transverse sinus usually receives blood from the straight sinus. The transverse sinuses also receive blood from the superior petrosal sinus, veins from the inferior parts of the cerebral hemispheres and the cerebellum, and diploic and emissary veins. As the transverse sinuses leave the surface of the occipital bone, they become the sigmoid sinuses, which turn inferiorly, grooving the parietal, temporal, and occipital bones, before ending at the beginning of the internal jugular veins. The sigmoid sinuses also receive blood from cerebral, cerebrallar, diploic, and emissary veins (Drake et al. 2008).

Cavernous sinuses:

The paired cavernous sinuses are against the lateral aspect of the body of the sphenoid bone on either side of the sellaturica. The cavernous sinuses receive blood not only from cerebral veins, but also from the ophthalmic veins (from the orbit) and emissary veins (from the ptrygoid plexus of veins in the inferotemporal fossa). Connecting the right and left cavernous sinuses are the intercavernous sinuses on the anterior and posterior sides of the pituitary stalk. Sphenoparietal sinuses drain into the anterior ends of each cavernous sinus. These small sinuses are along the inferior surface of the lesser wings of the sphenoid and receive blood from the diploic and meningeal veins (Drake et al. 2008).

Superior and inferior petrosal sinuses:

The superior petrosal sinuses drain the cavernous sinuses into the transverse sinuses. Each superior petrosal sinus begins at the posterior end of the cavernous sinus, passes posterolaterally along the superior margin of the petrous part of each temporal bone, and connects to the transverse sinus. The superior petrosal sinuses also receive cerebral and cerebellar veins. The inferior petrosal sinuses also begin at the posterior ends of the cavernous sinuses. These bilateral sinuses pass posteroinferiorly in a groove between the petrous part of the temporal bone and the basal part of the occipital bone, ending in the internal jugular veins. They assist in draining the cavernous sinuses, and also receive blood from cerebellar veins, and veins from the internal ear and brainstem. Basilar sinuses connect the inferior petrosal sinuses to each other and to the vertebral plexus of veins. They are on the clivus, just posterior to the sellaturcica of the sphenoid bone (Drake et al. 2008)

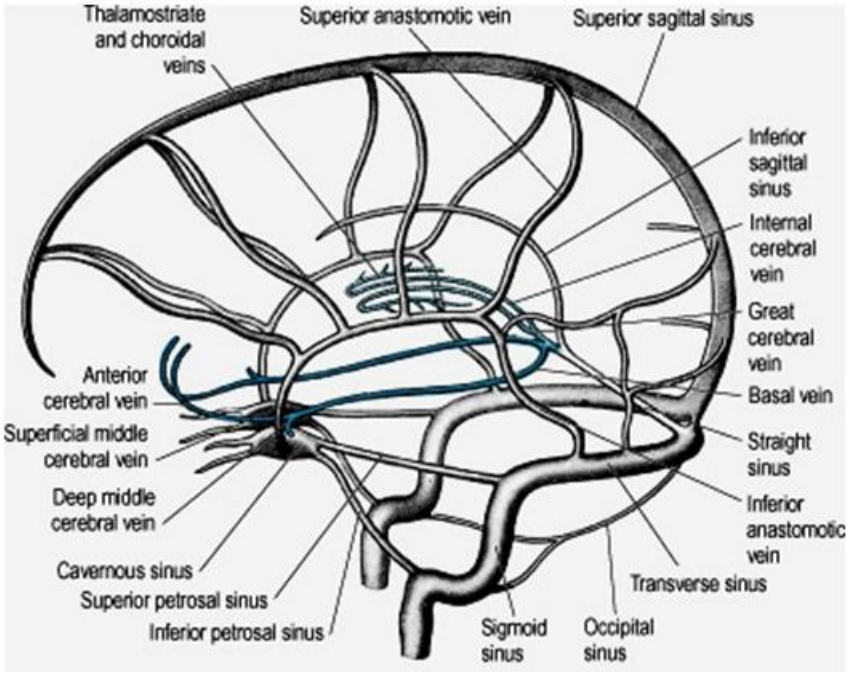


Fig 1.4 The venous drainage of the brain(Drake et al. 2008)

Pathology of the Brain

Neurological disorders are diseases of the central and peripheral nervous system. In other words, the brain, spinal cord, cranial nerves, peripheral nerves, nerve roots, autonomic nervous system, neuromuscular junction, and muscles. These disorders include epilepsy, Alzheimer disease and other dementias, cerebrovascular diseases including stroke, migraine and other headache disorders, multiple sclerosis, Parkinson's disease, neuroinfections, brain tumours, traumatic disorders of the nervous system such as brain trauma, and neurological disorders as a result of malnutrition.

Brain coma

Coma is defined as a state where the brain is no longer alert and the body does not respond to inner or external stimuli. Common causes of coma include brain injury, thrombosis, embolism, brain tumor, metabolic disease, nutritional deficiency, poisoning and brain infection caused by falciparum malaria, tuberculosis, or syphilis, for example. In some cases, loss of consciousness may be only partial and this is termed altered consciousness (Sudhir, 2008).

Epilepsy

This is caused by abnormal electrical activity in the brain (Sudhir, 2008).

Stroke

Interruption of the blood supply to the brain can lead to paralysis and other complications. The risk factors for stroke include high blood pressure, diabetes, obesity, high blood cholesterol, smoking, excessive alcohol abuse, previous stroke, use of birth control pills and genetic predisposition (Sudhir, 2008).

Types of Stroke

There are three main kinds of stroke; first type is Ischemic strokes happens when blood vessels are blocked by a clot or become too narrow for blood to get through to the brain, the reduced blood flow causes brain cells in the area to die from lack of oxygen, It accounts for more than 80% of all stroke cases, second 9 type is Hemorrhagic strokes it occurs when a weakened blood vessel ruptures, third type is Transient ischemic attacks (TIAs) also referred to as mini-strokes are caused by a temporary clot (Schwamm et al, 2005).

Embolic or ischemic stroke: An ischemic stroke occurs when a blood clot blocks a blood vessel, preventing blood and oxygen from getting to a part of the brain. There are two ways that this can happen. When a clot forms somewhere else in your body and gets lodged in a brain blood vessel, it is called an embolic stroke. When the clot forms in the brain blood vessel, it is called a thrombotic stroke.

Hemorrhagic stroke:

A hemorrhagic stroke occurs when a blood vessel ruptures, or hemorrhages, which then prevents blood from getting to part of the brain. The hemorrhage may occur in a blood vessel in the brain, or in the membrane that surrounds the brain.

Texture Analysis: Images component can be describe using computer facilities by decoding texture using several statistical

methodsasTextureanalysis approaches to texture analysis are usually categorized into structural, statistical, model-based and transform.

methods. Structural approaches.represent texture by well- defined primitives (microtexture) and a hierarchy of spatial arrangements (macrotexture) of those primitives. To describe the texture, one must define the primitives and the placement rules. The choice of a primitive (from a set of primitives) and the probability of the chosen primitive to be placed at a particular location can be a function of location or the primitives near the location. The advantage of the structural approach is that it provides a good symbolic description of the image; however, this feature is more useful for synthesis than analysis tasks. The descriptions can be will defined for natural textures because of the variability of both micro- and macrostructure and no clear distinction between them. A powerful tool for structural texture analysis is provided by mathematical morphology. It may prove to be useful for bone image analysis, e.g. for the detection of changes in bone microstructure. In contrast to structural methods, statistical approaches do not attempt to understand explicitly the hierarchical structure of the texture. Instead, they represent the texture indirectly by the non-deterministic properties that govern the distributions and relationships between the grey levels of an image. Methods based on second-order statistics have been shown to achieve higher discrimination rates than the power spectrum (transform-based) and structural

methods.Human texture discrimination in terms of texture statistical properties is investigated in. Accordingly, the textures in grey-level images are discriminated spontaneously only if they differ in second order moments. Equal second- order moments, but different third-order moments require deliberate cognitive effort. This may be an indication that also for automatic processing, statistics up to the second order may be most important.The most popular second-order statistical features for texture analysis are derived from the so-called co-occurrence matrix. They were demonstrated to feature a potential for effective texture discrimination in biomedical-images. The approach based on multidimensional co-occurrence matrices was recently shown to outperform wavelet packets (a transform-based technique) when applied to texture classification

Signs and Symptoms of Stroke:

Strokes occur quickly, and as such their symptoms often appear suddenly without warning like sudden numbness, confusion, trouble seeing and severe headache. The acronym FAST is a way to remember the signs of stroke, and can help toward identifying the onset of stroke in someone, F for Face drooping Arm weakness Speech difficulty Time to look for help (Schwamm et al, 2005).

Diagnose of Stroke:

There are several different types of diagnostic tests that can use in order to diagnose stroke including clinical examinations, lab test and imaging studies Clinical examinations: checking patient's symptoms, medical history, check blood pressure, listen to the carotid arteries in the neck and examine the blood vessels at the back of the eyes. Lab test is complete blood count (CBC) is a routine test to determine the number of red blood cells, white blood cells, and platelets in the body. Imaging modalities incudes CT, MRI, carotid ultrasound and cerebral angiogram (Schwamm et al, 2005).

Brain infection

Infections of the brain may affect the brain or the meninges. The brain is more prone to infection compared to other organs of the body such as the heart. Infections may be viral, bacterial or fungal(Sudhir, 2008).

Multiple sclerosis

Multiple sclerosis describes a condition where the protective myelin coating surrounding nerve fibres is damaged in the brain and spine causing problems with muscle movement, vision and balance. (Sudhir, 2008).

Such system like any others in the human body that could be involved by many factors and parameters. In such context; Brain ventricle volumes denote variability in some diseases such as hydrocephalus (Chiang et al, 2009), schizophrenia (Shenton et al, 2001), Alzheimer's (Nestor et al, 2008), and a group of neurodegenerative disorders (Whitwell et al, 2007), but some of these diseases also represent parenchymal atrophy leading to ventricle/brain ratio changes (Whitwell et al, 2007). In the same realm Coffey et al, (1998) showed different results related to brain ventricle volume and gender. Also, in the study carried out by Rania et al, (2018) in which they carried out a morphometric of hepatic ducts angle has been measured and related to some pathologies forthe importance of overcoming some further invasive techniques and deducing valuable diagnostic findings by using Image J\ImageJ.exe software program. Another morphometric study done by Mohammed et al, (2014) in which they used CT imaging to measure the cranial volume and correlated with the common pathologies that influencing their dimension such as brain ventricle volume and cranial volume. Their results revealed that: the incidence of pathologies that influencing the brain ventricle volumes and cranial volume was higher among male with 62% relative to 38% among female and the common pathology that influences the cranial and brain volume was the hydrocephalus taking a percent of 40.5%, mixed

(hydrocephalus and tumor) represents 23%, tumors 21.5% and schizophrenia 15%.

Despite many authors contribute in this domain, the gender and age impact in ventricle and brain changes is still obscure, therefore further studies may be in needful to this scope; as aging studies showed recently has an impact in human behavior, thinking and even responding to surrounding environment based on hypothesis called age differentiation (Anders and Kristine, 2010).

The trend and focus of this study are to reveal the impact of aging in cranial and ventricular system morphometry as well as the impact on medical imaging signals such as magnetic resonance imaging (T_1& T_2) and computerized tomography CT Hounsfield Unit (HU). Such trend will be based and rely on the fact that: signal intensity would provide independent biomarker for all anatomical structures with relative alteration during man development, aging and pathologies involvement (Salat et al., 2009; Westlye et al., 2009).

In medical field, the imaging modalities basically applied for diagnostic possibilities with different accuracy and relative hazards accordingly and moreover for texture analysis (Georgiadis et al, 2006; Deswal and Sharma, 2014). However, the morphometry could be derived from the images with the usage of algorithmic equation incorporated to the

relevant system (CT, MRI, U/S, NM) in addition to medical software program applied to retrieved image or DICOM.

1.2 The problem of the study:

The increased incidence of geriatric consequences and cranial pathologies that induce ventricular volume change as well as the lack of diagnosis could be considered as a main problem.

1.3 General objective:

Study of Brain Geriatric Consequences in Sudan using CT, MRI

1.4 Specific Objectives:

- To measure the ventricular volume and correlated with gender and age.
- To correlate the cranial dimension with gender and age.
- To correlate between the ventricular volume and cranial dimension.
- Correlation of HU of gray and white matter per area versus aging and pathology.
- To correlation of signal intensity and age

1.5 Thesis outline:

The following thesis will be built in five chapters. Chapter one will deal with introduction, problem of the study, objectives and thesis outline. Chapter two will highlight the literature review. Chapter three will express the methodology of the study. Chapter four will show the results and discussion. Chapter five will concern with the conclusion, recommendation, references and appendices.

Chapter Two

Literature Review

Relative to previous studies related to diseases and aging impact on brain and ventricular system volume, there were some scholars caring about. For instance: studies related to parameters of cranial volume and brain ventricles using CT (Akdogan et al, 2010), MRI (Jay et al, 1999;Shentonet al, 2001) and ultrasound (Chowdhary et al, 1992; Shahet al, 1993). One of the results related to brain ventricle volume, cranial volume and inter-cranial volume or dimension of maximum lateral ventricle and maximum of inter-cranial distance at same level have been highlighted by Akdogan1etal, (2010), in which they found that: the mean volume fraction of total ventricle volume to total brain volume was found to be 1.21% in the first and 3.37% in the last decades and the mean volume fraction was found to increase significantly with age ($p < 0.01$, $r = 0.630$, Pearson). While David et al, (2006) introduced study on measurements of the lateral

ventricles in normal Sudanese, which showed that the measurement of the different part of the lateral ventricles in Sudanese were: 26 mm for anterior horn and 44 mm in body

in both (CT and MRI), the posterior horn was 44 in (CT) imaging, while it was 25 mm in (MRI) imaging. Inferior horn it was 31 mm in (MRI), also she found that the different

part of the lateral ventricles was found to be large in males than females, the size of anterior horn and bodies of the lateral ventricles significant correlation with age, body

weight and length. The size of posterior and inferior horns of the lateral ventricles has no significant variation in relation to age, body weight and length.

In the same domain, Mohammed et al, (2014) studied the effects of aging in cranial volumes out of CT image (Fig. 2.1) in which they found that:there was a proportional linear relation between age in years and the cranial volume in mm^3 based on the following equation: $y = 18.4x + 277.6$, which was significant at $R^2 = 0.9$, where x refers to age in years and y refers to cranial volume in mm^3. The increment of cranial volume has been shown by Dekaban, (1977), in which he stated that: at 1 year of age, the cranial volume has increased by a factor of 2.3 and the head circumference, cranial width, length, and height by a factor of 1.4 over that at birth. And by 20 years of age the cranial volume is about 3.8 times that at birth, and the head circumference and the three principal cranial dimensions (width, length, and height) have increased by a total factor of about 1.6, hence it confirms that the cranial volume increases by aging.

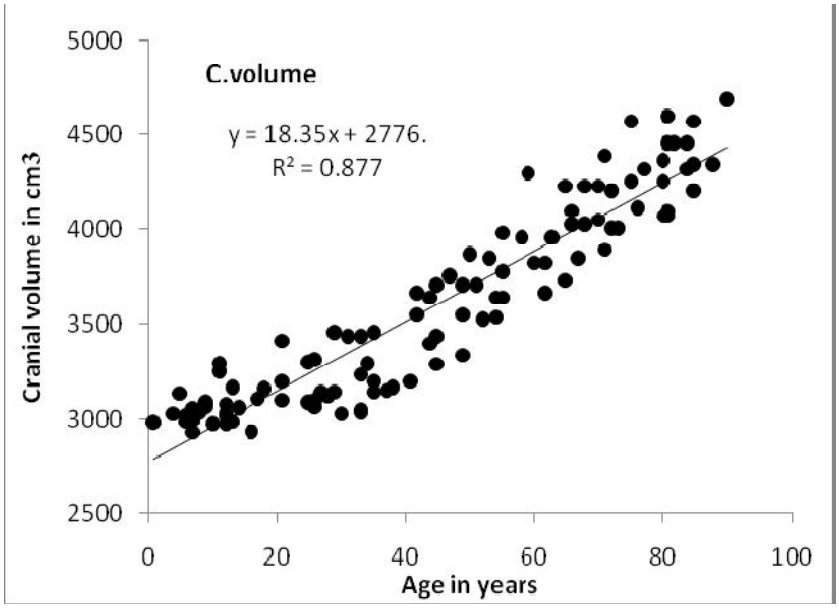


Figure 2.1: The correlation between the patient's age and the cranial volume in mm

While the impact of aging in ventricle volume had been highlighted in Fig. (2.2) in which they found that: the brain ventricle volume increases following the age increment in years, and the correlation could be fitted to the following equation: $y = 0.71x + 12.1$, which is so significant at $R^2 = 0.61$, where x refers to age in years and y refers to brain ventricle volume in cm. their result also be ascertained by the study done by Brij et al, (2014), in which he found that: a gradual progressive increase in ventricular size from the first through sixth decades followed by dramatic increase in the eighth and ninth decades.

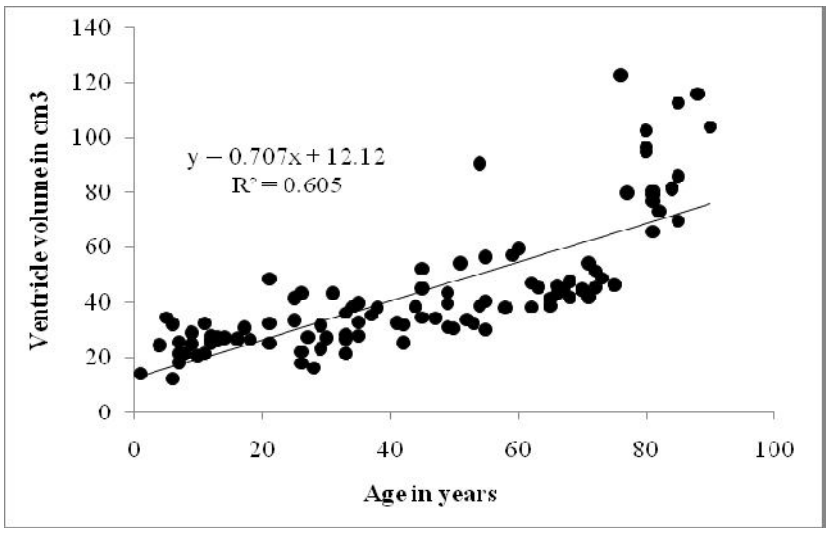


Figure 2.2: The correlation between patient age and the ventricles volume in mm.

And relative to correlation between age groups in years and brain ventricle volumes in cm^3 for male and female. Mohammed et al, (2014) also, found that: the brain ventricles volume increases significantly at R^2 = 0.8 with aging increment among both genders. However, the ventricles volumes of male appear greater than in female i.e. 50.6± STD17.9 for male and 41.5± STD17.3 for female.

Aging have also been showed an impact in atrophy of white matter, the amygdala, hypothalamus and fronto-medial cortex (Cerghet et al, 2009; Zaidi, 2010; Gyldensted, 1977; Sabancıoğulları et al, 2012).

Regarding the impact of diseases in ventricles/cranium ration, Mohammed et al, (2014) concluded that: the ventricular/cranial dimension was increases in case of mixedi.e. (tumor/hydrocephalus) which representing 0.04, 0.03 forhydrocephalus, 0.02 for tumor relative to normal case whichwas 0.01 and had been ascertained by Haslam, (1992) and Soni et al, (1994);

In same field, some authors studied the brain volume which was correlated with major disease such as schizophrenia (SZ), bipolar disorder (PD) and schizoaffective disorder) depending on intracerebral volume (ICV), total brain volume (TBV), ventricular volume (VV), ventricular/brain ratio (VBR) and TBV/ ICV ratio, and they obtained that: the (TBV)/(ICV) were significantly decrease, and (VBR) increase in the (SZ) and (PD) groups compare to Control group i.e. the ratio between brain ventricle volumes to cranial volume increases among all cases of pathologies (tumor, hydrocephalus and mixed). Also, Cerghet et al, (2009); Goldstein et al, (2001); Zaidi, (2010) and Franklin et al, (2000) stated that: men have a greater brain (mainly white matter, theamygdala, hypothalamus and fronto-medial cortex) andcerebrospinal fluid volume, with a greater age-related loss inbrain volume (specifically in the frontal and temporal lobes).

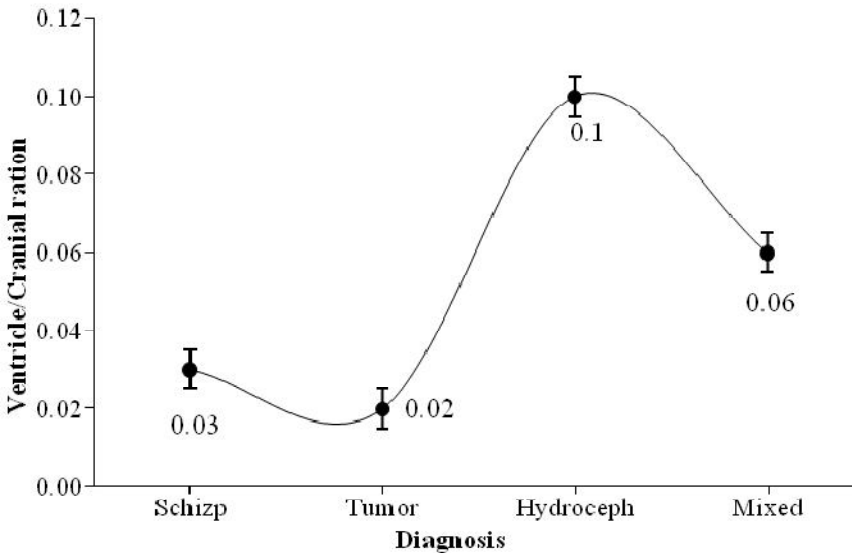


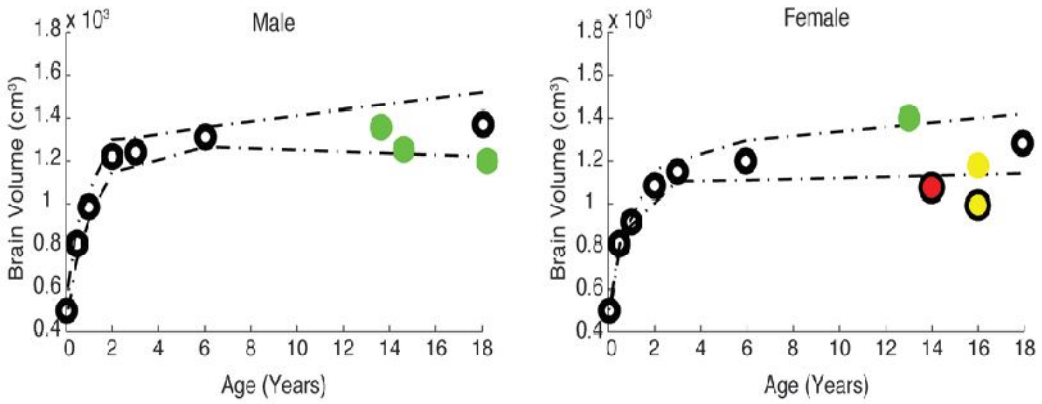
Figure (2.3): The ratio of brain ventricle\cranial volumes for common cranial pathologies

Other study related to morphometric study of brain and ventricles carried out by Brij et al, (2014) in which they observed that:the height and width of the fourth ventricle was larger in males as compared to females. The lengthof the third ventricle was observed to be greater in females than in males. The width of the third ventricle wasobserved to be greater in males than in females. Antero-posterior extent of the left frontal horn (males = 26.26 ±2.94, 95% CI 25.86 - 26.66 mm and females = 26.53 ± 3.38, 95% CI 25.99 - 27.08 mm) was greater than that ofthe right ones (males = 25.00 ± 3.18, 95% CI 24.57 - 25.44 mm and females = 25.34 ± 3.50, 95% CI 24.78 - 25.90mm).

Some authors found gender differences in brain atrophy with ageing and revealed that the degree of change was milder in women than in men (Kaye et al, 1992). Enlargement of cerebrospinal fluid spaces during ageing is generally diffused (Barrett et al, 1985). There is regression of thalamic nuclei after 50 years of age which explains demonstration of early third ventricular enlargement (Le et al, 1984). There is more shrinkage with age in the frontal cortex, brain stem and dienchephalic structure (Jernigan et al, 1991). Also, the left lateral ventricle is normally larger than the right (Gyldensted, 1982). Various studies clearly show an increase in the CSF spaces in dementia especially in Alzheimer's disease and Parkinson's disease (Andreasen et al, 1982).This was due to reduction in size of the nerve cells (Corsellis et al, 1976). Ventricular enlargement to be a more sensitive indicator of cortical atrophy due to increasing age and dementias (Haaga et al, 2009). Studies show there was enlarger of the lateral ventricles in epilepsy and also in depression (McRae, 1974).

Jason et al, (2015) carried out study related to volumetric brain analysis using CT analysis as a predictor of seizure outcome following temporal lobectomy; they found that the male Ugandan epilepsy patients show normalto-small brain volumes. One of the female patients had a brain volume on the high end of normal, while brain volumes in the rest were normal to small compared with the control population, however with

aging there was an increase in brain volume generally as shown in figure (2.4)



Figure(2.4): Brain volumes of 7 Ugandan epilepsy patients (colored circles) plotted on normative growth curves for male (left) and female (right) North American children and adolescents. The normal means are indicated by open black circles and the dashed lines represent ± 1 SD. The colors show Engel classification of seizure outcome: green represents Class IA, yellow Class IB, and red Class IIB. Colored circles with a black outline represent brain volumes of patients with right-sided temporal lobe epilepsy (TLE). Colored circles without a black outline represent brain volumes of patients with left-sided TLE.

In other study carried out by Gur et al, (1991) in which they found that: there is an obvious feature of this plot is that the cranial vault increases in size until age of 10-20 then got plateaus. The cranial vault of males is approximately 13% larger than that of females. Another interesting point is that the cranial vault in males will grow until the age group of 15-20

while in the female group it stabilizes at ages of 10-15 as shown in Fig. (2.5). this plot shows that ventricles grow in size as one ages. This may be explained by the fact that brain naturally atrophies with age, leading to relative enlargement of the ventricles. This information can be used as normal range of ventricle volume for a particular age in a defined gender. Ventricle volume outside this normal range can be indicative of hydrocephalus or a neurodegenerative disease.

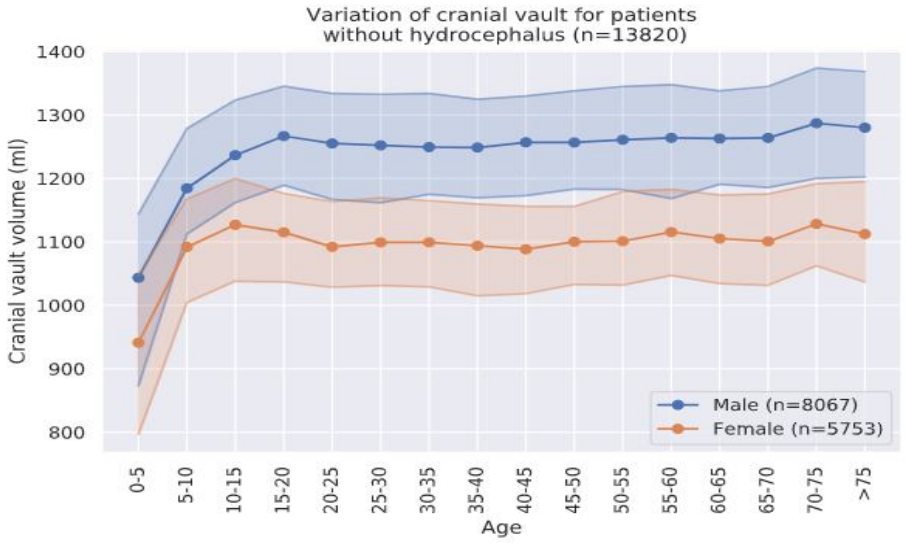


Figure (2.5) .The relation between the age and cranial vault for male and female

Chapter Three

Methodology

250 patients referred to hospital for CT imaging (version GE - bright speed 16 slice-2002). And according to basic protocol, spiral scanning with equal slice thickness andinterval space, patient without contrast media, supine position, head first, orbito-metal line as anatomical reference, radiographic base line (RBL) perpendicular to couch, and the reconstruction of images have been carried out according to organ of interest for diagnosis or for research requirement (spiral CT) to avoid the overlapping of organ of interest between slices or missing area. Then the

images have to be sending to Picture Archiving and Communication Systems PACS. The volumes of brain ventricles for the patients have been obtained from multiplication of slice thickness by the area of each ventricle then a summation done to obtain the total brain ventricle volume, the areas for each ventricle per slice has been traced and outlined by the system caliper then the system software used to calculate the area. While for the cranial volume, the measurement taken from maximum bi-parietal distance (width), from internal acoustic meatus to the highest point of vertex (Pregma) (height) and from glabella to inion(longitudinal) have been used to determine the cranial volume. And the other variables (age, gender, diagnosis) have been collected from Picture Archiving Computerized System PACS of each patient.

Chapter Four

Results

The following results reflecting the main impact of aging and geriatric on brain, with selective focus on correlation between age versus ventricles volume generally, ventricle volume based on gender, ventricle to cranium volume ratio, signal intensity (T_1) for gray and white matter, signal intensity (T_2) for gray and white matter, signal intensity (T_1, T_2) for white matter, signal intensity (T_1, T_2) for gray matter, HU for white and gray matter and HU versus signal intensity of white and gray matter.

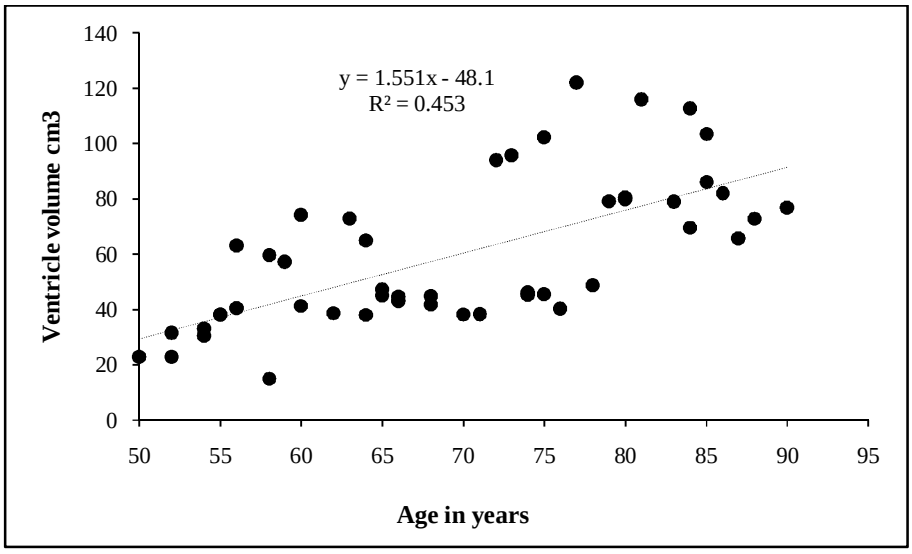


Fig (4.1): The correlation between age in years and ventricle volume in cm^3 in Sudan

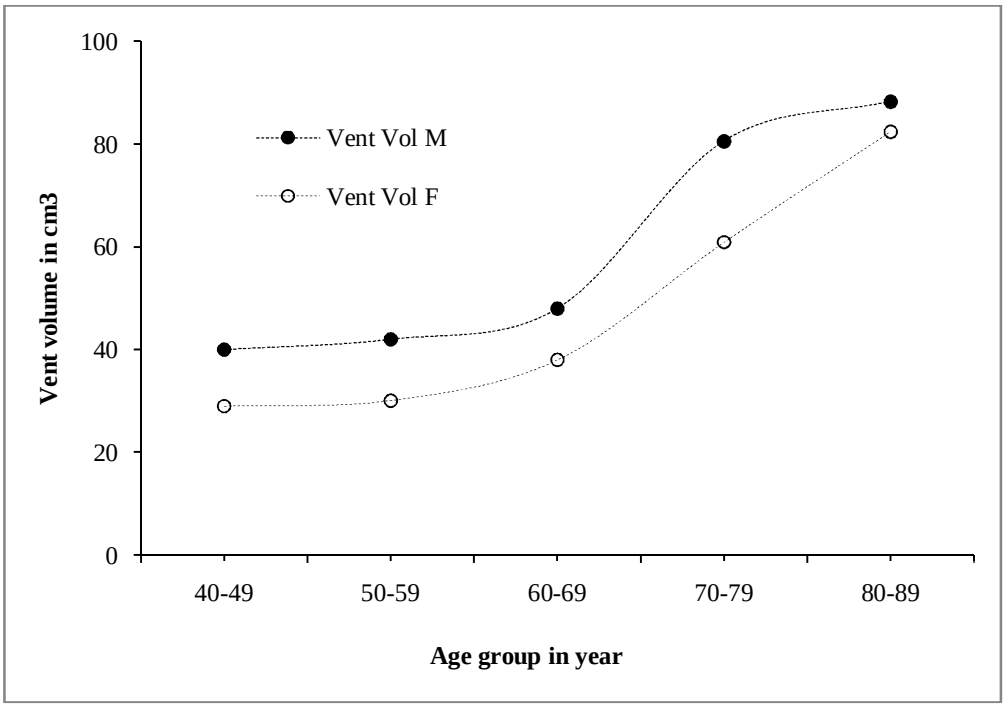
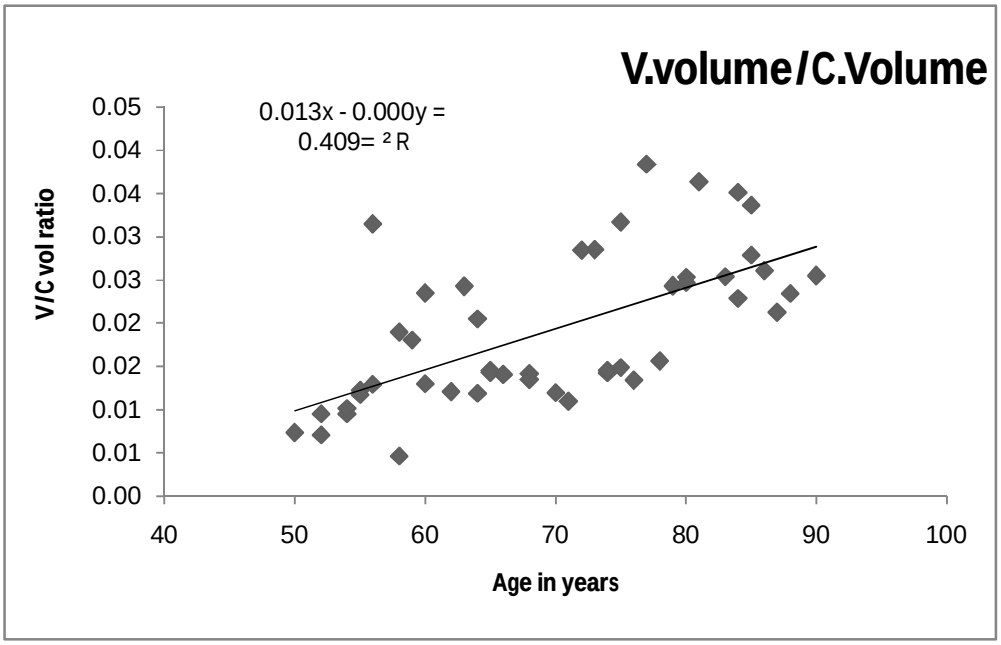
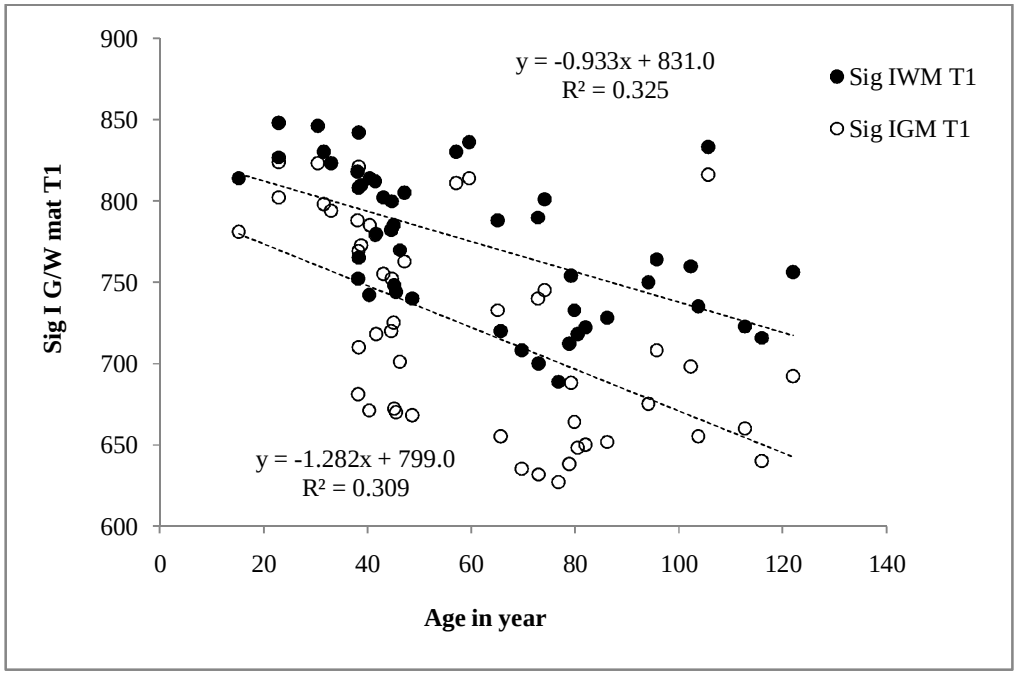


Fig (4.2): The correlation between age in years and ventricles volume in cm3 for male and female in Sudan



Fig(4.3): The correlation between the age in years and ventricle to cranium volume ratio in Sudan



Fig(4.4): The correlation between age in years and signal intensity (T_1) for gray and white matter in Sudan

Fig (4.5): The correlation between age in years and signal intensity (T_2) for gray and white matter in Sudan

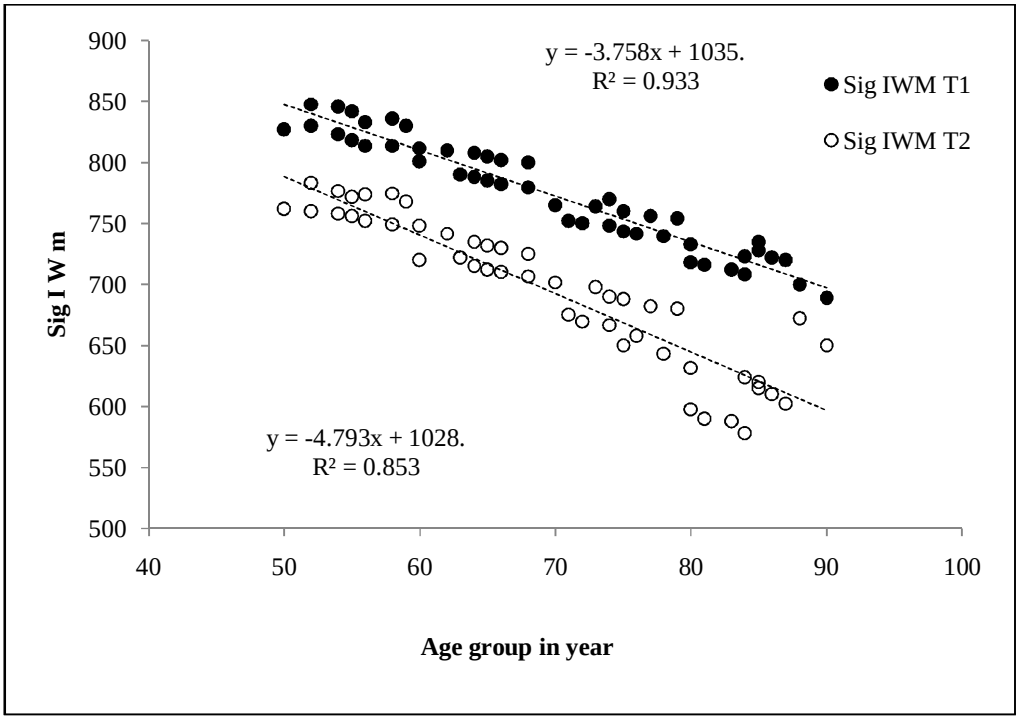


Fig (4.6): The correlation between age in years and signal intensity (T_1, T_2) for white matter in Sudan

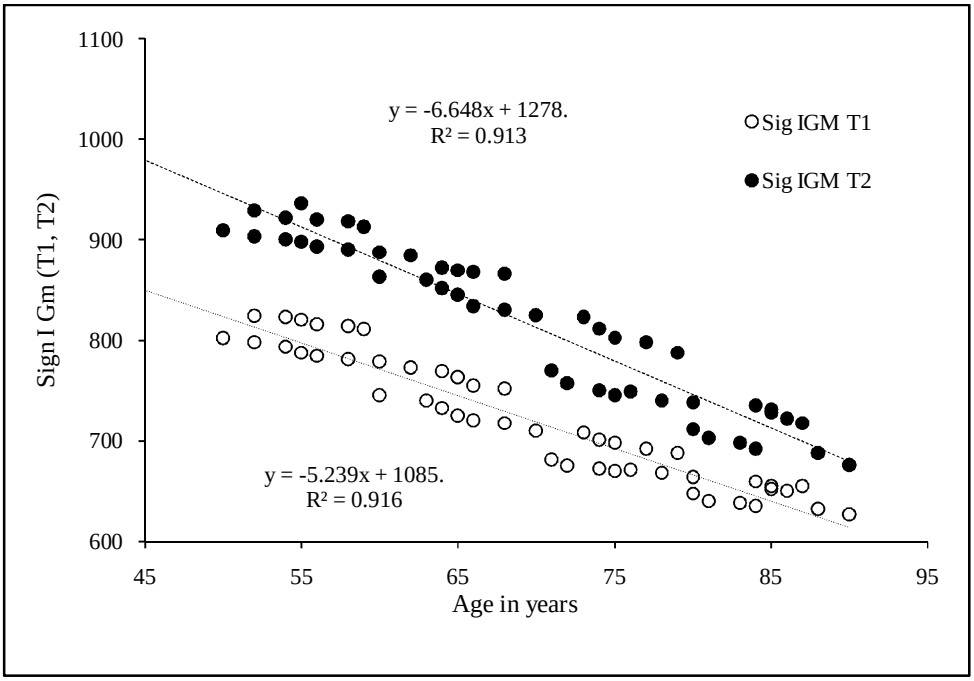


Fig (4.7): The correlation between age in years and signal intensity (T_1, T_2) for gray matter in Sudan

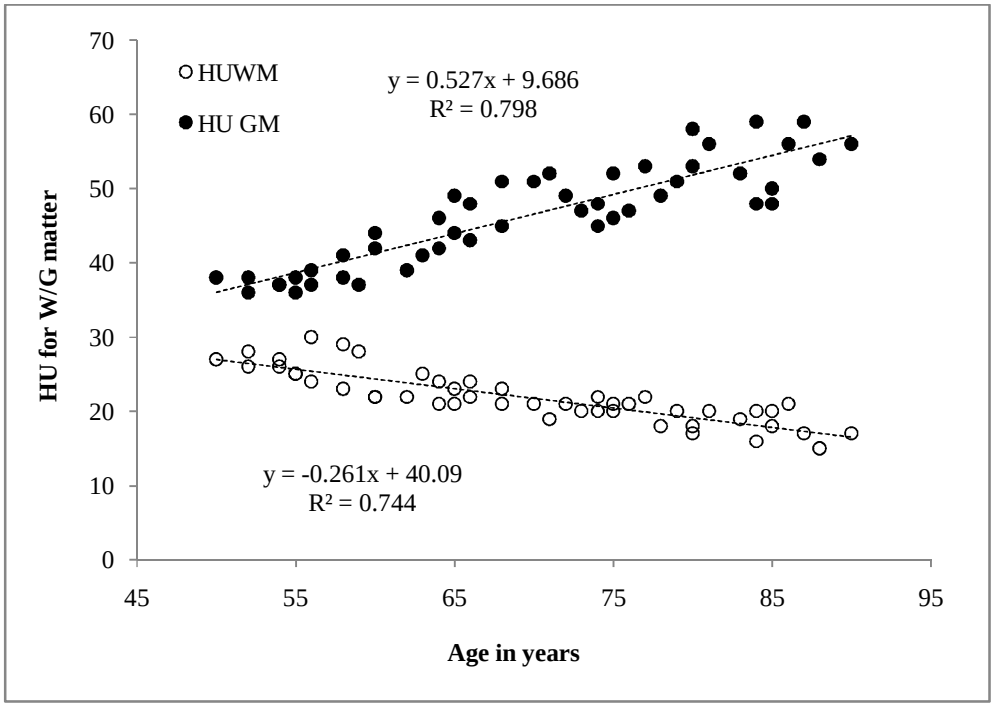


Fig (4.8): The correlation between age in years and HU for white and gray matter in Sudan

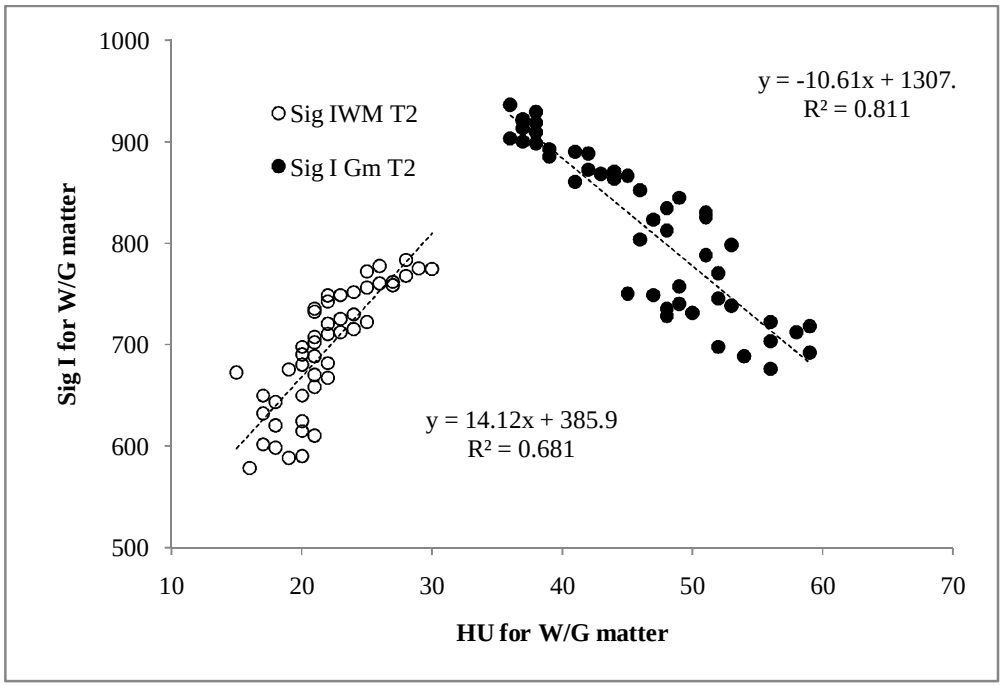


Fig (4.9): The correlation between HU versus signal intensity of white and gray matter in Sudan

Chapter Five

Discussion & Analysis

With reference to Figure 4.1 that shows the correlation between age in years and ventricle volume in cm^3 in Sudan. In which the aging shows less significant (R^2 =0.4) impact on ventricle volume generally (*due to gender factor*) and the correlation best fitted to equation: $y = 1.4588x - 40.742$, where *x* refers to age in years and *y* refers to ventricle volume in cm^3. However, the impact of aging in ventricles volume for male and female shows significant (p = 0.05) increment in ventricle volume after 69 years with prominent effect among male; while before the age of 69 years old the impact on volume was so steady as shown in Figure 4.2. The increment of ventricle volume with aging accompanied by excessive volume of cerebrospinal fluid (CSF) which will be as reductive impact to the brain volume. And due to such impact in brain the relative behavior of man would be deteriorated or influenced. Such result is agreed with the study done by Stephen et al, (2005) in which he found that: a gradually progressive increase in ventricular size from the first through sixth decades followed by dramatic increase in the eighth and ninth decades. In such context; Ruffman et al, (2008); Scheibe et al, (2011) have showed that aging could affect cognitive capability more significant than emotional state.

With reference to Figure 4.3 that shows the correlation between age in years and ventricle/cranium volume ratio in Sudan. It shows that: aging was less significant (R^2 =0.4) impact on ventricle/cranium volume ratio generally and the correlation has been increases following the aging increment that could be best fitted to equation: $y = 0.0005x - 0.0139$, where x refers to age in years and y refers to ventricle/cranium volume ratio. Such increment of V/C ratio is due to normal growth by aging among both gender which has been ascertained by Bijaylakshmi, (2014) in which he found that: Sizes of all three ventricles were more in elderly individuals. In both higher age-groups, males had more expansion of ventricular system than females. Increase in ventricular size was more evident in the lateral ventricle. Changes in ventricular size did not show any effective change in cranial diameters. Such volumetric study has been prone to medical imaging to deduce the effect in MRI signal; in such context Figure 4.4 showing the correlation between age in a year and signal intensity of white and gray matter in T_1. The aging showing less significant impact (R^2 = 0.3) in signal intensity (T_1) of white and gray matter which are in decreasing proportionality with aging with prominent high signal intensity of white mater relative to gray mater. The low signal intensity of gray matter could be ascribed to an increased water content in the white matter and the progressive neuronal loss in the grey matter that occurs with age. Same result has been found byMagnaldi et al,

(1993).The correlation between ageing and signal intensity for white/gray matter at (T_1) could be best fitted to equation $y = 0.9337x + 831.09$ (white matter) and y=1.2823x +799.03 (gray matter), where *x* refers to age in years and *y* refers to signal intensity of (T_1). Such results have been agreed with the study done by Lars et al, (2010),in which he found that: decline of signal intensity of white and gray matter respectively with age and the reducing intensity following the age increment was ascribed to decrease of proton density and water content with aging. Same significant ($R^2 = 0.9$) phenomena of reduced signal intensity (T_2) following aging for white and gray matter have been noticed in Figure 4.5 with correlation could be fitted to equations of the form $y = -6.6489x + 1278.2$ (white matter) and $y = -4.7937x + 1028.4$ (gray matter) which is ascribed to decrease of water content (Kim et al, 2002) in which he found that: effect of age on signal intensity was significant inverse relationship between age and signal intensity of both gray and white matter with prominent high signal intensity for white matter compared to gray mater. The decrement of signal intensity for both white and gray matter following aging reflects important fact that: aging lead to brain deterioration that obviously reflected in man behavior, controlling, interpretation, thinking and even response to surrounding environment (Anders and Kristine, 2010) in which they found that: reductions in specific cognitive abilities for instance processing speed, executive functions, and episodic memory are

seen in healthy aging. whereas aging has less significant (R^2 = 0.3) impact in reducing signal intensity of W & G matter at T_1, however there is high significant (R^2 = 0.9) impact in reducing signal intensity of W & G matter at T_2 and also the signal intensity at T_1 is higher for white matter while at T_2 the gray matter signal is higher.

Figur4.6 : shows the correlation between age in years and signal intensity (T_1, T_2) for white matter in Sudan. It reveals that: there is decreasing proportional correlation between aging and signal intensity (T_1, T_2) for white matter with prominent signal of T_1 relative to T_2. The relevant correlation could be fitted to equations: y = -3.758x + 1035.7 (white matter at T_1) and the other is y = -4.7937x + 1028.4 (white matter at T_2) with high significant correlation (R^2 = 0.9). same correlation has been noticed in Figure 4.7 that: shows the correlation between age in years and signal intensity (T_1, T_2) for gray matter in Sudan with only shifting of signal intensity of gray matter at T_2 to higher value relative to T_1.

The aging effect has been studied by CT imaging as in Figure 4.8 that showing the correlation between age in year and the HU for white and gray matter. In which the age showed high significant (R^2 = 0.8) reducing impact in white matter HU that fitted to equations of the following forms: y = 0.5274x + 9.6864; while there is an increasing impact in gray matter HU that fitted to equation: y = -0.2618x + 40.093, where *x* refers to age in year and *y* refers to HU for relative white and gray matter. The age

reduction impact in HU for white matter and the increasing impact in HU for gray matter indicates the dense compound of white matter and the presence of many contents factors such iron, blood, myelin content, macromolecular chemical exchange, and fiber orientation relative gray matter (Christian et al, 2012). Based on the reduced HU that attribute to low CT number and further less radiation absorption, researchers could judge that: by aging the white matter lose it is density and or undergoes atrophy. However, with reference to Figure4.9 which shows the correlation between HU (*CT parameter*) and signal intensity (*MRI parameter*) of white and gray matter. It is obviously noticed that: the HU influencing the signal intensity significantly (R^2 = 0.7) as increasing correlation fitted to equation: $y = 14.121x + 385.94$, and as a reduction significant (R^2 = 0.8) impact in gray matter that could be fitted the equation of the following form: $y = -10.614x + 1307.9$, where x refers to HU and y refers to signal intensity for white and gray matter.

Chapter Six

Conclusion and Recommendation

6. 1 Conclusion:

After successful scoring of the relative objectives, the worth to be included in the conclusion are:

Aging shows less significant (R^2 =0.4) impact on ventricle volume generally (*due to gender factor*) and the correlation best fitted to equation: $y = 1.4588x - 40.742$, where x refers to age in years and y refers to ventricle volume in cm^3. The impact of aging in ventricles volume for male and female shows significant ($p = 0.05$) increment in ventricle volume after 69 years with prominent effect among male; while before the age of 69 years old the impact on volume was so steady.

Aging was less significant (R^2 =0.4) impact on ventricle/cranium volume ratio generally and the correlation has been increases following the aging increment that could be best fitted to equation: $y = 0.0005x - 0.0139$, where x refers to age in years and y refers to ventricle/cranium volume ratio.

The aging showed less significant impact ($R^2 = 0.3$) in signal intensity (T_1) of white and gray matter which are in decreasing proportionality with aging and having prominent high signal intensity of white mater relative to gray mater. The correlation between ageing and signal

intensity for white/gray matter at (T_1) could be best fitted to equation y = 0.9337x + 831.09 (white matter) and y=1.2823x +799.03 (gray matter), where x refers to age in years and y refers to signal intensity of (T_1). A reduced signal intensity has been noticed at (T_2) following aging for white and gray matter have with correlation could be fitted to equations of the form y = -6.6489x + 1278.2 (white matter) and y = -4.7937x + 1028.4 (gray matter).

In the correlation between age in years and signal intensity (T_1, T_2) for white matter in; there is decreasing proportional correlation between aging and signal intensity (T_1, T_2) for white matter with prominent signal of T_1 relative to T_2. The relevant correlation could be fitted to equations: y = -3.758x + 1035.7 (white matter at T_1) and the other is y = -4.7937x + 1028.4 (white matter at T_2) with high significant correlation (R^2 = 0.9). same correlation has been noticed in the correlation between age in years and signal intensity (T_1, T_2) for gray matter; with only shifting of signal intensity of gray matter at T_2 to higher value relative to T_1.

In the correlation between age in year and the HU for white and gray matter; the age showed high significant (R^2 = 0.8) reducing impact in white matter HU that fitted to equations of the following forms: y = 0.5274x + 9.6864; while there is an increasing impact in gray matter HU that fitted to equation: y = -0.2618x + 40.093, where x refers to age in year and y refers to HU for relative white and gray matter.

In the correlation between HU (*CT parameter*) and signal intensity (*MRI parameter*) of white and gray matter, It is obviously noticed that: the HU influencing the signal intensity significantly (R^2 = 0.7) as increasing correlation fitted to equation: $y = 14.121x + 385.94$, and as a reduction significant (R^2 = 0.8) impact in gray matter that could be fitted the equation of the following form: $y = -10.614x + 1307.9$, where x refers to HU and y refers to signal intensity for white and gray matter.

6.2 Recommendation

By the end of the following thesis, the researcher would like torecommend the following points:

- Another research using large sample of patients is recommendedfor further assessment.
- For future research doing the study in brainventricles volume and correlate with brain tissue volume instead ofcranial dimensions.
- Similar study could be done using function magnetic resonance image(MRI)due to the fact that functional MRI more useful in brain stud
- The future studies should include sagittalplane to measure brain ventricle volume plus axial plane and themin will considered.
- The location of tumors has to be observed as it will affects thevolume positively case its originated inside the ventricle orreducing the volume case its originated outside.
- Thefuture studies for measuring the ratiobetween brain hemisphere and the ventricles for childhood.

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