Sudan University of Sciences & Technology

Collage of graduate studies

Detection of Midline Shift from CT scan Predicate Outcome in Patients with Head Injuries

الكشف عن انحراف خط وسط الدماغ من نتائج الاشعة المقطعية للمرضي الذين لديهم اصابات في الرأس

A Thesis submitted in partial fulfillment for requirement of the Degree of M.Sc IN Diagnostic Radiology

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

الآية

قال تعالي:

(وَلَوْ أَنَّمَا فِي الْأَرْضِ مِنْ شَجَرَةٍ أَقْلَامٌ وَالْبَحْرُ يَمُدُّهُ مِنْ بَعْدِهِ سَبْعَةُ أَبْحُرٍ مَا نَفِدَتْ كَلِمَاتُ اللَّهِ إِنَّ اللَّهَ عَزِيزٌ حَكِيمٌ)

صدق الله العظيم

سورة لقمان الآية (27)

Dedication

Praise and love be to my family,

My respective mother

Lovely sister and brothers

My son

To my lovely wife who have been my constant source of support and inspiration.

To all who care and believe in me.

ACKNOWLEDGMENT

Alhamdulillah, all praises to Allah for granting the will and determination to completing this work.

I acknowledge my family who supported me throughout my whole life, Dr**. IKHLAS Abdelaziz** whose support encouragement and guidance paved my way for this long journey.

I am very grate full to the staff in **Gezira Traumatology Center** for their cooperation and help.

Thank you all for being the tem of my work and light which guided me through this journey.

Abstract

This study aim to detect the midline shift from CT scan predicated outcome in patients with head injuries.

This study was done in Al gazira Traumatology center during the period from feb.2016 to November 2016.

Fifty patients (36 males and 14 females), males represent (72%) of study population and (28%) are males, the age range of patients was between 15-95 years.

(16%) of patients aged range between 15-35years, their GCS according to classification to mild, moderate, and severe (21.2%12.5%, and 0%). For patients aged between 36-55years, (34%) their GCS (39.4%, 33.3% and 12.5%). (38%) of patientsofaged between 56-75 their GCS (30.3%, 55.6%, and 50%). While (12%) of patients of age between 76-95, their GCS are (9.1%, 0%, and 37.5%).

The result shows the degree of midline shift in patient's brain injury was statically significant as a determinant of outcome. It appeared that probability of poor outcome was higher when there is combination of midline shift with other type of intracranial hemorrhage, clinical factor such as sex, age GCS score and associated injury. Also the outcome would be poorest if the midline shift with SDH compared to other lesion in patients with brain injury.

the degree of midline shift did not prove to be of a predictive significance of all the patients with midline shift

ملخص البحث

هذه الدراسة أجريت لقياس انحراف خط الوسط باستخدام الأشعة المقطعية ومقارنته بالحالة المرضية للمصاب.

أجريت هذه الدراسة في مركز الجزيرة للإصابات وجراحة المخ والإعصاب في الفترة ما بين فبراير 2016 الى فبراير 2016. وقد أجريت على 50 مريض، 76% من الذكور و28% من الإناث تراوحت الأعمار مابين 15 – 95عاماً .

أثبتت النتائج الإحصائية إن 16% تراوحت أعمارهم 15 – 35 سنة فإن مؤشر الحياة الموزع إلى جيد ومتوسط وخطير كان (21.2%، 12.5%، 0%) أما بالنسبة للمرضى الذين تراوحت أعمارهم مابين 35- 55 سنة فإن مؤشرات الحياة كانت (39.4%، 33.3%، 12.5%). المرضى الذين تراوحت أعمارهم ما بين 56 – 75 بنسبة 38% فان مؤشرات الحياة كانت (30.3%، 55.6%، 50.5%). (12%) من المرضى الذين تراوحت أعمارهم ما بين 76 – 95 فان مؤشرات الحياة كانت (9.1%، 0%، 37.5%).

أوضحت نتيجة الدراسة إحصائيا إن انحراف خط الوسط للدماغ له علاقة بالحالة المرضية للمصاب. كما بينت النتائج إن علاقة الحالة المرضية للمصاب بنوع النزيف في الدماغ، فاعتبار انه مهما كان انحراف خط الوسط كبيراً فانهلا يرتبط بحالة المريض ولا بمؤشرات الحياة.إضافة إلى عوامل العمر والنوع فان لها علاقة أيضاً .

Abbreviation

MLS	MIDLINE SHIFT
iML	IDEAL MIDLINE SHIFT
dML	DEFORMED MIDLINE SHIFT
CT	COMPUTED TOMOGRAPHY
H-MLS	HEMORRGAHE MIDLINE SHIFT
ICP	INTRACRANIAL PRESSURE
ADLs	A DIALY LIVING
GCS	GLASGOW COMA SCORE
TBI	TRAUMATIC BRAIN INJURY
PNS	PERIPHERAL NERVOUE SYSTEM
CNS	CENTRAL NERVOUS SYSTEM
CSF	CEREBROSPINAL FLUID
HE	HYPERTENSIVE ENCEPHALOPATHY
PRES	POSTERIOR REVERSIBLE ENCEPHALOPATHY SYNDROM
IA	INTRCRANIAL ANEURYSMS
SAH	SUBARACHNOID HEMORRHAGE
AVMs	Arteriovenous malformations
CCM	CEREBRAL CAVENOUS MALFORMATIONS
CCA	CEREBRAL AMYLOID ANGIOPATHY
ICH	INTRACRANIAL HEMORRGHAE
LOC	LOSS OF CONSCIOUSNES
SPSS	STATISTICAL PACKAGE FOR SOCIAL SCINECE
EDH	EPIDURAL HEMORRGAHE
DAI	DIFFUSE AXONAL INJURY

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Chapter one

Chapter one

1.1 Introduction:

CT scan is widely used in today's neurology diagnosis. In intracranial pathological examination, brain midline shift (MLS) is an important diagnostic feature. Despite the functional difference of the brain hemispheres , the normal anatomical structure of the brain is symmetric to the so called the midsagittal plane , which is shown in single CT slice as the brain midline .intracranial pathology changes , such as hemorrhage or tumor may cause the brain midline shift (MLS) . Patients presenting MLS may suffer from continual disequilibrium. Moreover, MLS is often associated with high intracranial pressure (ICP), which can be deadly.[Englander J, Cifu DX, Wright JM, Black K]

Furthermore, studies show that MLS is significant in indicating the survival probability of patients. Therefore, MLS is used as a measurement of the change of the brain symmetry and an important indicator of the pathological severity.

Degree of midline shift after traumatic brain injury is widely recognized as an important marker of severs injury. Numerous reports describe the association of a large amount of midline shift on computed tomography (CT) scan with poor outcome or other adverse squeal of traumatic brain injury. A study by Englader J, concluded that the presence of either a midline shift greater than 5 mm or subcortical concussion on acute CT scan is associated with a greater need of assistance with ambulation, activates of a daily living (ADLs), and global supervision at rehabilitation discharge. Although other variables such as Glasgow Coma Score (GCS), age abnormal motor responses, other CT finding, and episodes of hypoxia and hypertension, have been subsequently introduced to build more complex and accurate prognostic model. [Englander J, Cifu DX, Wright JM, Black K]

Given the significance of MLS in diagnosis, automated detection and computation of MLS using image processing techniques is an important task. A robust and efficient algorithm to compute MLS is an essential component of a computer – aided neurology diagnosis system. Few works can found in the literature that focus on MLS automated detection and computation. Genetic algorithm was used to minimize the summed score of each point of deformed midline on symmetry map. The method was proved to be effective; however, it is mainly based on symmetry

of the brain structure along the image ventricle direction that maybe lost if large hemorrhage or tumor, subdural and epidural exists. This shortcoming often causes its failure in the intracerebral hemorrhage (ICH) case, the use of generic algorithm makes the method time inefficient. [Valadka AB, Gopinath SP, Robertson CS]

In this study, a method of tracing the brain midline shift in traumatic brain injury (TBI) CT images, instead of being based on symmetry information in the imaged, I resort to cause of midline shift. In traumatic brain injury,hemorrhage is main cause of brain midline shift. We model the relationship between the hemorrhage and the midline deformation caused by it using a linear regression model (H-MLS). Secondly, using the H-MLS model, the deformed midline is predicated from the hemorrhage detected in CT scan. Finally, the predicated deformed midline adjusted according to the visual symmetry information. Preliminary experimental results demonstrate the effectiveness of the method.[K.B. Quattro chi, P. Prasad, N.H. Willits, and F.C. Wagner].

1.2 Problem of the study:

Increased incidence of head injuries, and difficulty assessing the medical condition of the patients.

1.3 Objectives:

1.3.1 General objective:

- To detect the degree of midline shift from CT SCAN and clinical situation of the patient.

1.3.2 Specific objective:

- To evaluate the relationship between the degree of midline shift by CT scan finding and Glasgow Coma Score (GCS) as a predictive of clinical outcome in patient head injury.
- To asses therelationship of midline shifts with age, gender, and causes.

1.4 Significance of the study:

Computed tomography of the brain useful in tracing the brain midline shift in traumatic brain injury and intracranial pathologic.

1.5 The Overview of the research:

Chapter one deals with introduction, problem, objective, significance, and overview of the research. Chapter two deals with literature review including the theoretical background (anatomy, physiology, and pathology) and previous studies. Chapter three deals with research Materials and Method. Chapter four deals with results and finally, Chapter five deals with discussion, conclusion and recommendation. Referenced and appendices.

Chapter two

Chapter two

Literature Review

Theoretical background

2.1CTBrain Anatomy:

2.1.1Meninges:

The meninges are thin layers of tissue found between the brain and the inner table of the skull. The meninges comprise the Dura mater, theArachnoid, and the pia mater. The Dura mater and Arachnoidis an anatomical unit, only separated by pathological processes.

The falx cerebri and the tentorium cerebella are thick infoldings of the meninges which are visible on CT imaging. Elsewhere the meningeal layers are not visible on CT as they are closely applied to the inner table of the skull. [Athiappan S, Muthukumar N, Sri Nivasan US]

The meninges:

- Dura mater tough outermost layer closely applied to the inner table of the skull.
- Arachnoid thin layer closely applied to the Dura mater.
- Subarachnoid space – space between the Arachnoid mater and the pia mater which contains delicate trabeculated connective tissue and CSF.
- Pia mater very thin layer applied to the surface of the brain.

2.1.2Tentorium cerebella:

An in folding of the Dura mater forms a tent-like sheet which separates the cerebrum (brain) from the cerebellum. It's anchored by the petrous bones. [Athiappan S, Muthukumar N, Sri Nivasan US]

2.1.3Falx cerebri:

The falx is and infolding of the meninges which lies in the midline and separates the left and right cerebral hemispheres.

2.1.4CSF spaces:

The brain is surrounded by cerebrospinal fluid (CSF) within the sulci, fissures and basal cisterns.CSF is also found centrally within the ventricles. The sulci, fissures, basal cisterns and ventricles together form the “CSF spaces”, also known as “extra-axial spaces”.

CSF is of lower density than the grey or white matter of the brain, and therefore appears darker on CT scan.

An appreciation of the normal appearances of the CSF spaces is required to allow assessment of the brain volume.

The brain surface is formed by folds of the cerebral cortex known as gyri. Between these gyri there are furrows, know as sulci, which contain CSF. [Athiappan S, Muthukumar N, Sri Nivasan US]

2.1.5Fissures:

The fissures are large CSF-filled clefts which separate structure of the brain. The interhemispheric fissure separates the cerebral hemispheres, the two halves of the brain. The sylvian fissure separates the frontal and temporal lobes. [Athiappan S, Muthukumar N, Sri Nivasan US]

2.1.6Ventricles:

The ventricles are spaces located deep inside the brain which contain CSF.

LATERAL VENTRICALE:

The paired lateral ventricles are located on either side of the brain; the lateral ventricles contain the choroid plexus which produces CSF. The choroid plexus is almost always calcified in adults.

THIRD VENTRICLE:

The third ventricle is located centrally. The lateral ventricles communicate with the third via small holes (foramina of monro).

FOURTH VENTRICLE:

The fourth ventricle is located in the posterior fossa between the brain stem and cerebellum, it communicates with the third ventricle above via a very narrow canal, the aqueduct of sylvius. [Athiappan S, Muthukumar N, Sri Nivasan US]

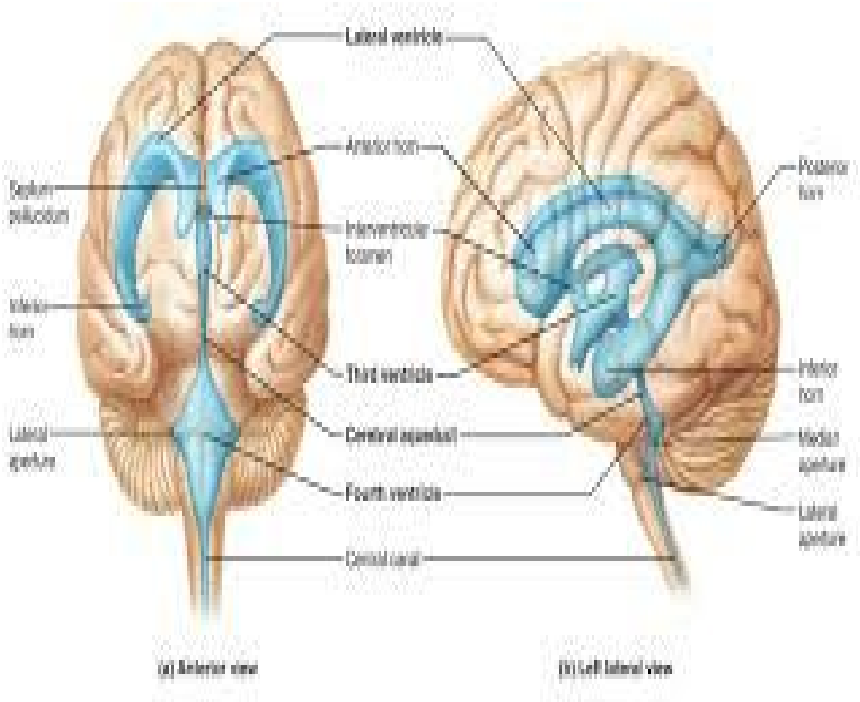

Fig. (2-1) Brain ventricles

2.1..7Basal cisterns:

CSF in the basal cisterns surrounds the brain stem structures.

2.1.8Brain parenchyma and lobes:

The brain consists of gray and white matter structures which are differentiated on CT by differences in density. White matter has high content of myelinated axon. Grey matter contains relatively few axon and higher number of cell bodies. As myelin is fatty substance it is of relatively low density compared to the cellular grey matter. White matter, therefore, appears blacker than grey matter. [Athiappan S, Muthukumar N, Sri Nivasan US]

Brain lobes:

On both sides the frontal lobes are separated from the parietal lobes by the central sulcus. The frontal lobes are large and the parietal and occipital are relatively small.

The most anterior parts of the frontal lobes occupy the anterior cranial fossa. The temporal lobes occupy the middle cranial fossa. The cerebellum and brain stem occupy the posterior fossa. [Athiappan S, Muthukumar N, Sri Nivasan US]

2.1.9 Grey matter structures:

Important gray matter structures visible on CT images of the brain include the cortex, insula, basal ganglia, and thalamus. [Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Motero A, et al].

Cerebral cortex:

The cerebral cortex is layer of grey matter formed in gyri (fold) over the entire brain surface.[Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Motero A, et al].

Cortical grey matter:

The grey matter of the cerebral cortex is formed in formed in folds called gyri. The cortex appears whiter (denser) than the underlying white matter.[Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Motero A, et al].

2.1.10 Insula:

The insula forms an inner surface of the cerebral cortex found deep to the sylvian fissure. [Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Motero A, et al].

Basal ganglia and thalamus:

The basal ganglia and the thalamus are important grey matter structures which are located deep to the insula. Basal ganglia= lentiform nucleus + caudate nucleus.[Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Motero A, et al].

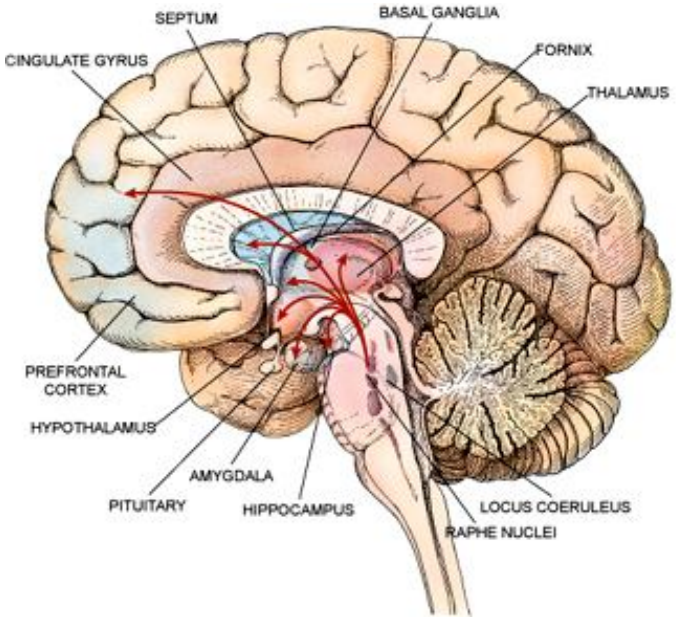

Fig. (2-2) Brain anatomy

2.1.2 Brain physiology:

The nervous system is your body's decision and communication center. The central nervous system (CNS) is made of the brain and the spinal cord and the peripheral nervous system (PNS) are made of nerves. Together they control every part of your daily life, from breathing and blinking to helping you memorize facts for a test.

Nerves reach from your brain to your face, ears, eyes, nose, and spinal cord and from the spinal cords to the rest of your body. Sensory nerves gather information from the environment; send that info to the massage to the brain. The brain then makes sense of that massage and fires off a response. Motor neurons deliver the instructions from the brain to the rest of your body. The spinal cord, made of a bundle of nerves running up and down the spine, is similar to superhighway, speeding massage to and from the brain at every second.

The brain is made of three main parts: the forebrain, midbrain, and hindbrain. The forebrain consists of cerebrum, thalamus, and hypothalamus (part of the limbic system). The midbrain consists of the tectum and tegmentum. The hindbrain is made of cerebellum, pons, and medulla. Often the midbrain, pons, and medulla are referred together as brainstem. [Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

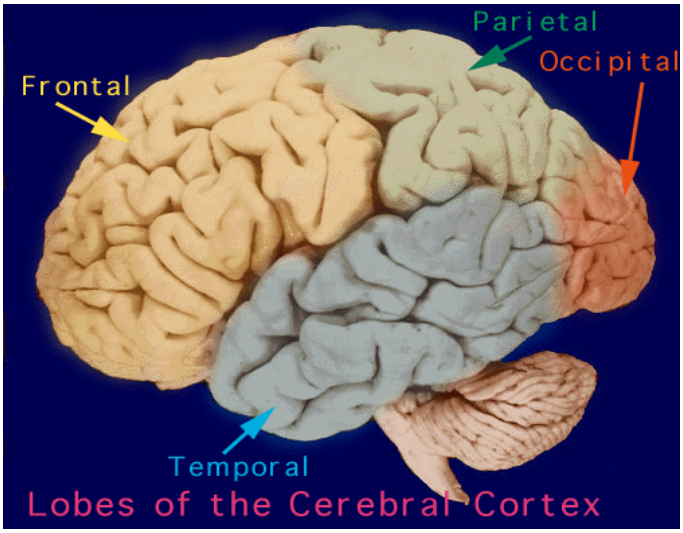

Fig. (2-3) lobes of the cerebral cortex

2.1.2.1 The cerebrum:

The cerebrum or cortex is the largest part of the human brain, associated with higher brain function such as thought and action. The cerebral cortex is divided into four sections, called “lobes”:

The frontal lobe: associated with reasoning, planning, parts of speech, movement, emotions, and problem solving.

Parietal lobe: associated with movement, orientation, recognition, perception of stimuli.

Occipital lobe: associated with visual processing.

Temporal lobe: associated with perception and recognition of auditory stimuli, memory, and speech.

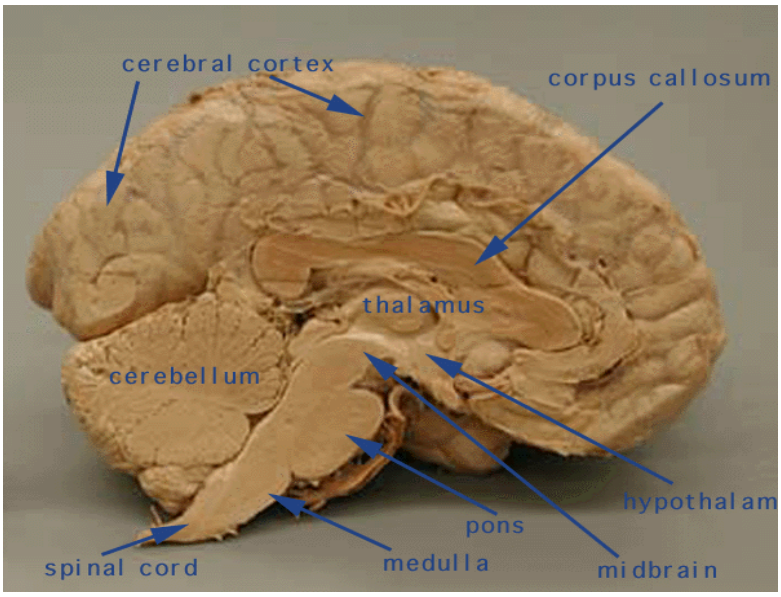

Fig. (2-4) the cerebral cortex & cerebellum

A deep furrow divides the cerebrum into two halves, known as left and right hemispheres. He two hemispheres look mostly symmetrical yet it has been shown that each side functions slightly different than the other. Sometimes the right hemisphere is associated with creativity and the left hemispheres are associated with logic abilities. The corpus callosum is a bundle of axons with connects these two hemispheres

Nerve cells make up the gray surface of the cerebrum which is a little thicker than your thumb. White nerve fibers underneath carry signals between the nerve cells and other parts of the brain and body.

The neocortex occupies the bulk of the cerebrum. This is a six layered structure of the cerebral cortex which is only found in mammals. It is thought that the neocortex is a recently evolved structure, and is associated with "higher" information processing by more fully evolved animals.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

2.1.2.2 The cerebellum:

The cerebellum, or "little brain", is similar to the cerebrum in that it has two hemispheres and has a highly folded surface or cortex, this structure is associated with regulation and coordination of movement, posture, and balance.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

2.1.2.3 Limbic system:

The limbic system often referred to as the "emotional brain" is found buried within the cerebrum.

This system contains the thalamus, hypothalamus, amygdale, and hippocampus. [Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

2.1.2.3.1 Thalamus:

Thalamus a large mass gray matter deeply situated in the forebrain at topmost portion of diencephalon. The structure has sensory and motor functions. Almost all sensory information enters this structure where neurons sent that information to the overlying cortex. Axons from every sensory system (except olfaction) synapse here as the last relay site before the information reaches the cerebral cortex.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

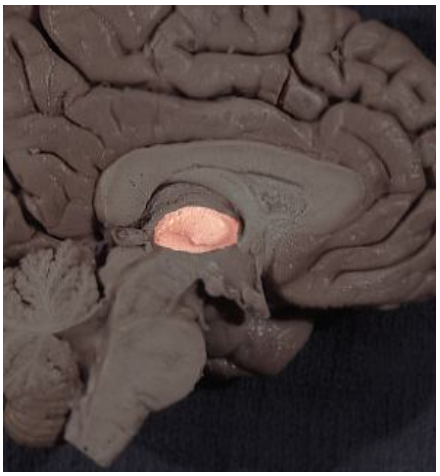

Fig. (2-5) Thalamus

2.1.2.3.2 Hypothalamus:

Hypothalamus is part of the diencephalon ventral to the thalamus. The structure is involved in functions including homeostasis, emotion, thirst, hunger, circadian rhythms, and control of autonomic nervous system. It controls the pituitary.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

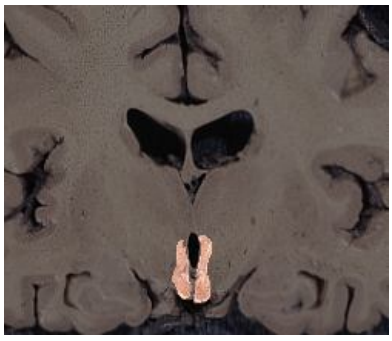

Fig. (2-6) Hypothalamus

2.1.2.3.3 Amygdala:

Amygdala is part of the telencephalon located in the temporal lobe, involved in memory, emotion, and fear. The amygdala is both large and just beneath the surface of the front, medial part of the temporal lobe where it cause the bulge on the surface called the uncus. [Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

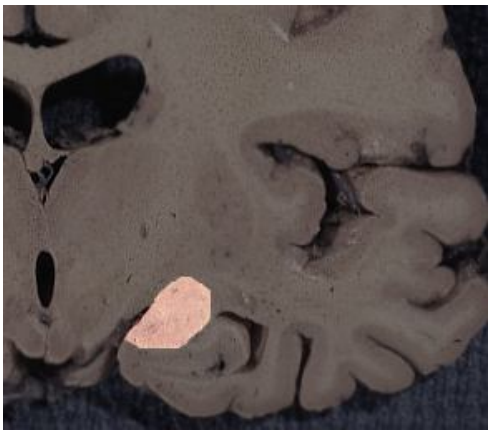

Fig. (2-7) amygdala

2.1.2.3.4 Hippocampus:

Is the portion of the cerebral hemisphere in basal medial part of the temporal lobe. This part of the brain is important for learning and memory, for converting short term memory to more permanent memory, and for recalling spatial relationships in the world about us.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G]

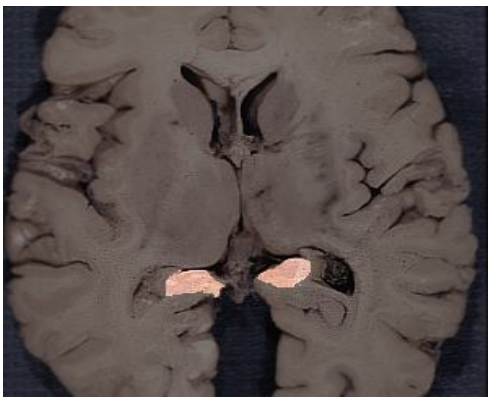

Fig. (2-8) Hippocampus

2.1.2.4 Brain stem:

Underneath the limbic system is the brain stem. This structure is responsible for basic vital life functions such as breathing, heartbeat, and blood pressure.

The brain stem is made of *the midbrain, pons, and medulla*.

2.1.2.4.1 Midbrain:

Midbrain – mesencephalon the rostral part of the brain stem, which includes the tectum and tegmentum. It is involved in functions such as vision, hearing, eye movement, and body movement. The anterior part has the cerebral peduncle, which is a huge bundle of axons travelling from the cerebral cortex through the brain stem and these fibers (along with other structures) are important for voluntary motor function.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G].

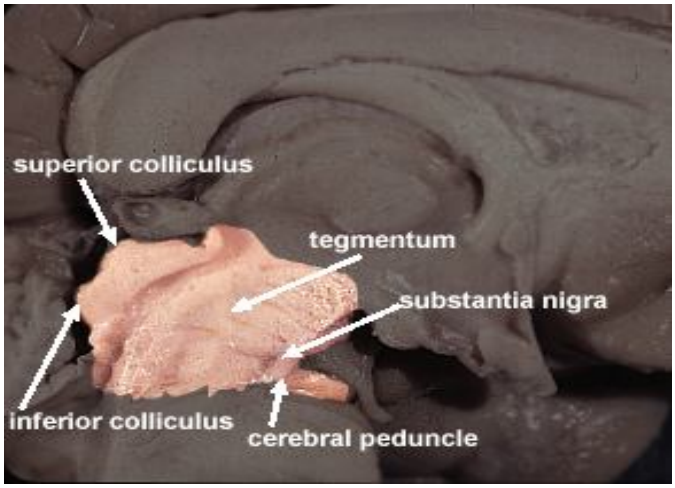

Fig. (2-9) Midbrain

2.1.2.4.2 Pons:

Pons – is part of the metencephalon in the hindbrain. It is involved in motor control and sensory analysis it has parts that are important for the level of consciousness and for sleep. Some structure within the pons are linked to the cerebellum, thus are involved in movement and posture.[Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G]

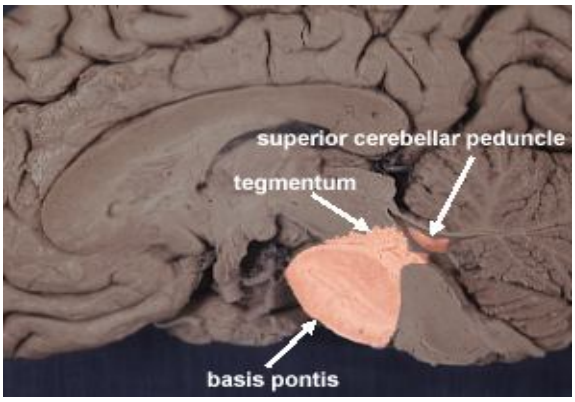

Fig. (2-10) Pons

2.1.2.4.3 Medulla

Medulla oblongata this structure is the caudal most part of the brain stem, between the pons and spinal cord. It is responsible for maintaining vital body functions, such as breathing and heart rate. [Mendelow AD, Teasdale G, Jennett B, Bryden J, Hasett C, Murry G]
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Fig. (2-11) Medulla

2.1.3 Pathology of the brain

2.1.3.1 Cerebral ischemia and stroke:

2.1.3.1.1 Hemorrhagic strokes (intracerebral and subarachnoid hemorrhage):

Approximately 15%to 20% of strokes are due to rupture of blood vessels causing intracerebral (parenchymal) or subarachnoid hemorrhage. The major cause of hemorrhagic stroke are hypertension, anticoagulants and bleeding disorders malformations and other vascular anomalies, intracerebral and subarachnoid hemorrhage are also very common in head trauma.[Bullock R, Teasdale G].

2.1.3.1.2 Hypertensive intracerebral hemorrhage:

This hemorrhage results from rupture of small, penetrating arteries. Hypertensive angiopathy (small vessel disease) stiffens vessel walls and makes them fragile. This is in conjunction with increased pressure from within the lumen, cause vascular rupture and hemorrhage.

Hypertensive hemorrhage is parenchymal and it's most frequent sites of are the basal ganglia and thalamus. Less commonly it involves the cerebellum, the pons, and occasionally the subcortical white matter.

Parenchymal hemorrhage disrupts brain tissue and accumulates rapidly within a few hours until pressure from the hematoma collapses the bleeding vessels. The blood clot is surrounded by a zone, cause cerebral edema, which increases over a few days. Thus, the hemorrhage causes focal neurological deficits and more important, increase intracranial pressure. Improve control of hypertension in last 20 years has lead to a dramatic reduction in incidence of hypertensive intracerebral hemorrhage. [Bullock R, Teasdale G].

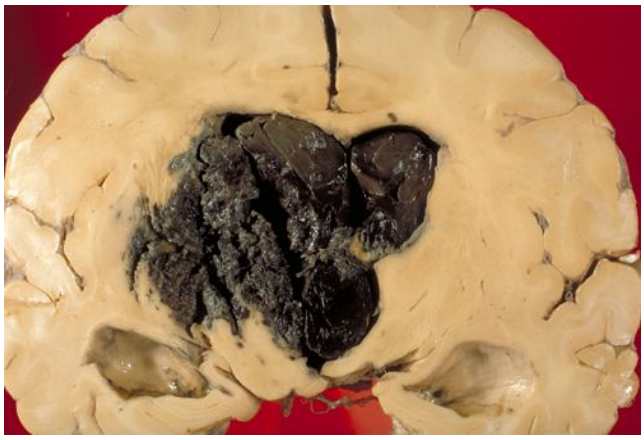


Fig. (2-12) Hypertensive intracerebral hemorrhage

2.1.3.1.3 Hypertensive encephalopathy:

Hypertensive encephalopathy (HE) is a syndrome characterized by severe headache, nausea, and vomiting, papilledema, visual disturbances, seizures, confusion, and severe cases coma. These clinical finding are seen in the background of severe (malignant) hypertension and are accompanied by retinopathy and nephropathy. In adult HE is usually the culmination of severe chronic hypertension, in women with eclampsia and in children with new onset hypertension, it develops rapidly and with lower level of blood pressure.

The clinical syndrome of HE is called posterior reversible encephalopathy syndrome (PRES). The cause of PRES is thought to be vasogenic edema. The neuropathology of PRES is largely unknown. A recent autopsy report revealed microvascular changes including fibrinoid necrosis, indicating that the underlying mechanism of PRES is similar to the previously studied HE cases.

[Bullock R, Teasdale G]

2.1.3.1.4 Arterial aneurysms:

Intracranial aneurysms (IA), also referred to as saccular or berry aneurysms, develop in the walls of major cerebral arteries at branching points, where there are gaps in the media and internal elastic. The majority of them are on the circle of Willis and the first bifurcation of the middle cerebral artery. They are multiple in 20% of cases.

Non ruptured aneurysms are seen in 2% of adult autopsies. The defects in the vessel wall are present since birth but aneurysms are rare in children, they develop later in adulthood due to gradual weakening of vessels from the constant force of even normal blood pressure and structural changes that occur with advancing age. They are more common in women than men and occur with increased frequency in patients with coarctation of the aorta and polycystic kidney disease. Other factor including smoking, and alcohol consumption.

Large IAs can cause symptoms by compressing cranial nerves, vessels, and brain tissue but their most feared complication is rupture. The vessel bearing the aneurysms are in the subarachnoid space. Consequently, their rupture causes subarachnoid hemorrhage (SAH). Blood spurts out the ruptured aneurysm with a force that can tear the soft brain. If the stream of blood directed toward the brain, it cause intracerebral and intraventricualr hemorrhage. The larger the aneurysm, the higher is the likehood of rupture.[Bullock R, Teasdale G].

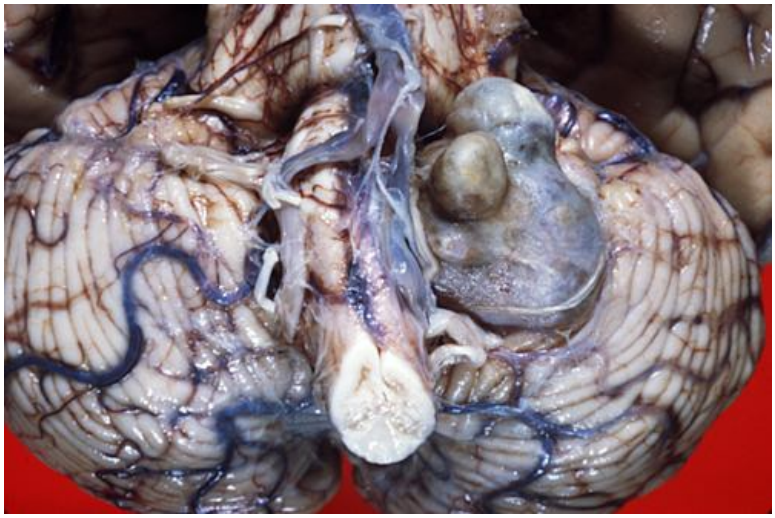


Fig. (2-13) Arterial aneurysms

2.1.3.1.5 Arteriovenous malformations (AVMs):

AVMs are developmental abnormalities of cerebral vessels. They consist of a tangle of abnormal vessels interposed between a feeding artery and draining vein. Most AVMs are in the distribution of the middle cerebral artery but they may occur anywhere. In addition to classical AVMs, there are several other related types of vascular anomalies and hamartomas that have similar manifestations. The abnormal vessel may be in brain tissue, in the subarachnoid space, or both. AVMs and other vascular anomalies cause seizures and neurologic, deficits due to chronic compression and ischemia of brain tissue.

A related vascular lesion, cerebral cavernous malformation (CCM) or cavernoma consists of clusters of thin walled cavernous vessels without intervening stroma. CCMs are present in 0.5% o the population. An approximately 20% of CCMs are familial, autosomal dominant, and the rest are sporadic. Familial CCMs tent to be multiple.[Bullock R, Teasdale G] .

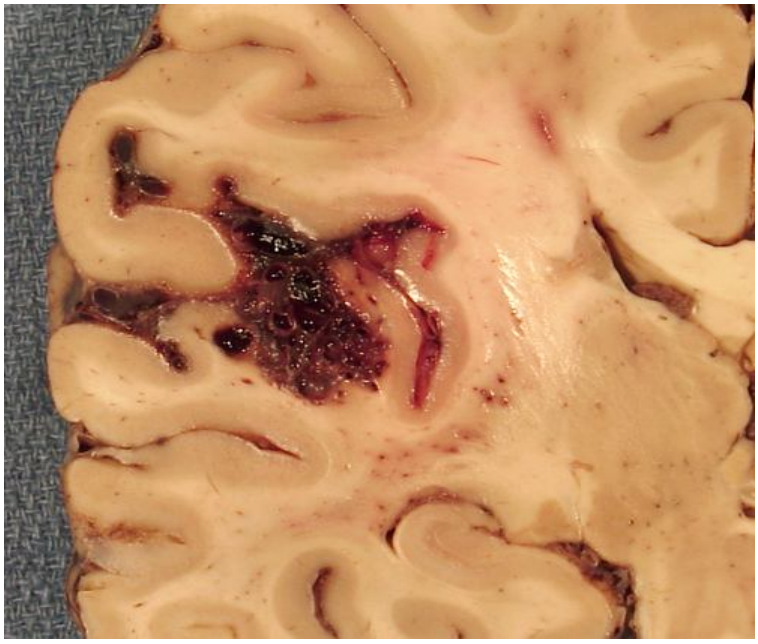


Fig. (2-14) arteriovenous malformations (AVMs)

2.1.3.1.6 Cerebral amyloid angiopathy:

Cerebral amyloid angiopathy (CCA) is a frequent cause of parenchymal brain hemorrhage. Insoluble 8-10nm thick amyloid fibrils are deposited in the walls of leptomeningeal and capillaries. Similar to small vessel disease, this process destroys normal vascular elements, makes vessels fragile, causes thickening, and impairs their permeability. This pathology causes ischemic and hemorrhagic lesion. The ischemic lesion includes mircoinfracts which in imaging studies presents as leukoaraiosis.

The ischemic lesion of CAA causes dementia. The hemorrhage lesions are micro bleeds and large hemorrhages. Both thalamus- basal ganglia, which are common sites of hypertensive bleeds.

However, CAA related hemorrhage can occur anywhere, a spontaneous cerebral hemorrhage in elderly person without an apparent cause should raise suspicion for CAA. Occasionally, amyloid deposition incites a granulomatous angiitis.

[Bullock R, Teasdale G]

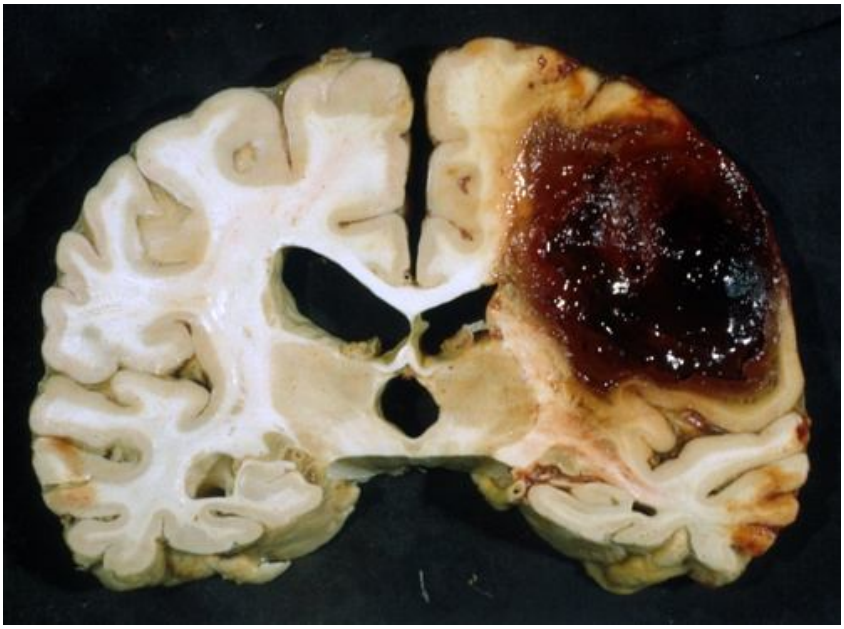


Fig. (2-15) cerebral amyloid angiopathy

2.1.3.2Intracranial hemorrhage:

Intracranial hemorrhage (ICH), also known as intracranial bleed is bleeding within the skull. It includes intracerebral bleeds (interventricural bleeds and intraparenchymal bleeds), subarachnoid bleeds, epidural bleeds, and subdural bleeds.

Intracranial hemorrhage is serious medical emergency because the buildup of blood within the skull can lead to increase in intracranial pressure, which can crush delicate tissue or limit its blood supply. Severe increase in intracranial pressure (ICP) can cause brain herniation, in which parts of the brain are squeezed past structures in the skull.[Bullock R, Teasdale G].

Cause:

Intracranial bleeding occurs when a blood vessel within the skull is ruptured or leaks. It can result from physical trauma (as occurs in head injury) or nontraumatic causes (asoccur in hemorrhagic stroke) such as a rupturedaneurysm. Anticoagulanttherapy, as well as disordered with blood clotting can heighten the risk that an intracranial hemorrhage will occur.

Classification:

Types of intracranial hemorrhage are roughly grouped into intra- axial and extra-axial. The hemorrhage is considers a focal brain injury, that is it occurs in a localized spot rather than causing diffuse damage over wider area.

[Bullock R, Teasdale G]

- *Intra-axial bleed*
  Intra-axial hemorrhage is bleeding within the brain itself, or cerebral hemorrhage. This category includes intraparenchymal hemorrhage, or bleeding within the brain tissue, and intraventricualrhemorrhage, bleeding within the brain's ventricles (particularly or premature infants). Intra-axialhemorrhages are more dangerous and harder to treat than extra-axial bleeds.

- *Extra-axial bleed*
  Extra-axial hemorrhage, bleeding that occurs within the skull but outside the brain tissue, falls into three subtypes:

1. **Epidural hemorrhage (extradural hemorrhage)** which occurs between the Dura mater (the outermost meninx) and the skull is caused by trauma. It may result from laceration of an artery, most commonly the middle meningeal artery. This is a very dangers type of injury because the bleed is from a high-pressure system and deadly increase in intracranial pressure can resultrapidly. However, it is the least common type of meningeal bleeding and is seen in 1% to 3% cases of head injury.

- Patients have a loss of consciousness (LOC), then a lucid interval, then sudden deterioration (vomiting,restlessness, LOC).
- Head CT shows lenticular (convex) deformity.

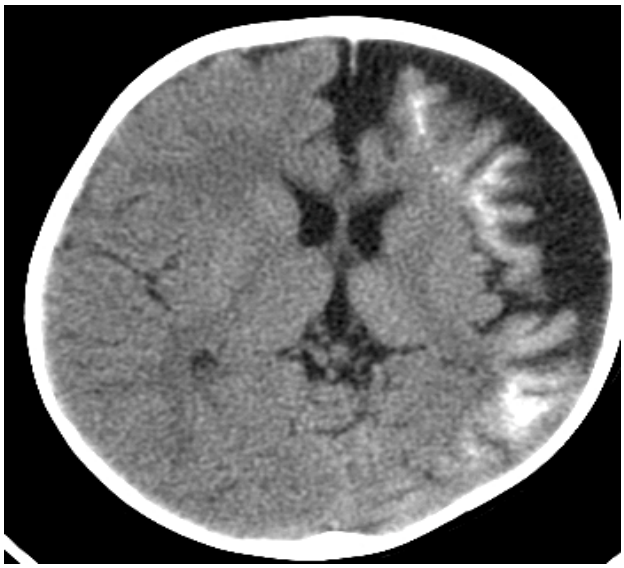


Fig. (2-16) epidural hemorrhage

2. **Subdural hemorrhage** results from tearing of the bridging veins in the subdural space between the Dura and arachnoids mater.
   Subdural hemorrhage, which occurs between the arachnoids and pia meningeal layers, like intraparenchymal hemorrhage, can result either from trauma or from ruptures of aneurysms or Arteriovenousmalformation. Blood is seen layering into the brain along sulci and fissure, or filling cisterns (most often the suprasellar cistern because of the presence of the vessels of the circle of Willis and their brachpoints within that space). The classic presentation of subarachnoid hemorrhage is the sudden onset of a sever headache (thunderclapheadache). This can be very dangerous entity, and requires emergent neurosurgical evaluation, and sometimes urgent intervention.

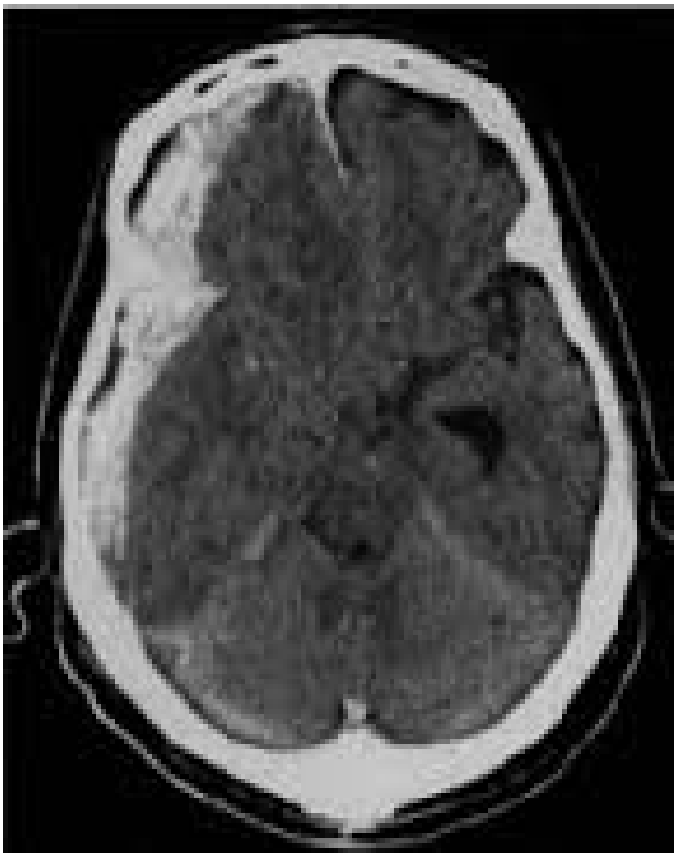


Fig. (2-17) Subdural hemorrhage

3. **Subarachnoid hemorrhage :**

Is bleeding into the subarachnoid space the area between the arachnoidsmembrane and the pia mater surrounding the brain. Beside from head injury, it may occur spontaneously, usually from a ruptured cerebral aneurysm.

Symptoms of SAH include a sever headache with a rapid onset thunderclap headache,vomiting, confusion or a lowered level of consciousness and sometimes seizures.

[Bullock R, Teasdale G]

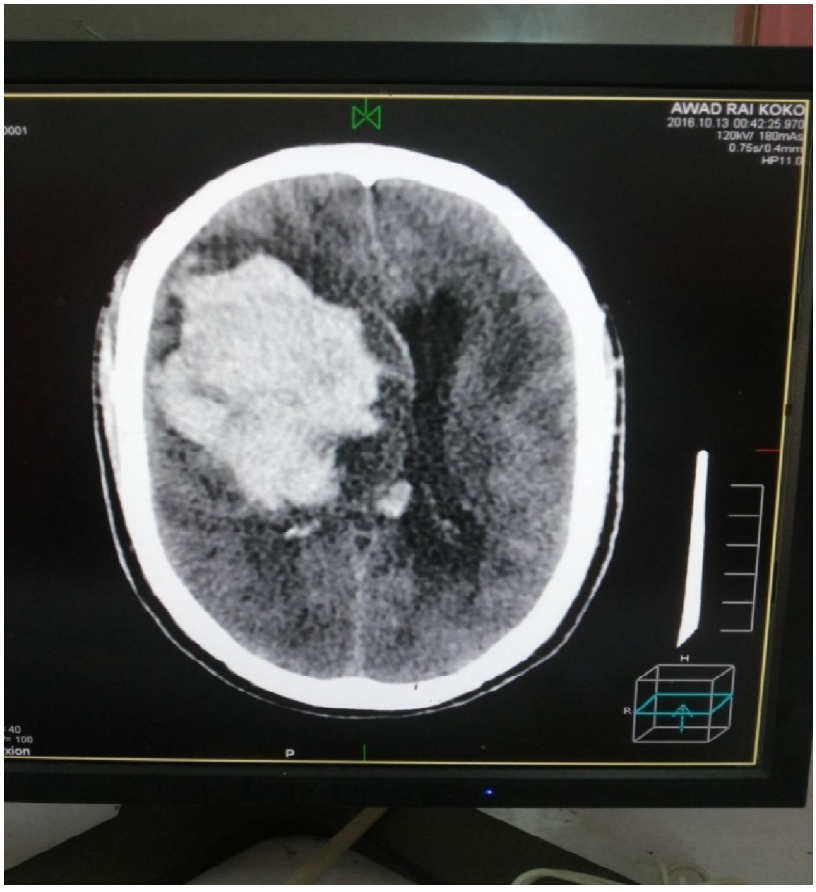


Fig. (2-18) Subarachnoid hemorrhage

2.1.4 Computed Tomography:

A CT scan, also called X-ray computed tomography (X-ray CT) and computerized axial tomography scan (CAT scan), makes use of computer- processed combinations of many X-ray images taken from different angles to produce crosssectional (tomographic) images(virtual "slices") of specific areas of a scanned object, allowing the user to see inside the object without cutting. Digital geometry processing is used to generate a three-dimensional image of the inside of the object from a large series of two-dimensional radiographic images taken around a single axis of rotation.[Azian AA, Nurulazman AA, Shuaib L, Mahayidin M, Ariff AR, Naing NN,et al]

Since its introduction in the 1970s, CT has become an important tool in medical imaging to supplement X-ray and medical ultrasonography. It has more recently been used for preventive medicine or screening for disease, for example CT colongraphy for people with high risk of colon cancer, or full-motion heart scans for people with high risk of heart disease or people with head injury. A number of institutions offer full-body sans for the general population although this practice goes against the device and official position of many professional organizations in the field.[Azian AA, Nurulazman AA, Shuaib L, Mahayidin M, Ariff AR, Naing NN,et al]

Major component of the computed tomography:

There are three major systems:

Imaging system

Computer system

Image display/recording/storage system

- Each system in a separate room.

Major component:

Scanner room:

- Imaging system
- Gantry assembly.

Computer and electric room:

- Power
- Computer
- Generator

Operator’s area display/recording/storage.

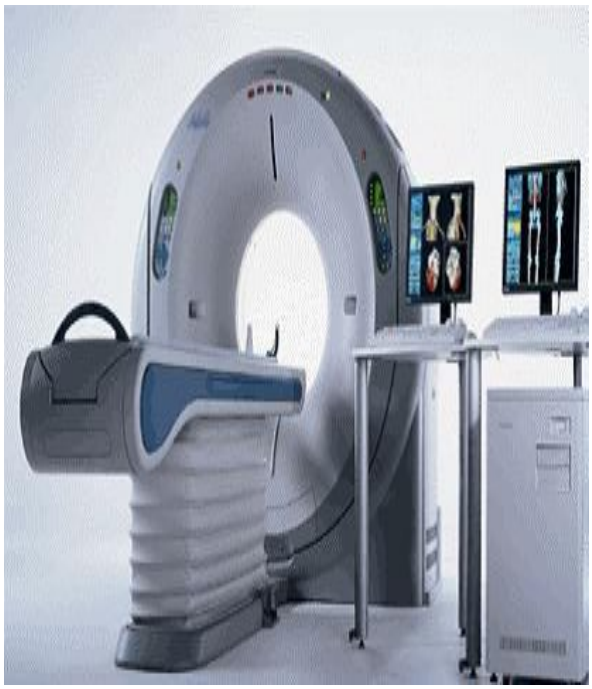


Fig (2-19) computed tomography units

2.2 previous studies:

Gan BK indicated that age and sex play a major role in the prognosis of head injury and also showed that the age must be considered an independent factor in outcome prediction in elderly with moderate and sever traumatic brain injury.

Shameran Slewa-Younan concluded that men's level of injury severity were greater than women's despite the same admission criteria being applied to both sexes.

GCS (Glasgow Coma Score) from Scottish intercollegiate Guideline Network (SIGN) 2000 was found to have a predictive factor of outcome following statistical analysis. The GCS was correlated with outcome in which higher mortality was associated with lower GCS, and degree of midline shift

Athiappan et and Toutant which found that 16 of 37 cases (43.2%) died, 17 cases improve in patients brain injury with midline shift greater than 10 mm, 16 cases of 59 cases died (27%) 39 cases improved in patients brain injury with midline shift up to 10mm while 17 of 121 cases died (14%) 84 cases improved in patients brain injury without midline shift.

Yamaura noted a higher mortality when SDH was associated with the presence of parenchyma lesion. Analysis did by Kunishio where 66.7% of their patients with contusion had a good outcome.

Studied by *Narayan*, the extent of midline shift did not add significantly to the prognostic capability of their model. Selladuri also noticed that the degree of midline shift did not prove to be predictive significance. Of all patients with midline shift, 29 patients (30.2%) had a GCS score of 12-15 while 68 patients (70.8%) fell into the GCS score < 12 which is unfavorable group.

Chapter three

Chapter three

Materials and Methods

This study was performed at department of radiology in ALGAZIRA TRAUMATOLOGY CENTER in ALgazira State during the period of feb.2016 to october2016.

3.1 Population:

This study included 50 subjects (36 males and 14 females).

3.1.1 Inclusion Criteria:

Subjects with normal brain.

3.1.2 Exclusion Criteria:

Patient with traumatic brain injury.

Patient evaluated for level of consciousness by a neurosurgeon.

3.1.3 Materials:

3.1.4Machines uses:

CT Toshiba 16 slices (Toshiba medical system, Nasu, Japan 2003).were used.

3.2 Methods:

CT BRAIN PROTOCOL:

Consider revising the ideal midline (IML) as the intersection of the CT SCAN and the midsagittal plane. As large mass of pathology such as hemorrhage emerges, ideal midline (IML) deforms and shifts to one side of the brain. The deformed midline (dML) is defined as a curve that best fits the actual position of the original points on the ideal midline after deformation. The displacement of points from IML to dML during the deformation is the amount of midline shift.

3.2.1 Patient position: patients lyingsupine.

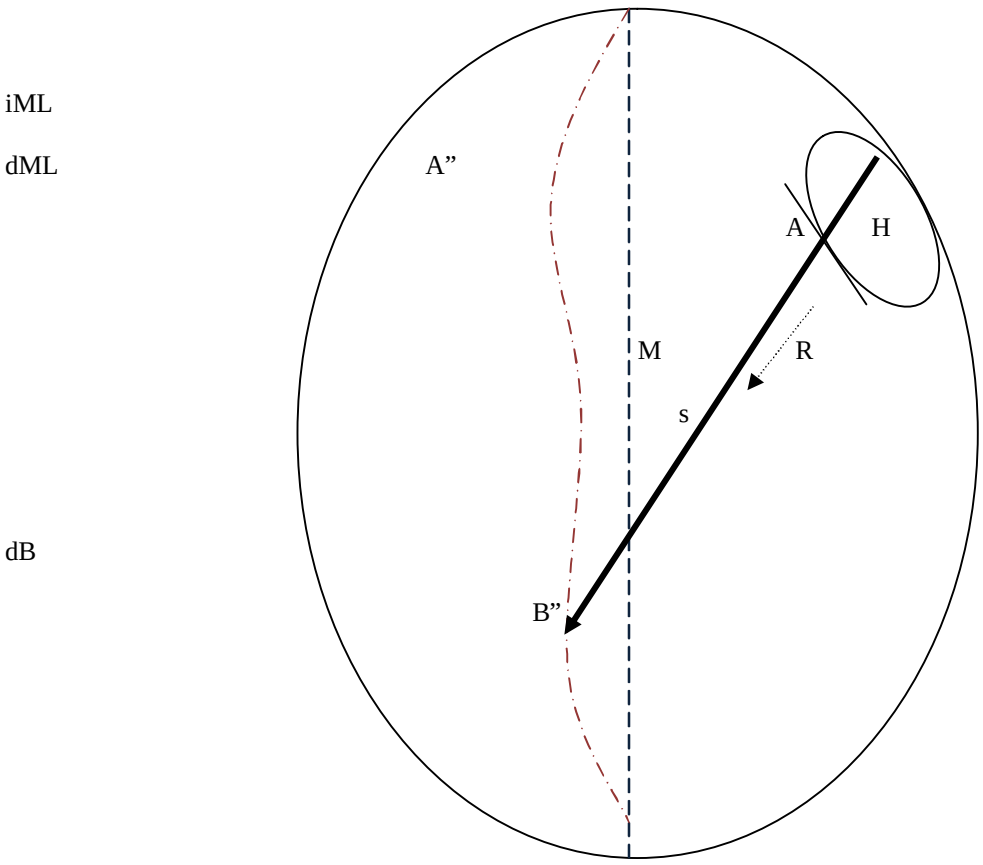
Contiguous 2mm slices were obtain using Toshiba 16 slices machine spiral technique (pitch 1.25-1.5, 0.75 s rotation time, 120kv, 2mm reconstruction interval).

3.2.2 Method of measure midline shift by using CTscan:

Hemorrhage is common pathology in traumatic brain injury, and it is the cause of most of the brain midline shift. From large number of CT scan presenting midline shift. We observe that generally, the amount of midline shift caused by hemorrhage is influenced by the following factors:

- The size of the hemorrhage: the larger the size is, the larger the amount of midline shifts.
- The distance between the hemorrhages to ideal midline (IML): the longer the distance is, the smaller the amount of midline shift.
- The midline elastic property: points on the ideal midline (iML) further apart from the skull are easier to be displaced

From these observations a heuristic model called hemorrhage midline shift (H-MLS) build up model to model the influence of the various factors on the amount of midline shift.



Fig(3-1):shows the H-MLS model

3.2.1.1 Tracing the deformed midline:

Based on the hemorrhage midline shift H-MLS a scheme of tracing the deformed midline, algorithm first computes the hemorrhage information presented in TBI CT scan. Then it uses the H-MLS model to predict the possible dML. The predicted dML is adjusted according to visual symmetry information.

- *Step1: hemorrhage segmentation*: intracranial hemorrhage region has higher intensity value than normal brain tissues in the CT image. Using simple

thresholding method to segment out the image regions corresponding to hemorrhage (thresholding using 160 < intensity value < 230).

- *Step2: computation of the hemorrhage information*: fit an ellipse H in to the boundary of the hemorrhage, ray R is shot from each point A on H. for each effective ray R; compute the corresponding point B on iML, and the corresponding r, s, and f.
- *Step3: Predicting the deformed midline*: Given the H-MLS model to compute the amount of midline shift d for each point B on iML which is also on the effective ray. Thus a corresponding point B" and applying a simple curve smoothing process, to get predicated dML.
- *Step4: Symmetry adjusting:*In this final step, the predicted dML is adjusted to best fit the visual symmetry information.

3.2.1.2 Method and technique:

In our hemorrhage-MLS (H-MLS) model, each hemorrhage H is represented as an ellipse H that best fits the hemorrhage boundary.For each point A on H , we shoot a ray (R) from A along the normal direction N at A .

If ray (R) intersect the ideal midline shift iML, at point B, it is called an effective ray, which means it effect the deformation of midline. Denote the intersection of effective ray (R) with the dML as B". Back extend (R) to let it intersect with H at A". Therefore, the amount of midline shift of point B is the image distance between B and B".

Donated as D = (BB")

The amount of midline shift of each point B on the iML is affected by the effective ray (R) passing through it. On each effective ray R, we use e = (AA") to measure the size of the hemorrhage, and use s = (AB) to measure the distance between the hemorrhage and the iML. Consider M the middle point of the iML, then f = (BM) measure the position of B on iML.

Then the H-MLS model is constructed as a simple linear equation:

$$D = r + s + f$$

Given a number of points B on the iML, the corresponding effective ray R and the amount of midline shift D, using the linear regression method. Therefore, H-MLS model is a linear regression model which reveals the relationship between intracranial hemorrhage and the MLS caused by it.

3.2.3 Data collection:

Data collection sheets used and other information were collected directly from patients in addition to references, websites and previous studies.

3.2.4 Data analysis:

The results were scheduled for analysis by using statistical package for social studies (SPSS) and Excel obtain the results related to correlation between variables.

Chapter four

Chapter four

Results

The data was presented by the following table and figures

Table (4-1): Distribution of patients according to gender

Gender	Frequency	%
Males	36	72
Females	14	28
Total	**50**	**100%**

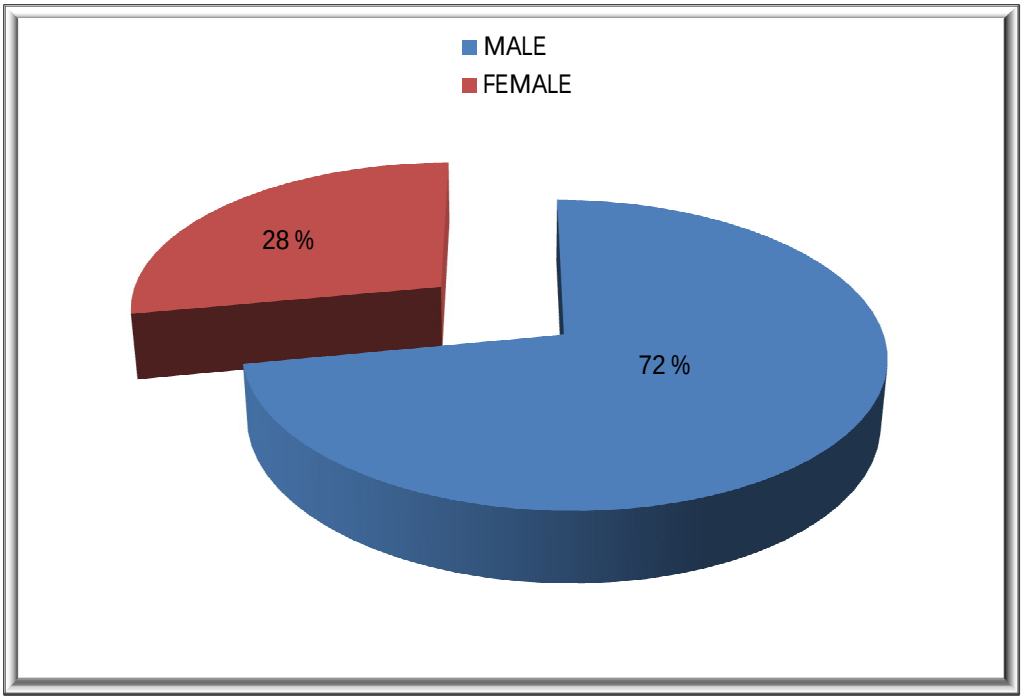


Fig. (4-1): Gender distribution

As ‘shown in table (4-1) and fig. (4-1), males represent (72%) of study population and (28%) are males

Table (4-2): distribution of patients according to age

Age group (years)	Frequency	%
15-35	8	16
36-55	17	34
56-75	19	38
76-95	6	12
Total	50	100%
Mean±SD	48.34±17.02	
Range	18-80	

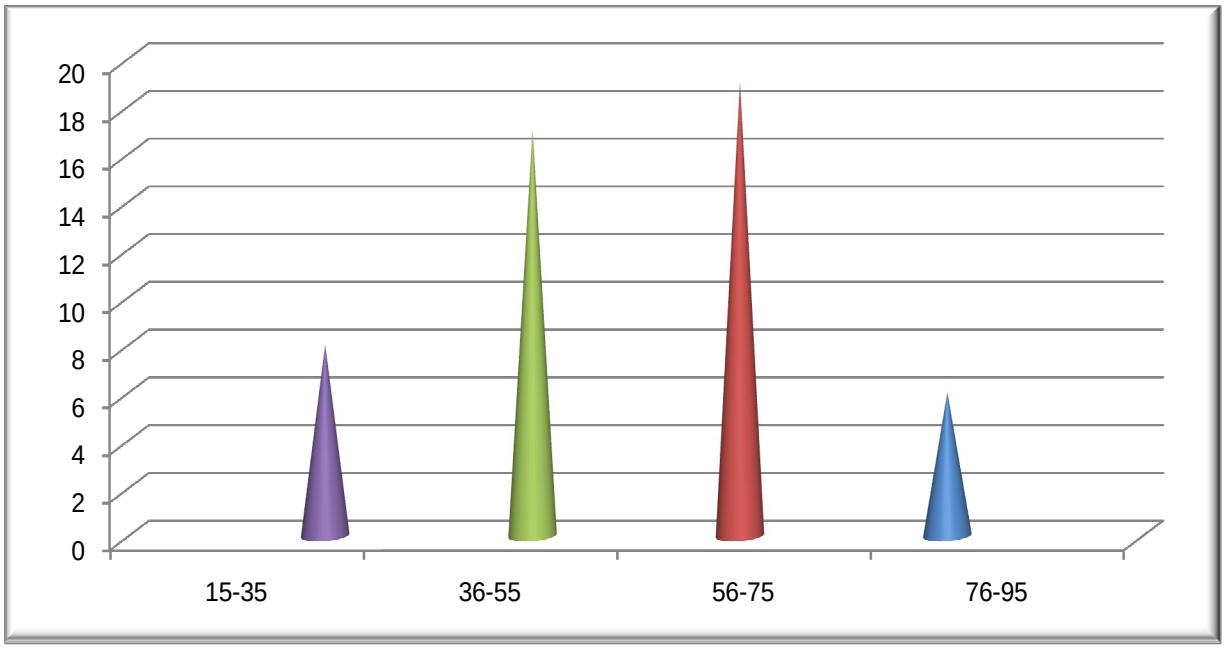


Fig. (4-2): age

illustrated in table (4-2) and fig. (4-2), shows distribution of patients according to age

Table (4-3): Distribution of patients according to Midline shift and GCS score

Midline shift classification	GCS severity		
	Mild	Moderate	Severe
Shift up to 10mm	28	6	3
Shift greater than 10mm	5	3	5
Total	33	9	8

GCS = Glasgow coma score

Table (4-4): Distribution of patients according to characteristic of brain injury with midline shift

Cause of midline shift	SHIFT UP TO 10 mm	Greater than 10 mm
SDH	17	8
EDH	9	6
ICH	6	3
DAI	-	1
FINAL OUTCOMES		
IMPROVE	31	13
DEATH	-	6

SDH = Subdural hematoma, EDH = epidural hematoma, ICH = Intracerebral hematoma, DAI = diffuse axonal injury.

Table (4-5): correlation betweenGCS and age

AEG	GCS						TOTAL	
	Mild	%	Moderate	%	Severe	%		%
15-35	**7**	**21.2**	**1**	**12.5**	**0**	**0**	**8**	**16**
36-55	13	39.4	3	33.3	1	12.5	17	34
56-75	10	30.3	5	55.6	4	50	19	38
76-95	3	9.1	0	0	3	37.5	6	12
TOTAL	33	100%	9	100%	8	100%	50	100%

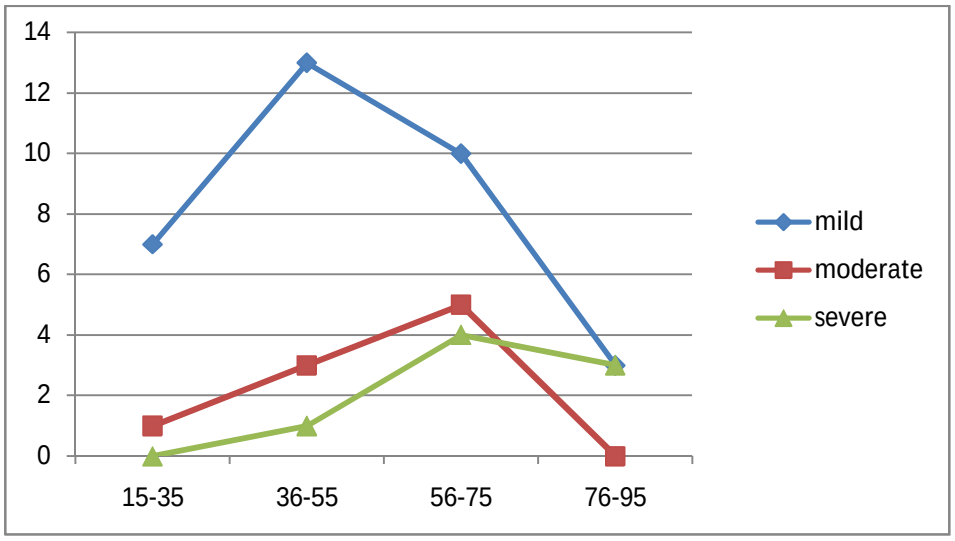


Fig.(4-3)

Relationship between GCS and age was illustrated in table (4-5) and fig. (4-3). (16%) of patients aged range between 15-35years, their GCS according to classification to mild, moderate, and severe (21.2%12.5%, and 0%). For patients aged between 36-55years, (34%) their GCS (39.4%, 33.3% and 12.5%). (38%) of patientsofaged between 56-75 their GCS (30.3%, 55.6%, and 50%). While (12%) of patients of age between 76-95, their GCS are (9.1%, 0%, and 37.5%).

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.705[a]	2	.000

Through the result we find the value of chi-square of less than 0.05, and therefore we accept the hypothesis that there is relationship between GCS and age.

Chi-Square Tests

Table (4-6) : correlation between GCS and gender

Gender	GSC						Total	
	mild	%	moderate	%	severe	%		%
Male	25	69.4	6	16.7	5	13.9	36	100
female	8	57.1	3	21.4	3	21.4	14	100
Total	33	66	9	18	8	16	50	100

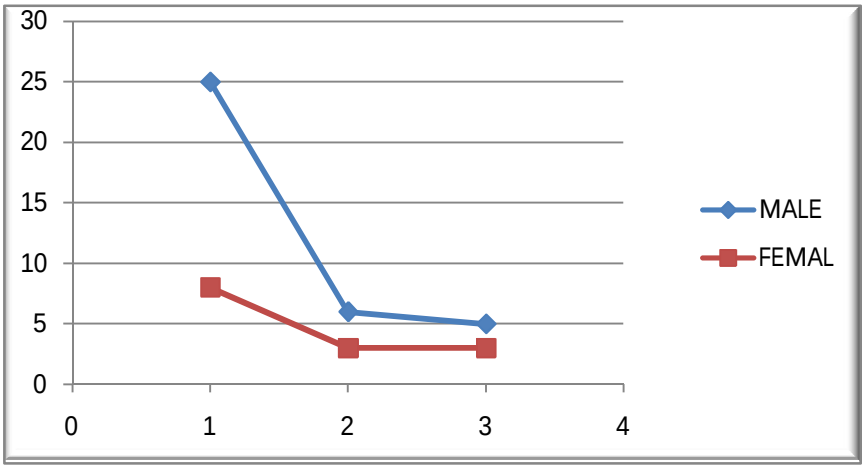


FIG.(4-3)

Correlation between GCS and age was illustrated in table (4-6) and fig. (4-3).

Through the result we find the value of chi-square of less than 0.05, and therefore we accept the hypothesis that there is no relationship between GCS and gender.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.714[a]	1	.010		

Table (4-7) Cross-tabulation between midline shift and age

	Age				Total
	15-35	36-55	56-75	76-95	
Shift up to 10mm	8	14	8	3	33
Shift greater than 10mm	0	3	11	3	17
Total	8	17	19	6	50

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.734[a]	3	.013
N of Valid Cases	50		

Through the result we find the value of chi-square of less than 0.05, and therefore we accept the hypothesis that there is no relationship between midline shift (MLD) and age.

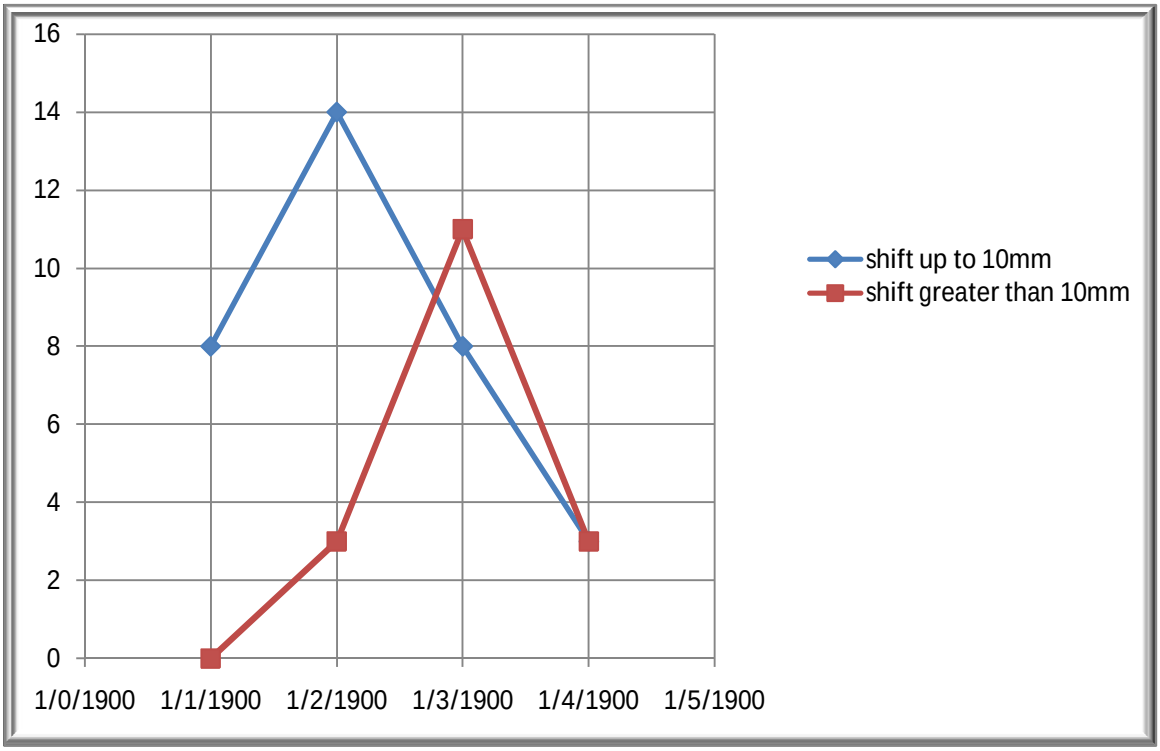


Fig. (4-4)

Chapter five

Chapter five`

Discussion, conclusion and recommendations

5.1 Discussion:

These results aimed to measure he degree of midline shift using computed tomography. An underwent CT Brain during the period from (Feb. 2016 to October 2016). Number of 50 subjects (33% were male and 16% were females).

Ct was the study of Pipat chiewvit MD, Suthisak Suthipogchai MD, which included 216 consecutive cases of traumatic head injury, 96 of 216 patients had midline shift, and 53 of 96 had CT scan midline shifting less than 10mm where 37 of 96 had CT scan greater than 10mm. The present study revealed that the lower GCS (<12) was not statistically significant correlated with a large degree of midline shift (shift up to 10 mm and shift greater than 10 mm). It found that degree of midline shift in patient's brain injury was also statistically significantly correlated with outcome. GCS has been widely adopted and used in classification of severity in head injury patients.

Pipat chiewvit MD, Suthisak Suthipogchai MD, showed the degree of midline shift in patient's brain injury was statically significant as a determinant of outcome. It appeared that probability of poor outcome was higher when there is combination of midline shift with other type of intracranial hemorrhage, clinical factor such as sex, age GCS score and associated injury. The similar results were also demonstrated by Gennarelli et and Lobato et, which pointed out that the type of lesion is an important factor in determining the outcome as severity of injury assessed by GCS. The degree of midline shift was found to be not significant in relation to GCS score in present study this meant that a larger midline shift tends to be not associated with a lower GCS score.

The present of midline shift especially with SDH was significant. This meant that the outcome would be poorest if the midline shift with SDH compared to other lesion in patients with brain injury. Reviews by V Juran et, showed that SDH with midline shift treatment was possible in certain cases. It could be successful in smaller hematomas in patients in a good clinical condition but also in smaller in those comatose patients where the midline shift is most likely caused by brain edema and contribution of brain compression is small.

In agreement with the results of the previous studies.

Selladuri noticed that the degree of midline shift did not prove to be of a predictive significance of all the patients with midline shift, 29 patients (30.2%) had a GSC score of 12-15 while 68 patients (70.8%) feel into the GSC <12 which is the un favorable group, in agreement with the result of the previous studies.

5.2 Conclusion:

The present study concluded that the increased degree of midline shift in patient with head injuries by CT scan was related to the severity of head injury (GCS = 3-12) and was significantly related to poor final clinical outcome , in agreement with the results of the previous studies.

This study also found that a larger midline shift tends to be not associated with a lower GCS score, and also the type of lesion is an important factor in determining the outcome as the severity of injury assessed by GSC.

From this study we found the degree of midline shift in patient's brain injury was statically significant as a determinant of outcome. It appeared that probability of poor outcome was higher when there is combination of midline shift with other type of intracranial hemorrhage, clinical factor such as sex, age GCS score and associated injury. Also the outcome would be poorest if the midline shift with SDH compared to other lesion in patients with brain injury.

In other word, the degree of midline shift did not prove to be of a predictive significance of all the patients with midline shift, 50 patients had a GSC score of 12-15 while 68 patients feel into the GSC <12 which is the unfavorable group, in agreement with the result of the previous studies.

5.3 Recommendations:

Evaluate the degree of midline shift may play an important role in aiding determine

The Glasglow Coma Score (GSC) and the clinical outcome in patients after head injury

Using of Computed tomography in evaluate of the midline shift is valuable and non invasive procedure.

Estimate midline shift by using CT scan may help in the future to develop a stander based on the amount, and causes of midline shift to determine the GCS.

References

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Appendix

Appendix (A)

No.	age	gender	MLD up to 10mm	MLD greater than 10mm	SDH	EDH	ICH	DAI	GCS		

Appendix (B)

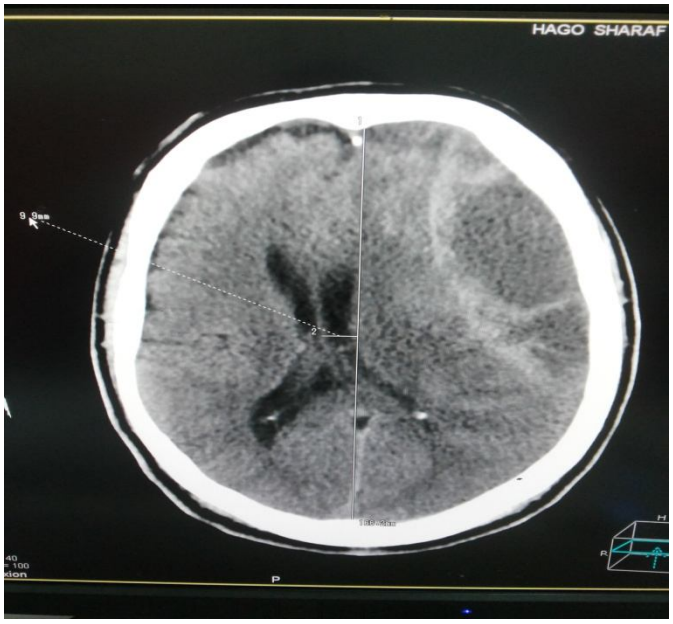

Figure (B.1): 59years old, male, SDH with midline shift 9.9mm. right side weakness, GCS 14.

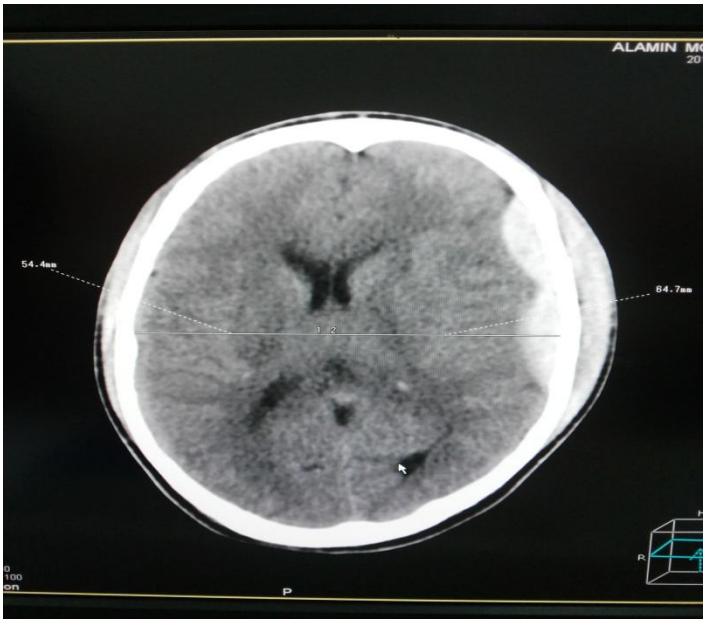

Figure (B.2): 36years old, male, EDH with midline shift 3.2mm.GSC10.

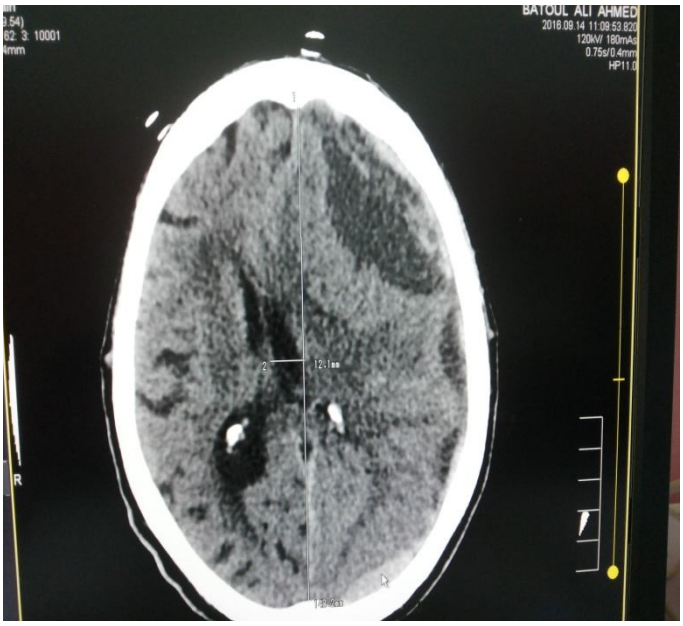

Figure (B.3): 64years old, female, EDH with midline 12.2mm.in coma GSC3.

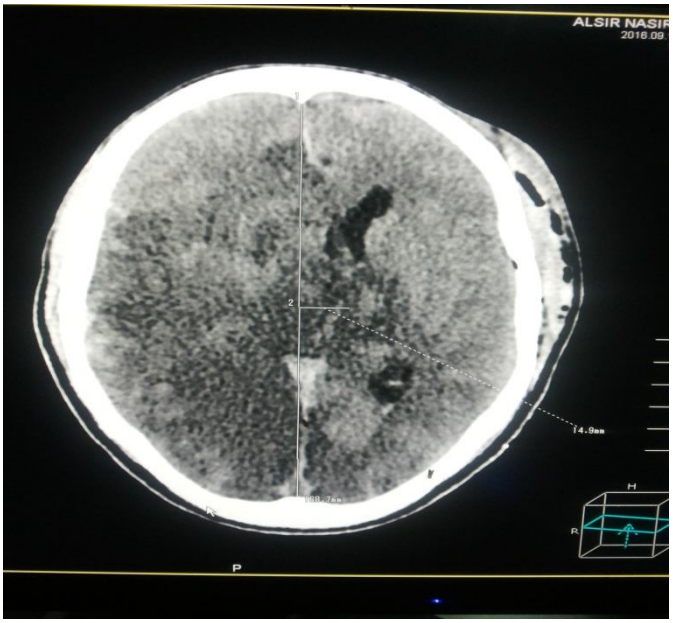

Figure (B.4): 45years old, male, intracerebral hemorrhage with SDH.GSC10.

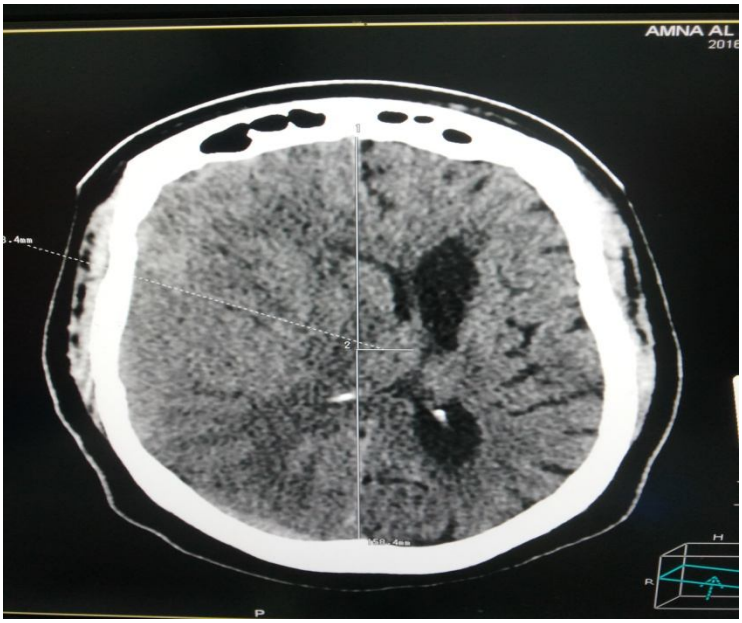

Figure (B.5): 60years old, female, SDH with midline shift 15.1mm, GSC15.

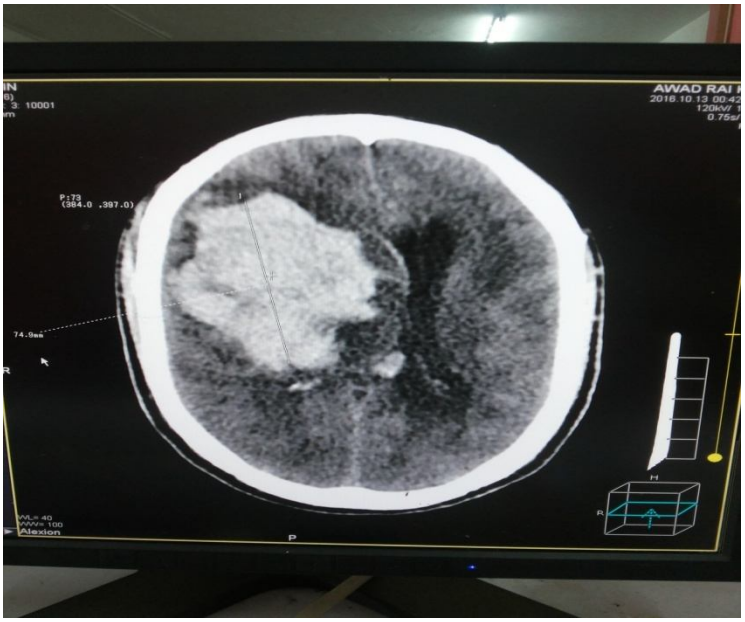

Figure (B.6): 38years old, male, intracerebral hemorrhage with midline shift 13.3, GSC3.