Sudan University of Science and Technology

College of Graduate Studies

Diagnosis of Hydrocephalus in Sudanese Neonates and Young

تشخيص داء الرأس المائي بحديثي الولادة وصغار الرضع السودانية بإستخدام الموجات فوق الصوتية

Thesis Submitted for Partial Fulfillment of Master Degree in medical ultrasound

Presented by:

Galal Mohammed Mohammed Nur

Supervisor:

Dr. Mohammed Elfadil Mohammed

Assistant professor

٢٠١٥

الآيـــــــــــة

قال تعالي:

(قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ)

صدق الله العظيم

سورة البقرة الآية

(٣٢)

Abstract

This study is about diagnosic of hydrocephals in Sudanese neonates and young infant using ultrasound as a modality of diagnosis.

This study was conducted to evaluate the use of c u s in assessing brain maturation and agency of hydrocephalus and other structural brain abnormalities the study was done in Khartoum state hospitals in the period from June 2013 to January 2014, using (Fukuda 4200 R) ultrasound machine with multi frequency 5-10 MHZ linear or convex sector transducer.

The result of this study showed that the incidence Of hydrocephalus in the selected sample was more in male infants compared to female, and the most detected ultrasound funding is dilated lateral ventricle in all samples 100% and all acquired hydrocephalus. Are noted to be post meningitis. The majority of cases were symptomatic.

ملخص البحث

هذه الدراسة كانت عن تشخيص داء الرأس المائي في حديثي الولادة وصغار الرضع السودانيين باستخدام الموجات الفوق الصوتية كوسيلة للتخشيص، الدراسة أجريت في مستشفيات ولاية الخرطوم في الفترة ما بين يونيو ٢٠١٣م إلي يناير ٢٠١٤م باستخدام جهاز الموجات فوق الصوتية فوكودا دتس أف سونك (٤٢٠٠ آر) ميجاهيرز بمجسات زر تردد ٥-١٠ محدب الشكل ولينير الشكل.

نتيجة هذه الدراسة أن:

الذكور أكثر إصابة من الإناث وأن ١٠٠% من حالات داءالرأس المائي الثانوية كانت نتيجة للإصابة بالحمى المخية الشوكية وأن معظم الحالات ٨٠%مصحوبة بأعراض.

To: My family - My Mother – to Hani

To: memory of my father

Dr. Mohammed Alfadil - Dr. Mobark

Dr. Mekki - Dr. Alttekaina

To: their Valuable Assistance

Acknowledgement

My acknowledgement and great fullness at the beginning and end to Allah.

My special gratitude to my supervisor Dr: Mohammed Alfadil who do his best helping and guiding me to this thesis. I am very grateful to, all my teachers in all educational levels, especiall thanks for my colleagues Dr. Mohammed Alfadil - Dr. Mobark - Dr. Mekki - Dr. Alttekaina

Table of contents

Topics	Page number
Quran	I
Abstract	II
ملخص البحث	III
Dedication	IV
Acknowledgement	V
List of Appreciations	VI
Table of contents	VII
List of figure	XI
List of tables	XII

CHAPTER ONE

Topic	Page No
1.1:Introduction	1
1.2. Significant of the study	2
1.3Objectives	2
1.3.1. General objectives	2
1.3.2. Specific objective	3
1.4: Overview of the study	3

CHAPTER TWO

Topic	Page No
2. Background & Literature review	5
2.1 Gross anatomy of the skull	5
2.2. External Views of the Skull	5
2.1.2. Major regions of the brain and their functions	16
2.1.3. The cerebral circulatory system	18
2.1. 4. Embryology and special feature of the neonatal brain	20

CHAPTER THREE

Topic	Page No
3. Research Methodology	40
3.1.Study design	40
3.2.Study period	40
3.3.Study area	40
3.4.Study population	40
3.5 Sampling and Sample size	40
3.6.Tools of data collection:	41
3.7.Data analysis	41
3.8. limitation of the study	41
3.9 .Ethical consideration	41

CHAPTER FOUR

Topic	Page No
Result	42

CHAPTER FIVE

Topic	Page No
5.Disscussion Conclusion and recommendation	49
5.1 Discussion	49
5.2 Conclusion	50
5.3 Recommendation	50
List of reference	52
Appendix	54

List of figure

Number	Figure	Page Number
2-1	Anterior view of the skull	7
2-2	Superior view of the skull	8
3-2	skull cap	9
4-2	posterior view of the skull	10
5-2	Lateral aspect of the skull	11
6-2	inferior view of the skull	12
7-2	internal surface of the base of the skull	13
8-2	Figure (8-2): The fetal skull	14
9-2	Show Meninges Anatomy	15
10-2	shows Cerebrospinal Fluid	16
11-2	ventricular system	16
12-2	shows Major Regions of the Brain	17
13-2	Major Regions of the cerebral hemispheres	18
14-2	Major cerebral arteries and the circle of Willis	20
15-2	show brain development with age	21
15-3	Equipment OF Ultrasound Machine	22
2-1	Well-fitting ultrasound probe	24
2-2	a Coronal ultrasound scan at the level of the parieto-occipital lobes in a full-term baby	25
2-3	a Coronal ultrasound scan in a full-term baby	26

3-1	Ultrasound examination performed in a full-term newborn infant while infant is seated on his mother's lap	28
3-2	a,b Ultrasound scan in a preterm infant with cystic periventricular leukomalacia	30
3-3	Coronal ultrasound scan in a very preterm infant at the level of the frontal horns of the lateral ventricles.	30
3-4	Probe positioning for obtaining parasagittal scan	31
3-5	Parasagittal ultrasound scan in a preterm infant through the left lateral ventricle	31
2-10	show the acousticwindows.AF anterior fontanel	36
2-11	show standard six coronal plane from	36
2-12	show a.Fourth coronal plane (C4) at the level of the bodies of the lateral ventricles	37
2-13	show a Third coronal plane (C3) at the level of the foramen of Monro and the third ventricle	37
2-14	show Second coronal plane (C2) at the level of the frontal horns of the lateral ventricles	38
2-15	show a First coronal plane (C1) at the level of the frontal lobes.	39

List of table

Number	Table	Page
4-1	Lateral Ventricle enlargement	45
4-2	3rd Ventricle Enlargement	45
4-3	3rd Ventricle Enlargement	45
4-4	Associated findings Type of Hydrocephalus Cross tabulation	47
4-5	Associated finding Associated with meylomingocele cross tabulation	48

1.1:Introduction:

Cranial ultrasonography (CUS) was introduced into neonatology in the Late 1970s and has become an essential diagnostic tool in modern neonatology. The non-invasive nature of ultrasonography makes it an ideal imaging technique in the neonate. In the neonate and young infant, the fontanels and many sutures of the skull are still open, and these can be used as acoustic windows to “look” into the brain. Transfontanellar CUS allows the use of high-frequency transducers, with high near-field resolution. As a result of ongoing development in ultrasonography, image quality is high nowadays, provided optimal settings and techniques are applied. Therefore, CUS is a reliable tool for detecting congenital and acquired anomalies of the perinatal brain and the most frequently occurring patterns of brain injury in both preterm and full-term neonates.[1]

Hydrocephalus refers to an increased intracranial content of cerebral spinal fluid (CSF). The term is generally used to refer to a situation in which an abnormal accumulation of cerebral spinal fluid results in an enlargement of the ventricular system. Hydrocephalus can be classified into communicating and non-communicating (obstructive). Both forms can be either congenital or acquired.(3)

A neonate is also called a newborn. The neonatal period" the first 4 weeks of a child's life " represents a time when changes are very rapid, and many critical events can occur. During the first 30 days, most present from birth (congenital) defects are discovered. Genetic abnormalities may show up. Infections, such as congenital herpes, Group B *Streptococcus*, toxoplasmosis, and other medical conditions become apparent in the neonatal period as they begin to have effects on the baby.

Cranial ultrasonography through anterior fontanelle is a rapid, non-invasive, efficient and generally available diagnostic tool and is advised for all neonates with any features suggestive of raised intracranial pressure. It is relatively unusual for neonates to show rapidly advancing signs of intracranial hypertension with hydrocephalus of straightforward congenital origin. It therefore follows that if a neonate does show particularly severe or rapidly evolving features then there is likely to be some serious underlying pathology such as intracranial tumor or ventriculitis due to unrecognized or partially treated meningitis.

1.2. Significant of the study:

Hydrocephalus is one of the more common birth defect and represent dilemma for sonologist because of its adverse causes multitude of possible associated anomalies and varying in prognosis, the optimal approach to the antenatal diagnosis of hydrocephalus with sonography is still an unresolved issue. The first attempts to identify hydrocephalus in utero were made by visualizing a gross enlargement of the fetal head (or macro crania). However, hydrocephalic fetuses usually do not develop macro crania until late in gestation. Therefore, head measurements are unreliable for an early diagnosis.

Study will reveal the finding of the ultrasound among Sudanese neonate in Omdurman pediatrics Hospital since it's contain neurosurgical department for management and treatment of hydrocephalus.

1.3Objectives:

1.3.1. General objectives:

To discuss Ultrasound finding of hydrocephalus in Sudanese neonate at Omdurman hospital

1.3.2. Specific objective:

To discuss incidence and prevalence of hydrocephalus in selected sample (Sudanese neonate).

To determine the ultrasound findings and potential methods for making a diagnosis of hydrocephalus among selected sample (Sudanese neonate).

To describe the ventricles grow to an abnormal size and the major types of hydrocephalus.

1.4: Overview of the study:

Chapter one will consist introduction, objectives, methodology of the research then concluded with the scope of the study.

Chapter two will consist:

- literature review
- Applied Anatomy and Pathology
- Ultrasound

Chapter three:

It will deal with the material & methods

Chapter four:

It will include result presentation

Chapter five:

It will deal with the discussion, conclusion & recommendation.

Chapter2

2. Background & Literature review

2.1 Gross anatomy of the skull

The skull is the skeleton of the head, **(Moore, Gray's anatomy 40)** It shields the brain, the organs of special sense and the cranial parts of the respiratory and digestive systems, and provides attachments for many of the muscles of the head and neck **(Gray's anatomy 40)** A series of bones from its two parts, the neurocranium and viscerocranium: The neurocranium is the bony case of the brain and its membranous coverings, the cranial meninges. It also contains proximal parts of the cranial nerves and the vasculature of the brain. The neurocranium in adults is formed by a series of eight bones: four singular bones centered on the midline (frontal, ethmoidal, sphenoidal, and occipital) and two sets of bones occurring as bilateral pairs (temporal and parietal). **(Moore)**

The skull has 22 bones, excluding the ossicles of the ear. **(Gray's for students)**

It is composed of several separate bones united at immobile joints called sutures. The connective tissue between the bones is called a sutural ligament. The mandible is an exception to this rule, for it is united to the skull by the mobile temporomandibular joint. **(Snell)**

2.2. External Views of the Skull

Anterior view of the skull: The frontal bone, or forehead bone, curves downward to make the upper margins of the orbits. The superciliary arches can be seen on either side, or the supraorbital notch, or foramen, can be

recognized. Medially, the frontal bone articulates with the frontal processes of the maxillae and with the nasal bones. Laterally, the frontal bone articulates with the zygomatic bone. **(Snell)**

The supra-orbital margin of the frontal bone, the angular boundary between the squamous and the orbital parts, has a supra-orbital foramen or notch in some crania for passage of the supra-orbital nerve and vessels. Just superior to the supra-orbital margin is a ridge, the superciliary arch that extends laterally on each side from the glabella. **(Moore)**

Within the frontal bone, just above the orbital margins, are two hollow spaces lined with mucous membrane called the frontal air sinuses. These communicate with the nose and serve as voice resonators. **(Snell)**

The zygomatic bones (cheek bones, malar bones), forming the prominences of the cheeks, lie on the inferolateral sides of the orbits and rest on the maxillae. The anterolateral rims, walls, floor, and much of the infra-orbital margins of the orbits are formed by these quadrilateral bones. A small zygomaticofacial foramen pierces the lateral aspect of each bone. The zygomatic bones articulate with the frontal, sphenoid, and temporal bones and the maxillae. **(Moore)**

The zygomatic bone forms the prominence of the cheek and part of the lateral wall and floor of the orbital cavity. Medially, it articulates with the maxilla and laterally it articulates with the zygomatic process of the temporal bone to form the zygomatic arch. The zygomatic bone is perforated by two foramina for the zygomaticofacial and zygomaticotemporal nerves **(Snell)**

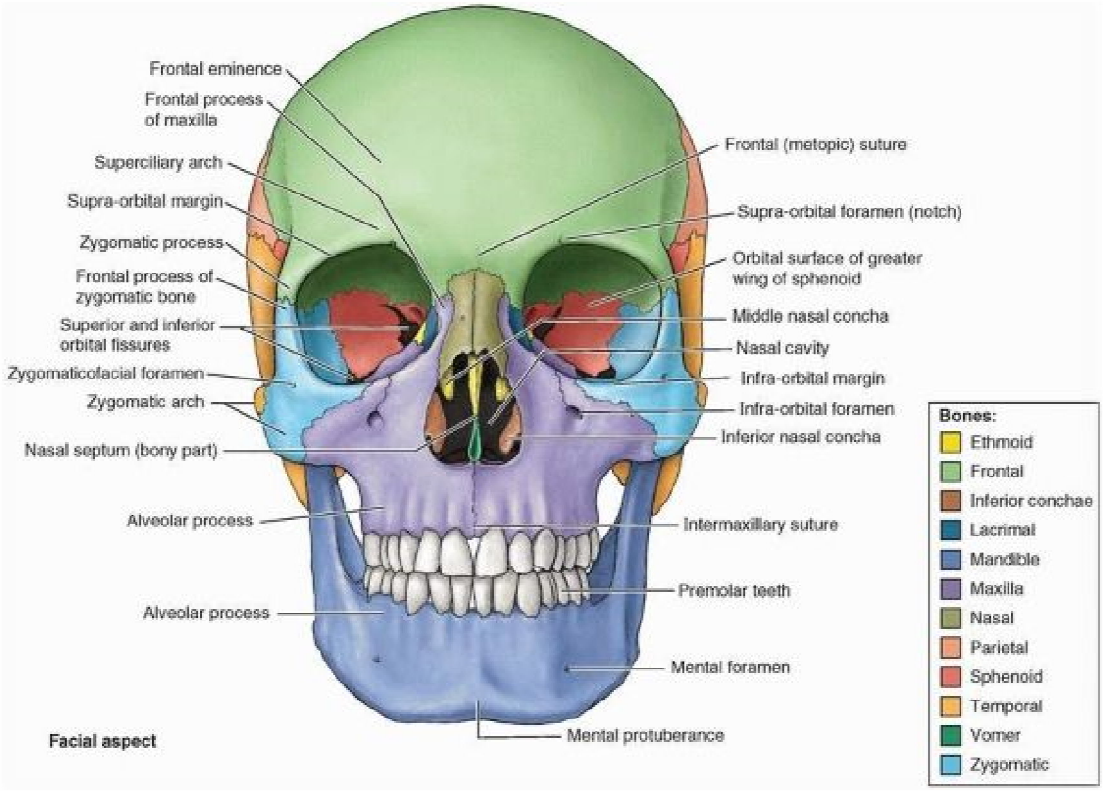


Figure (2-1): Anterior view of the skull (Reproduced from Moore{})

Superior view of the skull:

Anteriorly the frontal bone articulates with the pair of parietal bones at the coronal suture; the original two halves of the frontal bone occasionally fail to fuse, leaving a midline metopic suture. The midline meeting place of the bones is the bregma, the site of the anterior fontanelle. The coronal suture is straight for 3 cm or more lateral to the bregma (this is the line of closure of the anterior fontanelle) and then becomes highly tortuous as it curves transversely down to the lateral surface of the skull. Behind the bregma the parietal bones articulate in the midline sagittal suture. The anterior 3 cm of this is straight (the line of closure of the anterior fontanelle) and then comes a tortuous part for 5 cm, followed by a straight part. Alongside this a parietal foramen often perforates each parietal bone; an emissary vein leaves the

superior sagittal sinus through it. Thence the sagittal suture, tortuous again, curves down to the lambda, at the apex of the occipital bone. The Centre of the parietal bone is a low prominence, the parietal eminence, and this lies on the profile of the skull from this view. **(Last anatomy)**

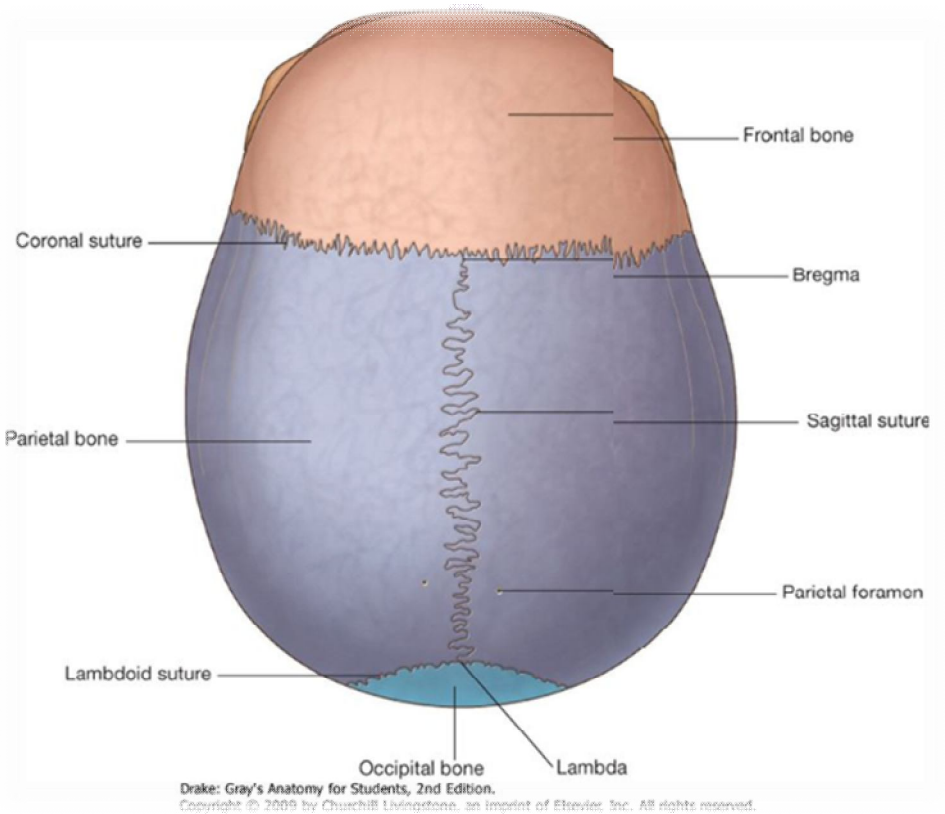


Figure (2-2): Superior view of the skull (Reproduced from gray's anatomy for students{})

The bones making up the calvaria are unique in their structure, consisting of dense internal and external tables of compact bone separated by a layer of spongy bone (the **diploë**)

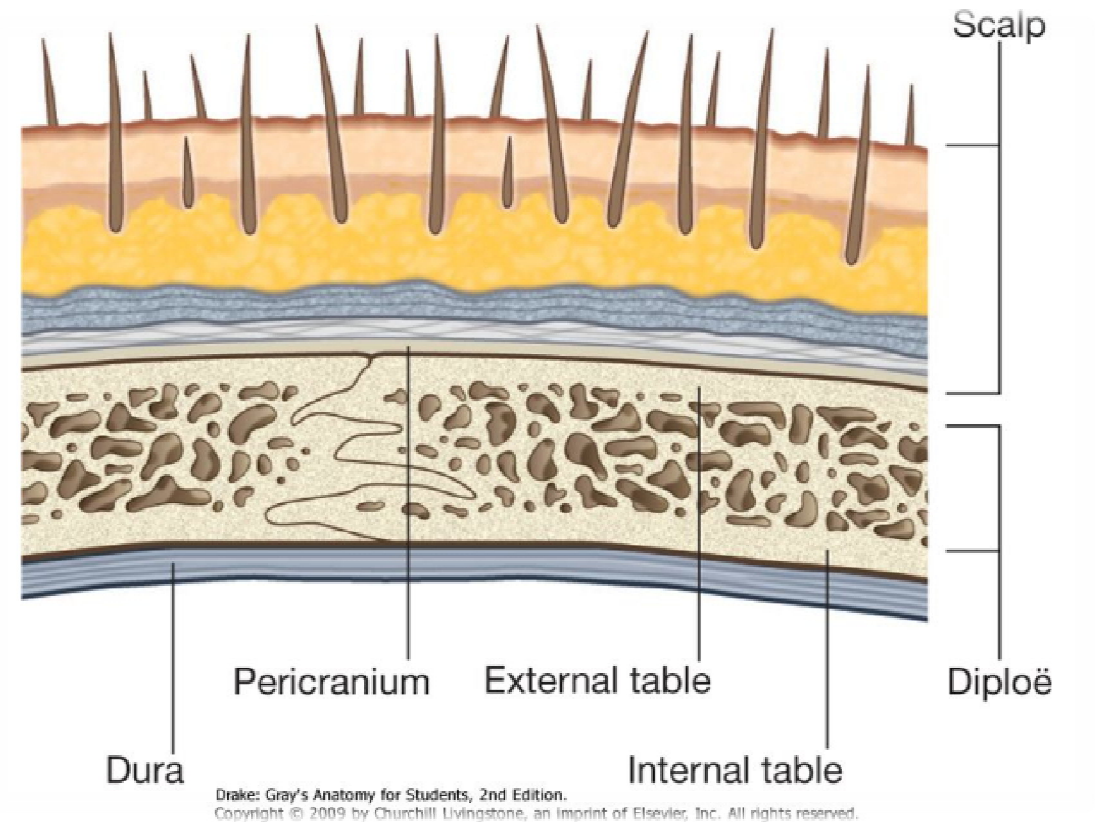


Figure (3-2): skull cap (Reproduced from gray's anatomy for students{})

Posterior view of the skull:

The posterior parts of the two parietal bones with the intervening sagittal suture are seen above. Below, the parietal bones articulate with the squamous part of the occipital bone at the lambdoid suture. On each side the occipital bone articulates with the temporal bone. In the midline of the occipital bone is a roughened elevation called the external occipital protuberance, which gives attachment to muscles and the ligamentum nuchae. On either side of the protuberance the superior nuchal lines extend laterally toward the temporal bone. **(Snell)**

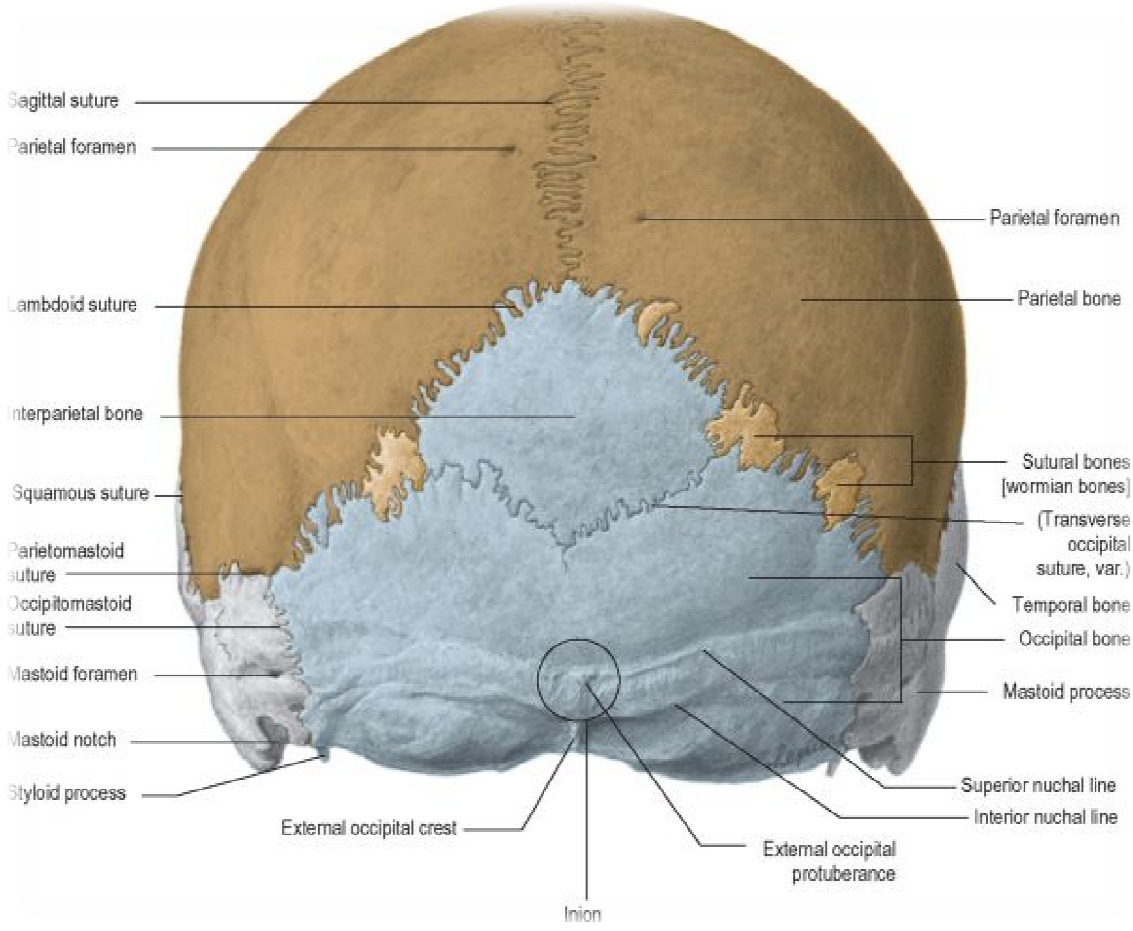


Figure (4-2): posterior view of the skull (Reproduced from moore {})

Lateral view of the skull:

The main features of the neurocranial part are the temporal fossa, the external acoustic opening, and the mastoid process of the temporal bone. The main features of the viscerocranial part are the infratemporal fossa, zygomatic arch, and lateral aspects of the maxilla and mandible. **(Moore)**

The temporal fossa is the area bounded by the superior temporal line, zygomatic arch and the frontal process of the zygomatic bone. **(Last)**

In the anterior part of the temporal fossa, 3-4 cm superior to the midpoint of the zygomatic arch, is a clinically important area of bone junctions: the

pterion (G. pteron, wing). It is usually indicated by an H-shaped formation of sutures that unite the frontal, parietal, sphenoid (greater wing), and temporal bones. Less commonly, the frontal and temporal bones articulate; sometimes all four bones meet at a point. **(Moore)**

The infratemporal fossa lies below the infratemporal crest on the greater wing of the sphenoid. The pterygomaxillary fissure is a vertical fissure that lies within the fossa between the pterygoid process of the sphenoid bone and back of the maxilla. It leads medially into the pterygopalatine fossa. **(Snell)**

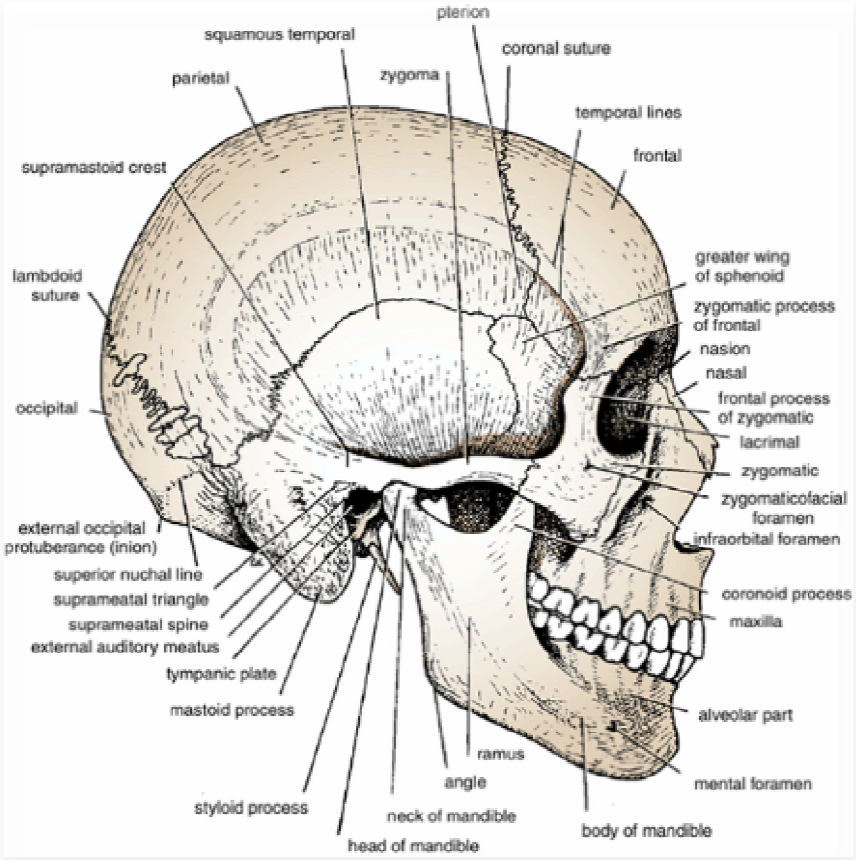


Figure (5-2): Lateral aspect of the skull (Reproduced from Snell {})

Inferior view of the skull:

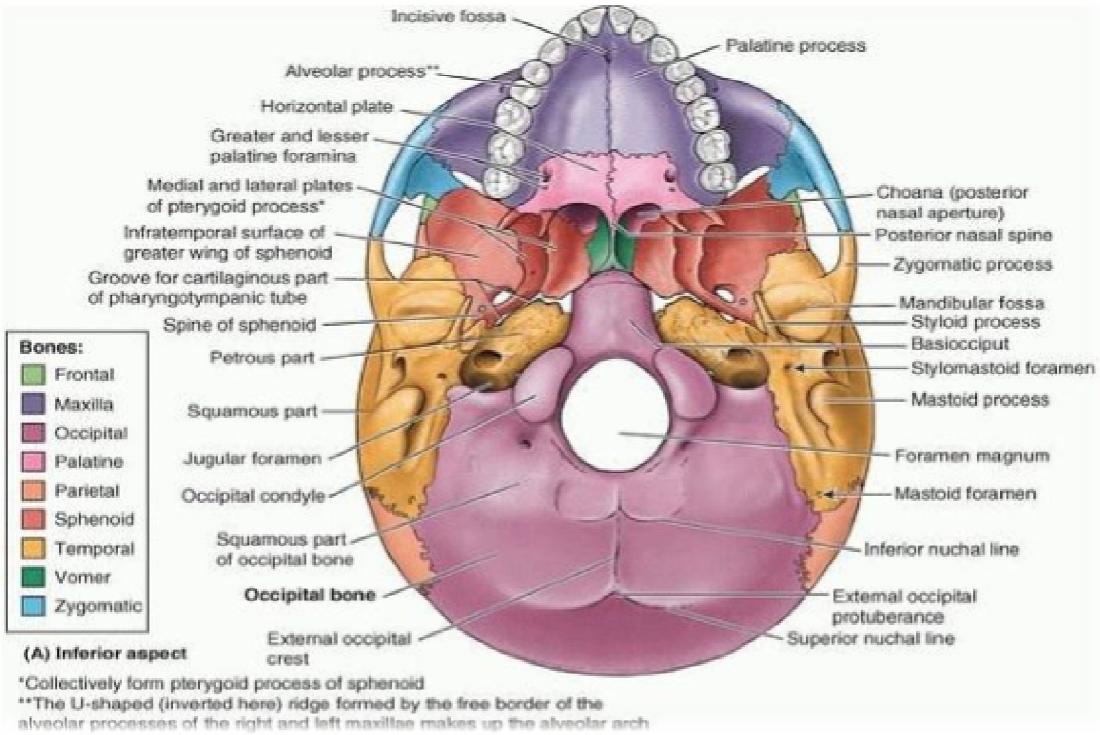


Figure (6-2): inferior view of the skull (Reproduced from **Moore** {})

Internal view of the skull (cranial cavity):

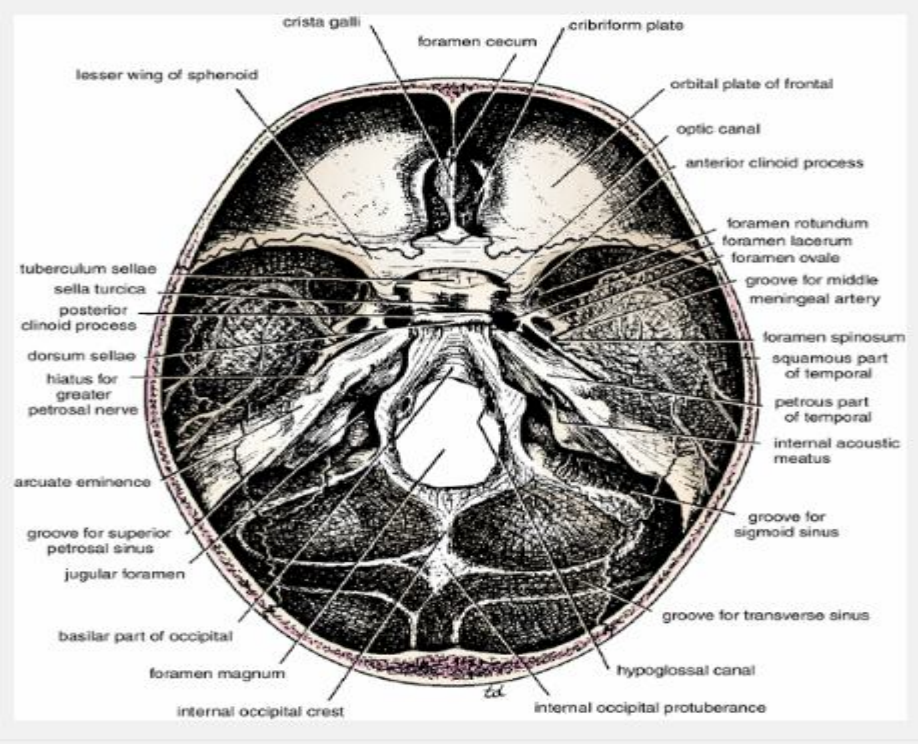


Figure (7-2): internal surface of the base of the skull (Reproduced from Snell {})

Development of the skull:

The skull vault develops in membrane, the skull base in cartilage. At birth, the square anterior fontanelle and triangular posterior fontanelle are widely open. The posterior fuses at about 3 months, the anterior at about 18 months. Up till then, blood can be obtained by puncturing the sagittal sinus immediately below the anterior fontanelle in the midline, and C.S.F. aspirated by passing a needle obliquely into the lateral ventricle. **(Ellis)**

The face at birth is considerably smaller proportionally to the skull than in the adult; this is due to the teeth being non-erupted and rudimentary and the nasal accessory sinuses being undeveloped; the sinuses are evident at about 8 years but only fully developed in the late teens. The mastoid and its air cells develop at the end of the 2nd year; until then the facial nerve is relatively superficial near its origin from the skull and may be damaged by quite trivial

injuries. With advancing age, the relative vertical measurement of the face again diminishes as a result of loss of teeth and subsequent absorption of the alveolar margins. **(Ellis)**

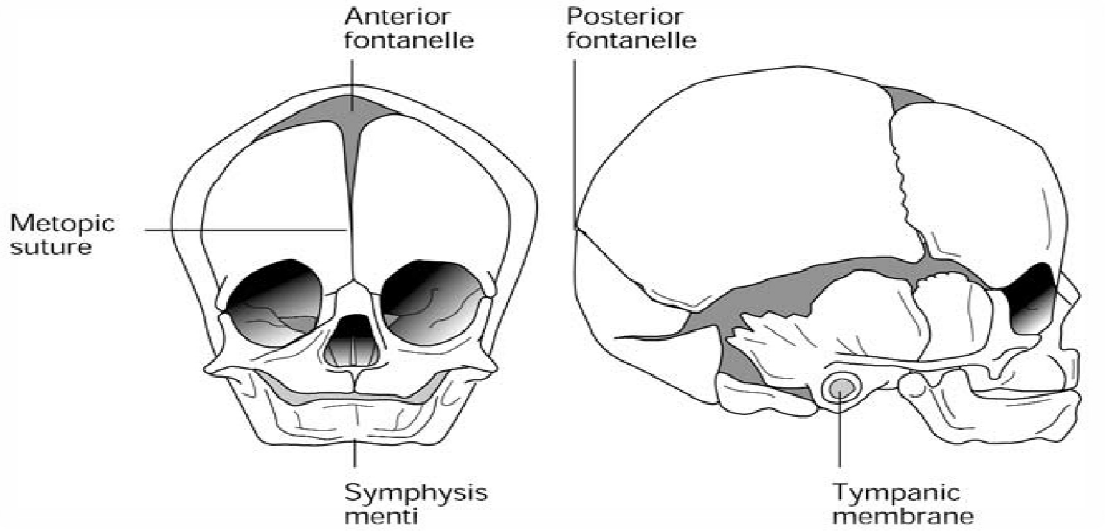


Figure (8-2): The fetal skull (Reproduced from Ellis {})

Meninges and ventricular system:

The meninges (Figure 2-2) are three connective tissue membranes enclosing the brain and the spinal cord. Their functions are to protect the CNS and blood vessels, enclose the venous sinuses, retain the cerebrospinal fluid, and form partitions within the skull. The outermost meninx is the dura mater, which encloses the arachnoid mater and the innermost pia mater. . (Elaine Nicpon-Marieb, 1991)

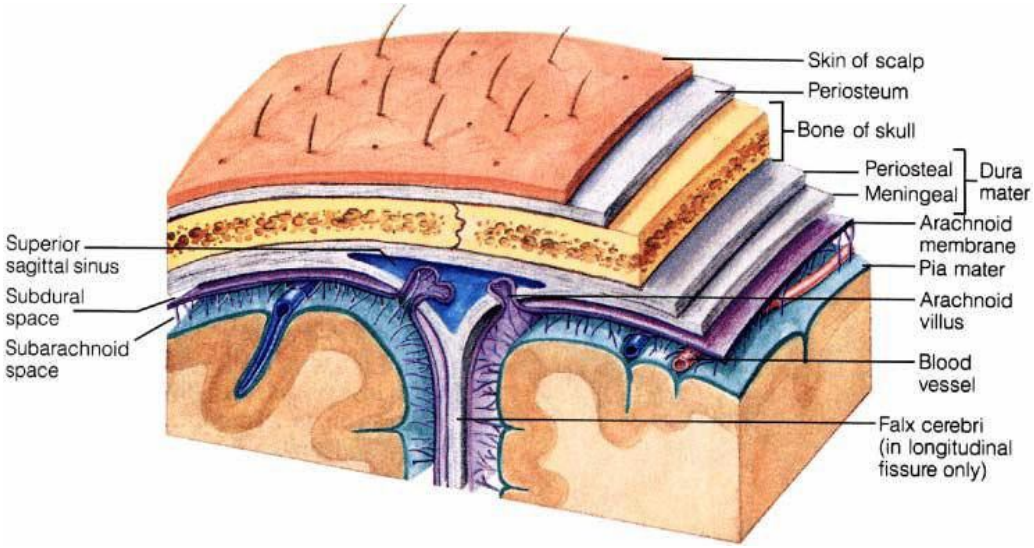


Figure (9-2) Show Meninges Anatomy. (Reproduced from [Marieb 1991]).

Cerebrospinal fluid Cerebrospinal fluid (CSF) is a watery liquid similar in composition to blood plasma. Cerebral spinal fluid is mainly formed by the choroid plexus, which are infolding of blood vessels covered by a thin tissue called pia and are located in the four ventricles of the brain ± the largest of which are found in the lateral ventricles. This CSF flows or communicates between the lateral ventricles and the third ventricle by way of the Intraventricular foramen (also called the foramen of Monro) (Figure 2-3) the cerebral spinal fluid then slowly flows from the third ventricle to the fourth ventricle through the aqueduct of Sylvius. From the fourth ventricle, the CSF then passes through the foramen of Luschka and the foramen of Magendie to enter the subarachnoid space that externally bathes the cerebral structures of the brain and spinal cord see (figure 2-3). Flowing along the subarachnoid cisterns, the CSF is then reabsorbed by the arachnoid granulations (also called the granulations of Pacchioni) that are mainly distributed along the superior sagittal sinus. (Elaine Nicpon-Marieb, 1991

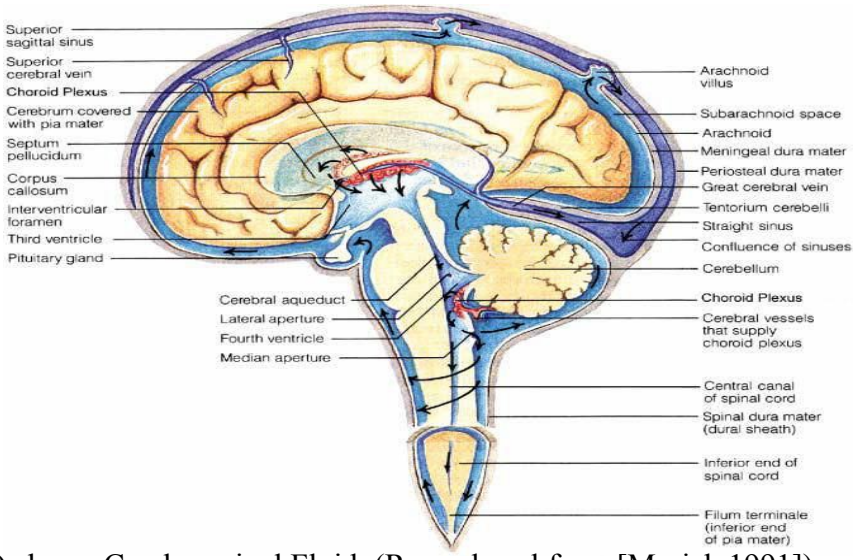
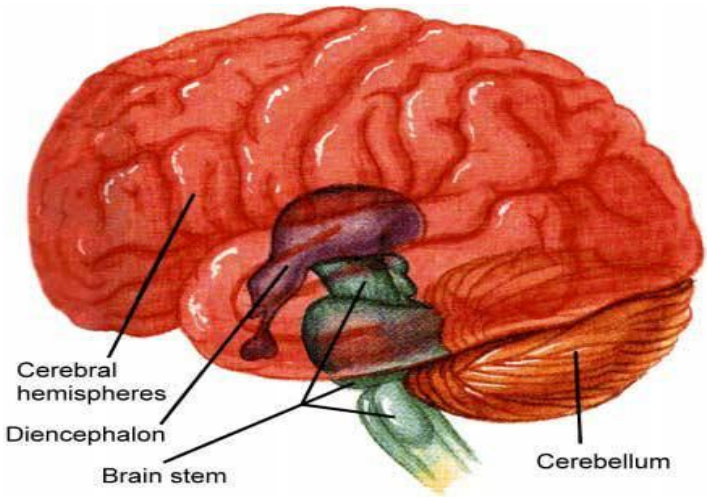


Figure (10-2) shows Cerebrospinal Fluid. (Reproduced from [Marieb 1991]).



(11-2) show ventricular system. (Reproduced from [Gray's Anatomy 1918]).

2.1.2. Major regions of the brain and their functions

The major regions of the brain (Figure 2±5) are the cerebral hemispheres, diencephalon, brain stem and cerebellum. (Elaine Nicpon-Marieb, 1991)

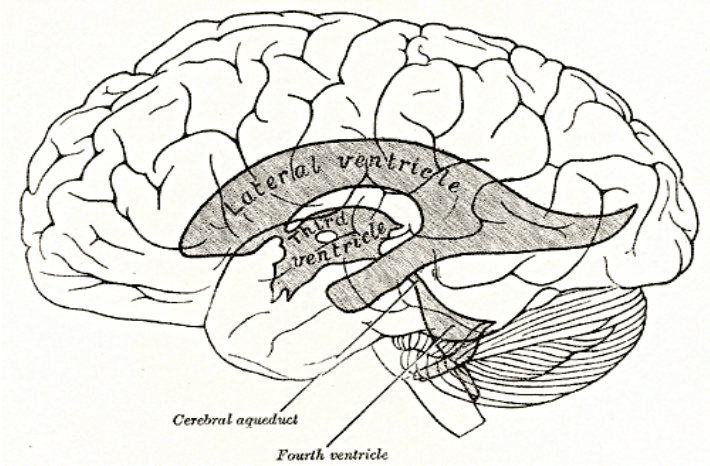


Figure (12-2) shows Major Regions of the Brain. (Reproduced from [Marieb1991]).

Cerebral hemispheres:

The cerebral hemispheres (Figure 2-5), located on the most superior part of the brain, are separated by the longitudinal fissure. They make up approximately 83% of total brain mass, and are collectively referred to as the cerebrum. The cerebral cortex constitutes a 2-4 mm thick grey matter surface layer and, because of its many convolutions, accounts for about 40% of total brain mass. It is responsible for conscious behavior and contains three different functional areas: the motor areas, sensory areas and association areas. Located internally are the white matter, responsible for communication between cerebral areas and between the cerebral cortex and lower regions of the CNS, as well as the basal nuclei (or basal ganglia), involved in controlling muscular movement. . (Elaine Nicpon- Marieb, 1991)

Diencephalon

The diencephalon is located centrally within the forebrain. It consists of the thalamus, hypothalamus and epithalamus, which together enclose the third ventricle. The thalamus acts as a grouping and relay station for sensory

inputs ascending to the sensory cortex and association areas. It also mediates motor activities, cortical arousal and memories. The hypothalamus, by controlling the autonomic (involuntary) nervous system, is responsible IRU epithalamus consists of the pineal gland and the CSF producing choroid

Plexus. (Elaine Nicpon-Marieb, 1991)

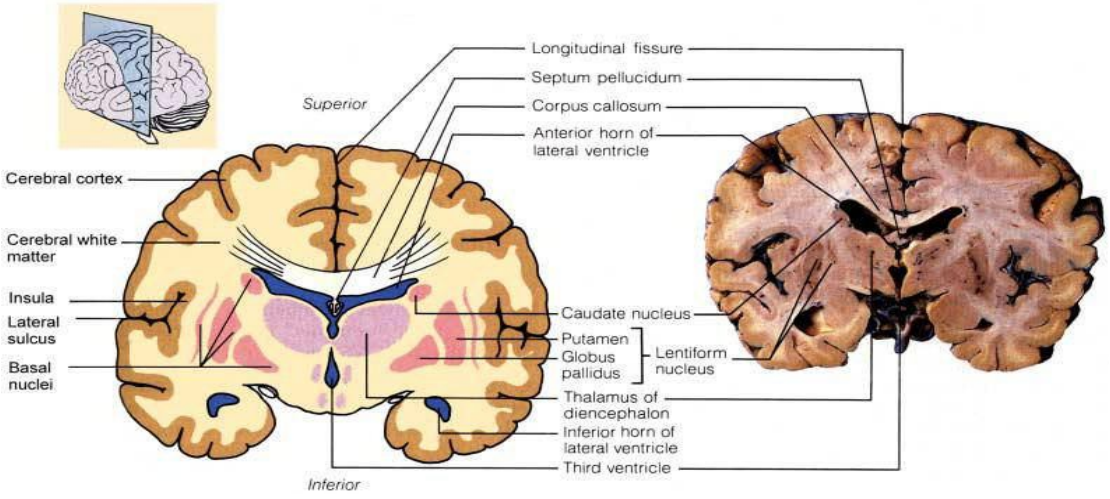


Figure 13-2) Major Regions of the cerebral hemispheres. (Reproduced from [Marieb 1991]).

Brain stem:

The brain stem is similarly structured as the spinal cord: it consists of grey matter surrounded by white matter fiber tracts. Its major regions are the midbrain, pons and medulla oblongata. The midbrain, which surrounds the cerebral aqueduct, provides fiber pathways between higher and lower brain centers, contains visual and auditory reflex and subcortical motor centers. The pons is mainly a conduction region, but its nuclei also contribute to the regulation of respiration and cranial nerves.

The medulla oblongata takes an important role as an autonomic reflex Centre involved in maintaining body homeostasis. In particular, nuclei in the medulla regulate respiratory rhythm, heart rate, blood pressure and several

cranial nerves. Moreover, it provides conduction pathways between the inferior spinal cord and higher brain centers. (Elaine Nicpon- Marieb, 1991)

Cerebellum

The cerebellum, which is located dorsal to the pons and medulla, accounts for about 11% of total brain mass. Like the cerebrum, it has a thin outer cortex of grey matter, internal white matter, and small, deeply situated, paired masses (nuclei) of grey matter. The cerebellum processes impulses received from the cerebral motor cortex, various brain stem nuclei and sensory receptors in order to appropriately control skeletal muscle contraction, thus giving smooth, coordinated movements. . (Elaine Nicpon-Marieb, 1991)

2.1.3. The cerebral circulatory system

Blood is transported through the body via a continuous system of blood vessels. Arteries carry oxygenated blood away from the heart into capillaries supplying tissue cells. Veins collect the blood from the capillary bed and carry it back to the heart. The main purpose of blood flow through body tissues is to deliver oxygen and nutrients to and waste from the cells, exchange gas in the lungs, absorb nutrients from the digestive tract, and help forming urine in the kidneys. All the circulation digestive tract and help forming urine in the kidneys. All the circulation besides the heart and the pulmonary circulation are called the systemic circulation. Since it is the ultimate aim of this research project to image cerebral oxygenation and hemodynamic some aspects of the cerebral circulatory system are described below (Elaine Nicpon-Marieb, 1991)

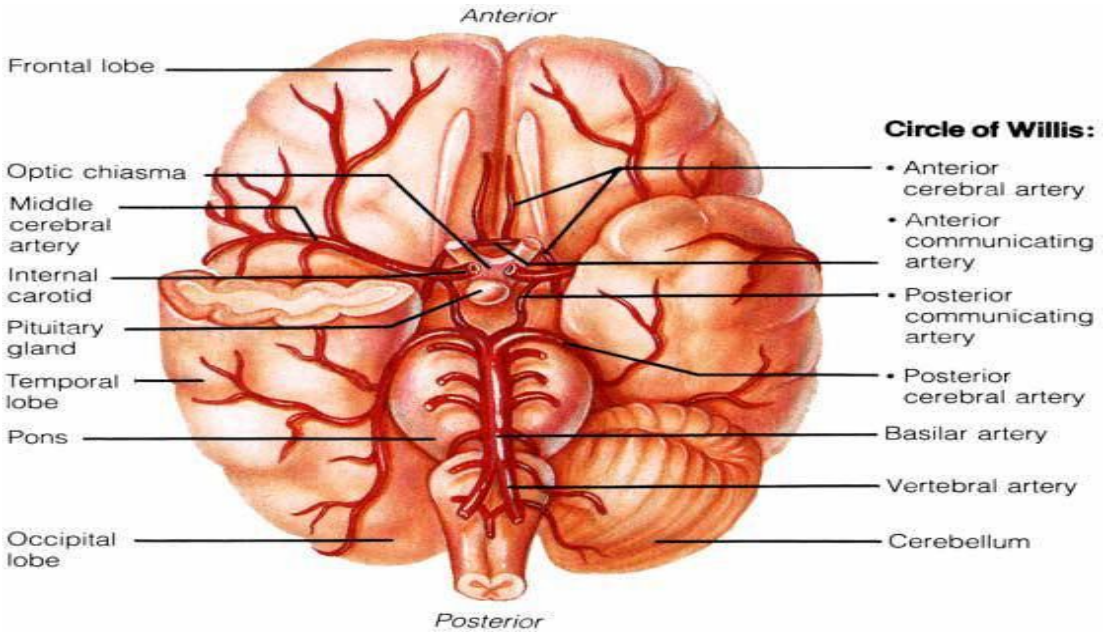


Figure (14-2) Major cerebral arteries and the circle of Willis. (Reproduced From [Marieb 1991]).

Blood supply to the brain:

Figure 2±6 shows an overview of the arterial system supplying the brain.The major arteries are the vertebral and internal carotid arteries. The two posterior and single anterior communicating arteries form the circle of Willis, which HTXDOLVHV EORRG SUHVVXUHV LQ WKHEUDLQ¶V DQWHULRU DQG posterior regions, and protects the brain from damage should one of the arteries become occluded. However, there is little communication between smaller arteries RQ WKH EUDLQ¶V VXUIDFH. +HQFH RFFOXVLRQ RI WKHVH arteries usually results in localized tissue damage (Elaine Nicpon-Marieb, 1991)

2.1. 4. Embryology and special feature of the neonatal brain

Having introduced some basics of the anatomy and physiology of the

adult brain, this section focuses on the specific differences in the neonate,(figure 2-7) The embryonic brain and spinal cord develop from the neural tube, which is formed by the fourth week of pregnancy. The brain grows immensely in both size and complexity during pregnancy and even soon after birth. Because a membranous skull restricts expansion, the forebrain is bent towards the brain stem, and the cerebral hemispheres almost completely envelop the diencephalon and midbrain. Moreover, the spatial restrictions cause the cerebral hemispheres to increase their surface area by becoming highly convoluted such that about two thirds of its surface is hidden in its fold. . (Elaine Nicpon-Marieb, 1991)

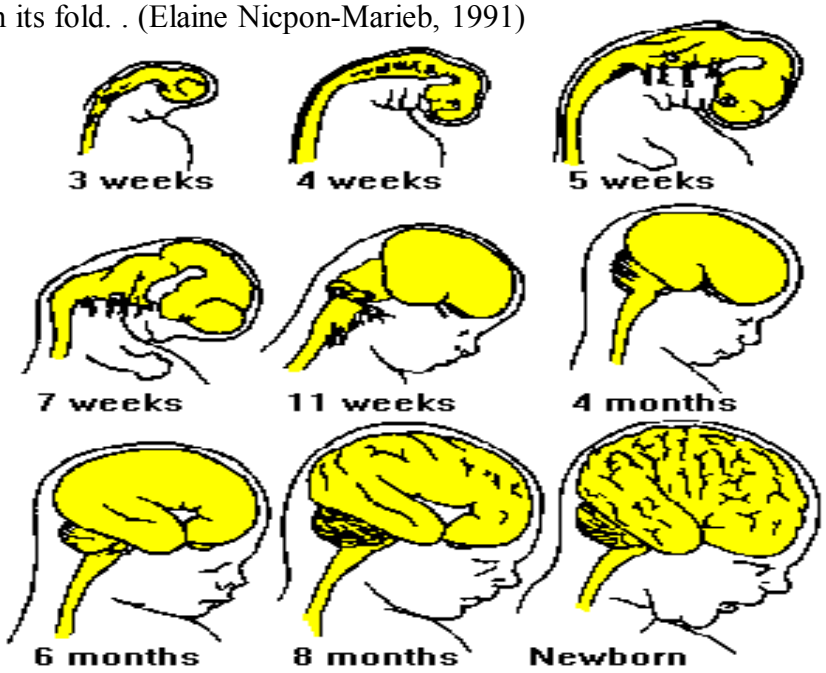
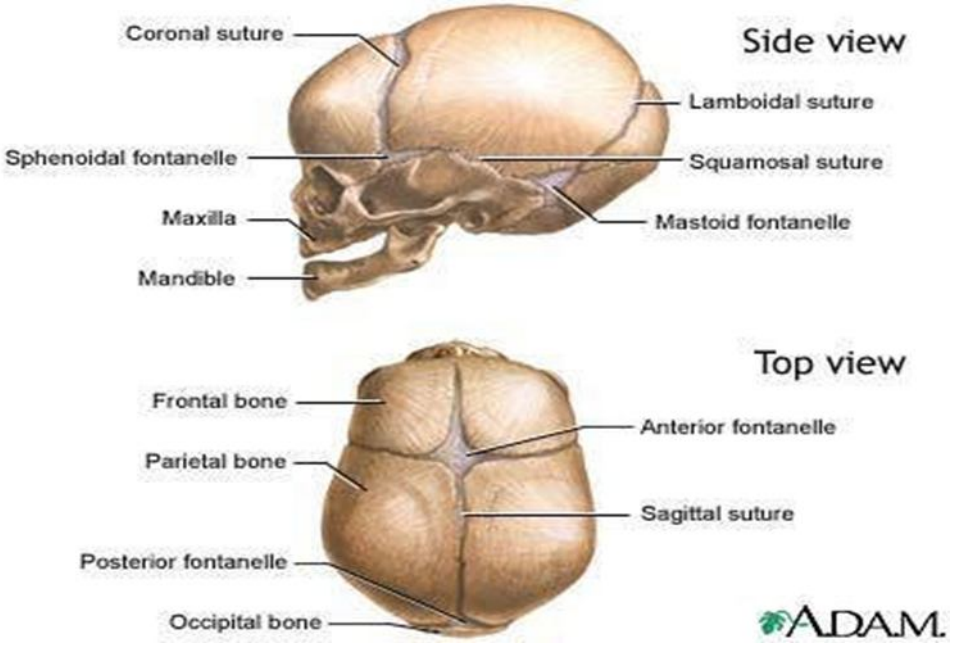


Figure (15-2) show brain development with age (from Neurology 1978)

The skull bones of the foetus and neonate are soft and the sutures are not yet fused. Hence the skull is very flexible and deforms under light pressure. Compared to the adult, neonates have a smaller head size (ca. 6- 12 cm in diameter), thinner surface tissue, skull and CSF layers, lower scattering coefficients of grey and white matter (due to lesser myelination in the case

of white matter). The neonatal skull (figure 2-8), anterior fontanelle lies between four bones. The two parietal bones bound it behind, the two halves of frontal bones lies in front .it overlies the superior sagittal dural venous sinus. The anterior fontanelle usually not palpable after the age of 18 month. The posterior fontanelle lies between the apex of squamous part of the occipital bone and posterior edges of two parietal bones. It is closed by the age of 6 month (chummy s. sinnatamby 1999)



15-3 Equipment OF Ultrasound Machine

The ultrasound machine should be a transportable real-time scanner, allowing bedside examinations without the need to transport the baby (see Fig. 1.1). It should be equipped with appropriate transducers, special software for CUS and colour Doppler flow measurements, and a storage system. Facilities for direct printing of images may be useful. Settings need to be optimised for neonatal brain imaging. It is recommended that special CUS presets be used; these can be installed by the application specialist. In individual cases and under certain circumstances, the settings can be adjusted.

Transducers

The use of sector or curved linear array transducers is recommended. High-frequency transducers have high near-field resolution (the higher the transducer frequency, the better the resolution), but they do not allow the same penetration as lower-frequency transducers. The ultrasound system should therefore be equipped with a multifrequency transducer (5–7.5–10 MHz) or different frequency transducers (5, 7.5, and 10 MHz). The transducers should be appropriately sized for an almost perfect fit on the anterior fontanel (Fig. 2.1). To allow good contact between the transducer and the skin, transducer gel is used. In most cases, especially in preterm infants, the distance between the transducer and the brain is small, allowing the use of high-frequency transducers. In most circumstances, good images can be obtained using a transducer frequency of around 7.5 MHz. This enables optimal visualisation of the peri- and intraventricular areas of the brain. For the evaluation of more superficial structures (cortex, subcortical white matter, subarachnoid spaces, superior sagittal sinus) and/or in very tiny infants with small heads, it is advised to perform an additional scan, using a higher frequency up to 10 MHz (Fig. 2.2). If deeper penetration of the beam is required, as in larger, older infants or infants with thick, curly hair or in order to obtain a better view of the deeper structures (posterior fossa, basal ganglia in fullterm infants), additional scanning with a lower frequency (down to about5 MHz) is recommended (Fig. 2.3) 10 MHz (Fig. 2.2). If deeper penetration of the beam is required, as in, older infants or infants with thick, curly hair or in order to obtain a better view of the deeper structures (posterior fossa, basal ganglia in fullterm), additional scanning with a lower frequency (down to about5 MHz) is recommended (Fig. 2.3)

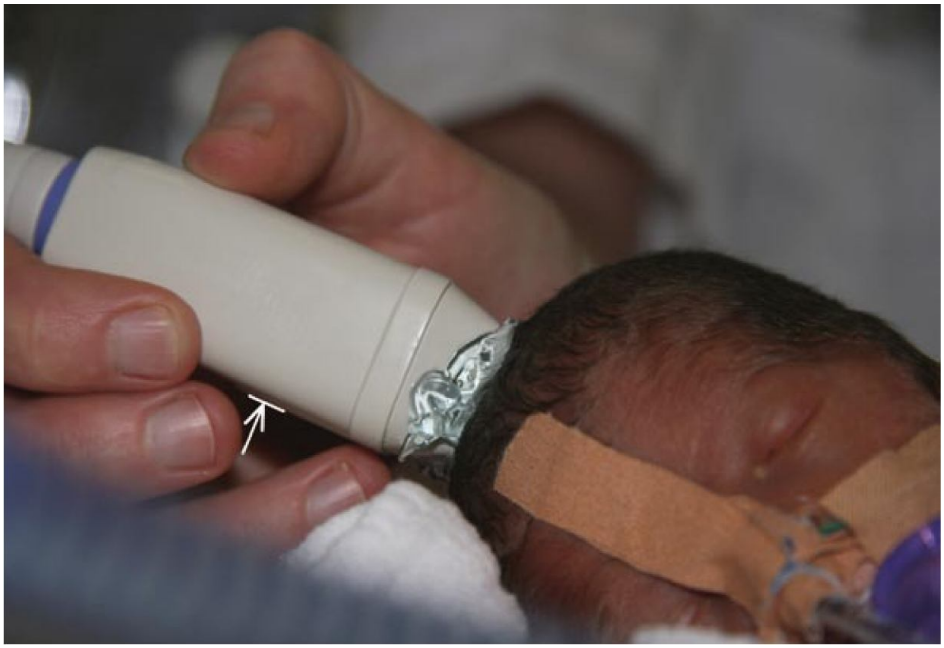
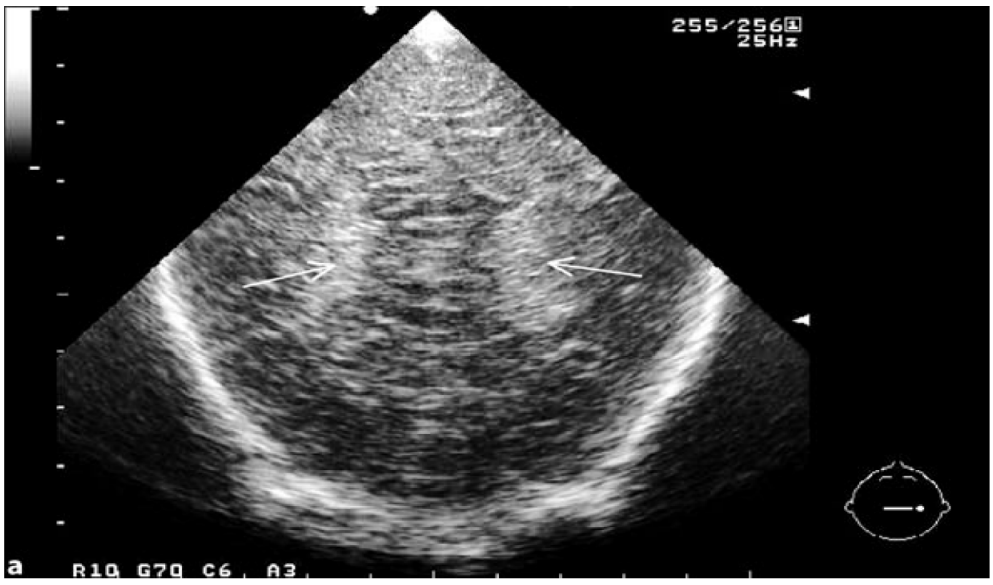


Fig. 2.1 Well-fitting ultrasound probe, positioned onto the anterior fontanel. Arrow indicates the marker on the probe



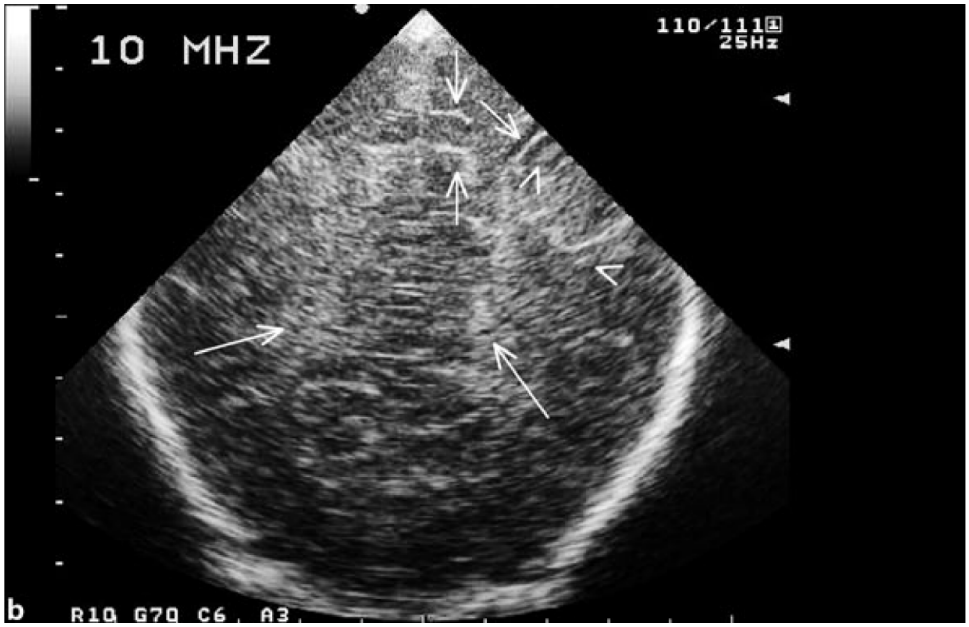


Fig. 2.2 a Coronal ultrasound scan at the level of the parieto-occipital lobes in a full-term baby, born asphyxiated, using a transducer frequency of 7.5 MHz b Coronal ultrasound scan in the same baby at the same level after increasing the transducer frequency up to 10 MHz, now showing more details of the superficial cortical (short arrows) and subcortical structures (arrowheads). Images show increased echogenicity of the parietal white matter (arrows), best seen with the transducer frequency set at 7.5 MHz (a), and the subcortical matter (arrowheads), best seen with transducer frequency of 10 MHz (b)

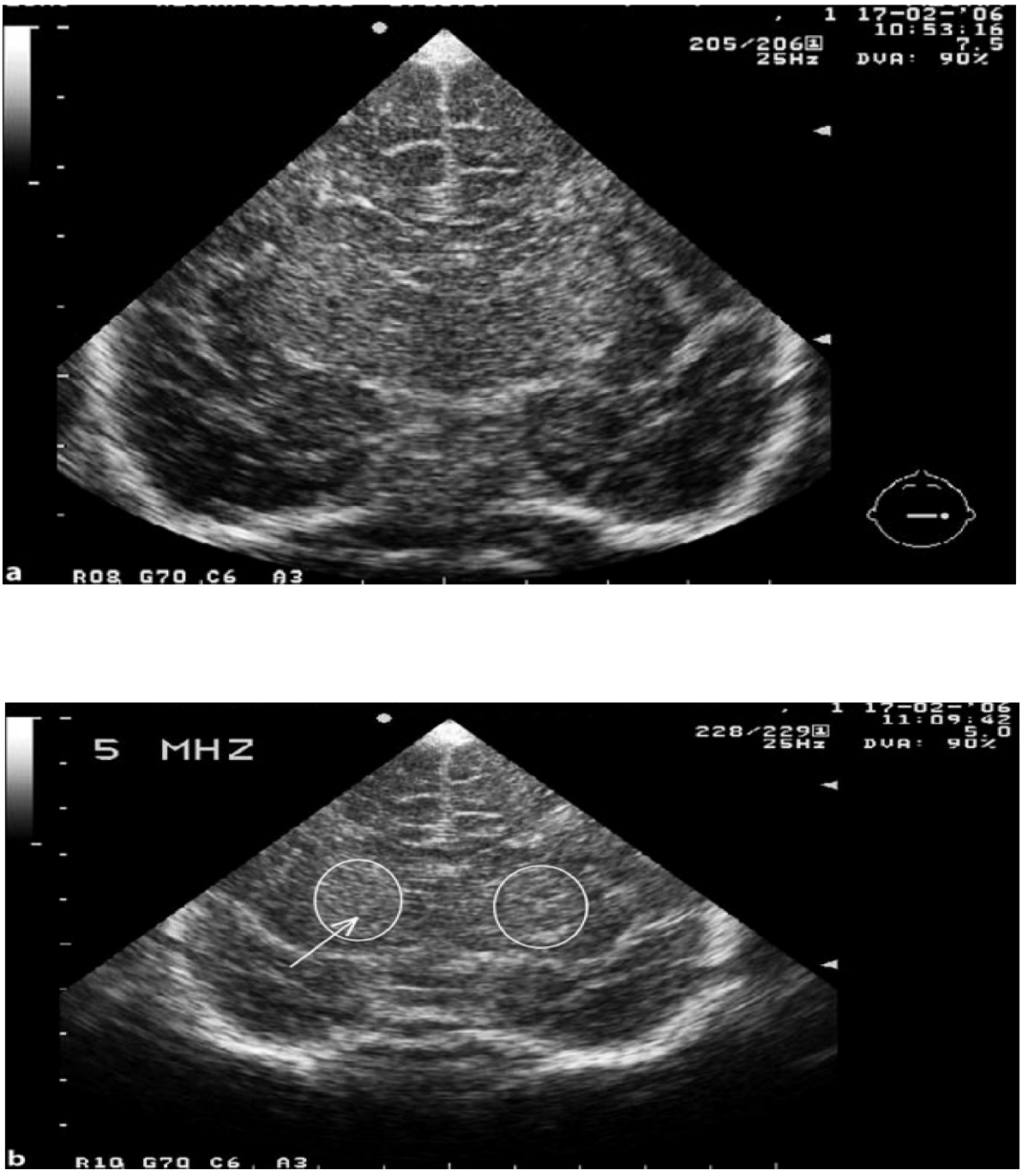


Fig. 2.3 a Coronal ultrasound scan in a full-term baby, born asphyxiated, at the level of the frontal horns of the lateral ventricles. Transducer frequency of 7.5 MHz. b Coronal ultrasound scan in the same baby after decreasing the transducer frequency down to 5 MHz, now showing more clearly the subtly increased echogenicity of the basal ganglia arrow). Basal ganglia injury became more obvious during the following days

Data Management

Images need to be reproducible. Therefore, it is recommended that a dedicated digital storage system be used, allowing reliable storage and postimaging assessment. In addition, direct printing of standard views and (suspected) abnormalities can be useful, as it enables storage in the medical files

Sonographer and Safety Precautions

The sonographer can be an ultrasound technician or a physician (i.e. ultrasound physician, neuro- or paediatric radiologist, neonatologist). He or she should be specially trained to perform safe, reliable neonatal CUS examinations. In addition, he or she should be well informed with regard to the normal ultrasound anatomy and specific features of the neonatal brain and to the maturational phenomena occurring in the (preterm) neonate's brain. He or she also needs to be well informed about frequently occurring, often (gestational) age-specific brain anomalies (whether congenital or acquired) in the neonate and young infant and be able to recognise these and search for them. The sonographer should also be aware of the special needs of vulnerable, sick (preterm) neonates and should take the necessary hygiene precautions (such as appropriate hand hygiene and cleaning of the ultrasound machine and transducers according to hospital regulations). The transducer gel should be sterile and stored at room temperature. Cooling of the infant due to opening of the incubator needs to be avoided.

Performing Cranial Ultrasound Examinations

Preterm infants and sick full-term infants are examined in their incubator while maintaining monitoring of vital functions (see also Chap. 2 and Fig.

1.1). It is recommended that the CUS examination be performed while only the incubator windows are open. Manipulation of the infant (with the exception of minor adjustments) is rarely necessary while scanning the anterior fontanel. Older infants and full-term, well neonates can be examined in their cot or car seat or on an adult's lap (Fig. 3.1).

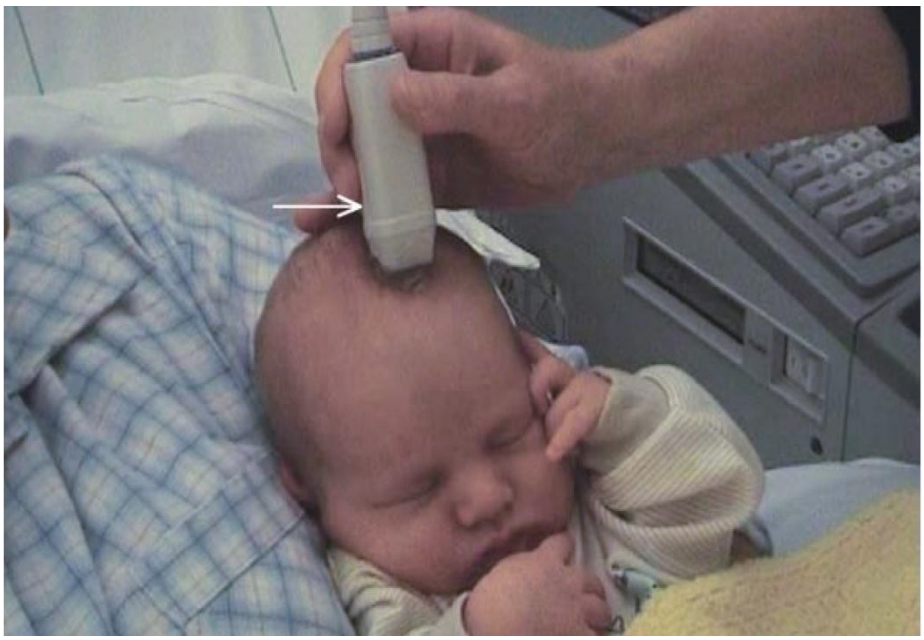


Fig. 3.1 Ultrasound examination performed in a full-term newborn infant while infant is seated on his mother's lap (arrow indicates marker on probe)

Standard Views

For a standard CUS procedure to enable optimal visualisation of the supratentorial structures, the anterior fontanel is used as an acoustic window. are recorded in at least six standard coronal and five standard sagittal planes. These standard planes and the anatomical structures visualised in these planes are presented in Part II In addition to the standard planes, the whole brain should be scanned to obtain an overview of the brain's appearance. This allows assessment of the anatomical structures and detection of subtle changes and small and/ or superficially located lesions. Besides the standard

views, for any suspected abnormality, images should be recorded in two planes (Fig. 3.2).

Coronal Planes

The anterior fontanel is palpated and the transducer is positioned in the middle, with the marker on the probe turned to the right side of the baby (see Fig. 2.1). The left side of the brain will thus be projected on the right side of the monitor, and vice versa (Fig. 3.3). The probe is subsequently angled suffciently far forwards and backwards to scan the entire brain from the frontal lobes at the level of the orbits to the occipital lobes (see Part II)

Sagittal Planes

The transducer is again positioned in the middle of the anterior fontanel, and the marker is now pointing towards the baby's mid-face (Fig. 3.4). The anterior part of the brain will thus be projected on the left side of the monitor (Fig. 3.5). First, a good view of the midline is obtained. The transducer is subsequently angled suffciently to the right and the left to scan out to the Sylvian fissures and insulae on both sides (see Part II). Because the lateral ventricles fan out posteriorly, the transducer should be positioned slightly slanting, with the back part of the transducer slightly more lateral than the front part. While the second or fourth parasagittal planes are being obtained, this enables visualisation of the lateral ventricle over its entire length (see Fig. 3.5 and Part II).

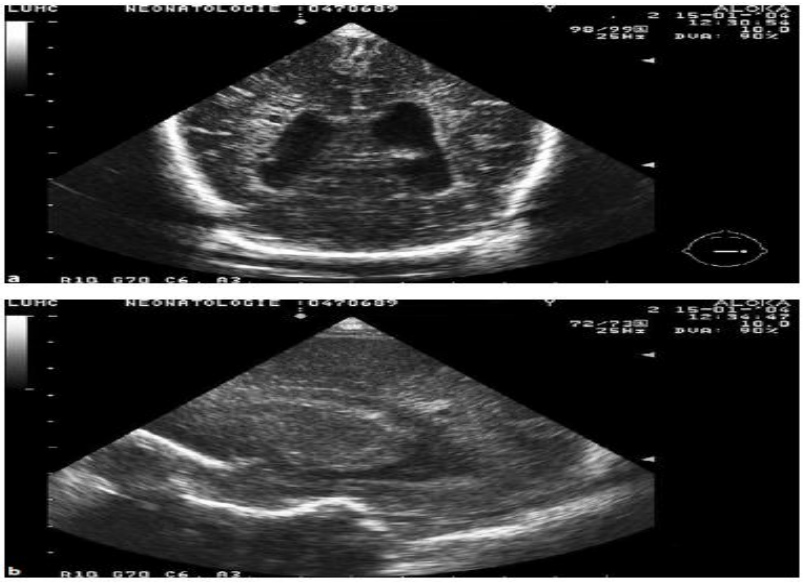


Fig. 3.2a,b Ultrasound scan in a preterm infant with cystic periventricular leukomalacia, showing cystic lesions and increased echogenicity in the parietal periventricular white matter, seen in two image directions. a Coronal scan at the level of the trigone of the lateral ventricles. B Parasagittal scan through the right lateral ventricle

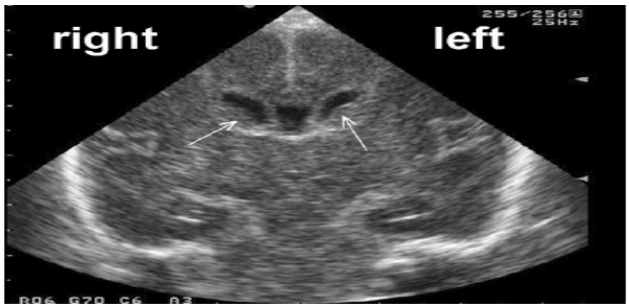


Fig. 3.3 Coronal ultrasound scan in a very preterm infant at the level of the frontal horns of the lateral ventricles. If the marker on the transducer is positioned in the right corner of the anterior fontanel (see Figs. 2.1 and 3.1), the right side of the brain is projected on the left side of the image, and vice versa. Image shows germinal matrix haemorrhages of older duration (arrows)

Fig. 3.4 Probe positioning for obtaining parasagittal scan. Arrow indicates marker

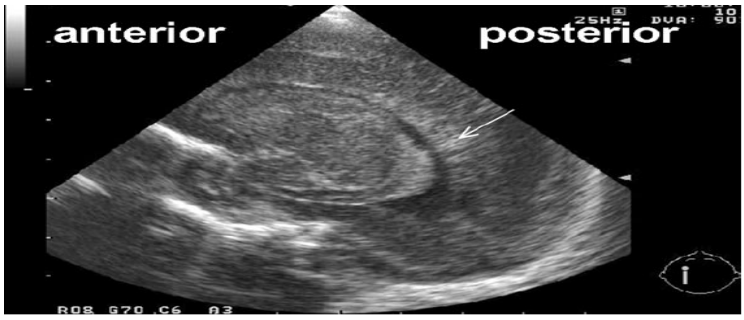


Fig. 3.5 Parasagittal ultrasound scan in a preterm infant through the left lateral ventricle. If the marker on the transducer is pointing towards the baby's nose (see Fig. 3.4), the anterior part of the brain will be projected on the left of the image and the posterior part on the right. Image shows some increased echogenicity in the parietal periventricular white matter (arrow)

Indications for neonatal cranial ultrasound:

Cranial ultrasonography provides important diagnostic information in neonates. The clinical indications for routine scanning in newborn infants are well established. Any change in the normal clinical behavior of the newborn is an indication for cranial ultrasound. Clinical symptoms may range from hypotonic body manifestation to seizures. A low incidence (less than 5%) of abnormal central nervous system findings was found in the nonasphyxiated term infants with split sutures, cephalohematoma, abnormal neurologic examination, and idiopathic jitteriness.(1) Routine scanning is

suggested in all premature infants as well as term infants with dysmorphic features, macrocephaly, seizure disorders, and in infants with 1- and 5-minute Apgar scores less than 7.1 Any critically ill preterm infant should receive a cranial ultrasound to search for abnormalities such as hemorrhage, hypoxic-ischemic insult, intrauterine infection, or congenital morphologic abnormalities. Routine screening of severe preterm and low birth weight infants should be performed. In addition, cranial ultrasound examination is the screening technique of choice for assessing preexisting neurological damage in potential neonatal extracorporeal membrane oxygenation (ECMO) candidates. Currently, ultrasound evidence of intracranial hemorrhage greater than grade I in severity is a contraindication to ECMO.(2) Infants undergoing ECMO are at high risk for brain injury and therefore should undergo serial cranial ultrasound imaging before, during, and after ECMO treatment.(3)

While cranial ultrasound is a very useful imaging modality and generally a first choice for initial imaging, there are limitations. In cases where very detailed brain parenchymal anatomy is needed, MRI provides greater resolution.(4) Also, in the acute trauma setting, CT is the preferred first line imaging modality (5)

Technique of cranial ultrasound

Cranial ultrasound is performed with basic grayscale imaging. For optimal resolution and good overview, a multifrequency (5–10 MHz) linear or convex sector transducer is used. Imaging is obtained through the anterior fontanel in the coronal and sagittal planes.6,7 Typically, six to eight coronal images are obtained beginning at the frontal lobes just anterior to the frontal horns and extending to the occipital lobes posterior to the lateral ventricle trigones.8 The transducer is then rotated 90°, and approximately five images are obtained, including a midline sagittal view of the corpus callosum and

cerebellar vermis in addition to bilateral parasagittal images beginning in the midline and progressing laterally through the peripheral cortex.7–9 The mastoid fontanel can be used as an additional port for visualization of the posterior fossa. The mastoid fontanel is located at the junction of the posterior temporal, parietal, and occipital bones and the transducer is positioned approximately 1 cm posterior to the helix of the ear at a level of approximately 1 cm above the tragus. Axial images are obtained with the transducer parallel to the orbitomeatal line. By convention, all images are presented with the patient facing left.10 Imaging through the posterior fontanel may allow additional views of the occipital lobes.11 Doppler images may be obtained for screening vascular structures.9,12 The arterial system is assessed for patency and resistance to flow by obtaining a color Doppler image of the circle of Willis. The images are obtained through the anterior fontanel and are used to localize the middle or the internal cerebral artery. Spectral tracings are obtained with peak systolic velocity, end-diastolic velocity, and resistive index. Systolic and diastolic velocities increase with advancing postnatal age and with increasing birth weight regardless of the gestational age. Resistive indices decrease with advancing postnatal age and with increasing birth weight. Any deviation from the normal pattern of the changes in the velocities and the resistive indices may indicate an illness or a pathologic event. The venous system is evaluated for patency of the sagittal sinus and the vein of Galen in the sagittal plane9.

Normal sonographic neonatal cranial anatomy

Knowledge of the normal anatomy is essential for recognizing abnormalities. A general overview of the anatomy and the maturation of the central nervous system can be depicted and correlated with the gestational age. The cortex and the development of the sulci correlate with normal brain maturity. The

sulci appear and develop in sequence. The calcarine fissure and most of the anterior part of cingulate sulcus begin to appear before 28 weeks. At 28–31 weeks, all the whole cingulate sulcus and postrolandic sulcus, and most of the superior temporal sulcus and covering of insula, are observable. All of the insular sulci and most of the secondary sulci from the cingulate sulcus appear after 31 weeks of gestation.(13,14) At ultrasound, early sulcal development is best depicted on images obtained perpendicular to the expected course of the sulci.(15) A fissure or sulcus is first seen as a small dot or dimple on the surface of the brain. Later, an obviousV-shaped indentation forms. Finally, the indentation deepens and is visible as a surface notch and an echogenic line that extends into the brain in a Y-shaped configuration. Ultrasound is useful for the evaluation of primary sulci on the medial hemispheric surface (parieto-occipital fissure, calcarine fissure, and cingulate sulcus) and on the lateral convex hemispheric surface (central, post-central, and superior temporal sulci).(15–17)

Advantages of Cranial Ultrasonography

- Major advantages of CUS are the following: It can be performed bedside, with little disturbance to the infant (Fig. 1.1); manipulation of the infant is hardly necessary.
- It can be initiated at a very early stage, even immediately after birth.
- It is safe; (safety guidelines are provided by the British Medical Ultrasound Society www.bmus.org and the American Institute of Ultrasound in Medicine www.aium.com) (British Medical Ultrasound Society 2006, American Institute of Ultrasound in Medicine 2006).

- It can be repeated as often as necessary, and thereby enables visualisation of ongoing brain maturation and the evolution of brain lesions. In addition, it can be used to assess the timing of brain damage
- It is a reliable tool for detection of most haemorrhagic, cystic, and ischaemic brain lesions as well as calcifications, cerebral infections, and major structural brain anomalies, both in preterm and full-term neonates.
- CUS is relatively inexpensive compared with other neuro-imaging techniques.
- For all these reasons it is an excellent tool for serial brain imaging during the neonatal period (and thereafter until closure of the fontanels).

Aims of Neonatal Cranial Ultrasonography

- The aims of neonatal CUS are to assess
- Brain maturation
- The presence of structural brain abnormalities and/or brain injury
- The timing of cerebral injury
- The neurological prognosis of the infant
- In seriously ill neonates and in neonates with serious cerebral abnormalities, either congenital or acquired, it plays a role in decisions on continuation or withdrawal of intensive treatment. In neonates surviving with cerebral injury, it may help to optimize treatment of the infant and support of the infant and his or her family, both during the neonatal period and thereafter.

Cranial window for ultrasound imaging

Several windows figure (2-10) in the un-fused skull of a neonate give the opportunity to look into various parts of the brain with a reasonable degree of accuracy and detail Standard or conventional views are those

obtained through anterior Fontanelle. (Van Wezel-Meijler G 2007)

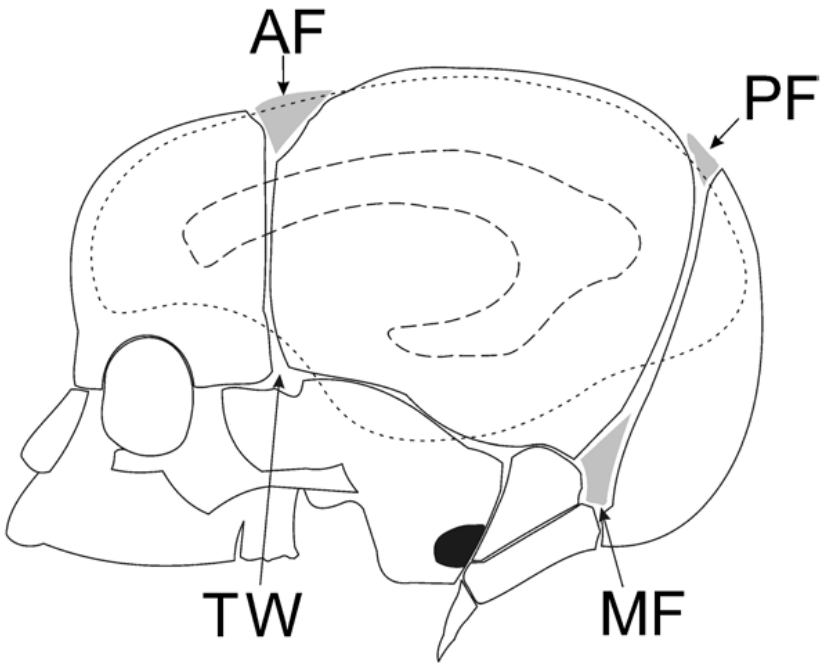


Figure (2-10) show the acousticwindows.AF anterior fontanel, PF posterior fontanel, MF mastoid(or postero-lateral)fontanel, Tw temporal window ultrasonography (from neonatal-cranial-ultrasonography2007) Neonatal brain survey (coronal survey) Standard six coronal plane figure (2-11) begin with transducer perpendicular at the anterior fontanel figure (2-12)

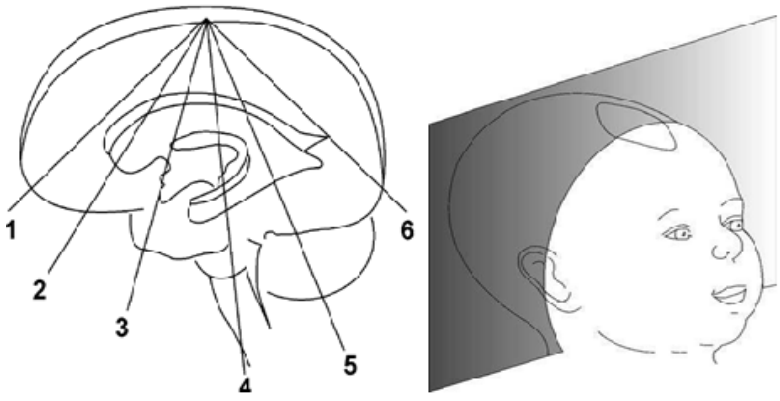


Figure 2-11 show standard six coronal plane from(neonatal cranial ultrasonography 2007)

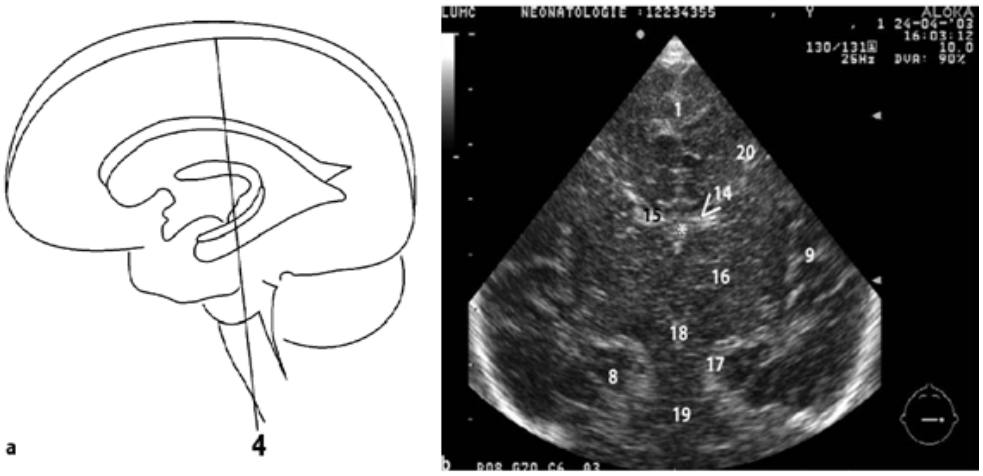


Figure 2-12 show a.Fourth coronal plane (C4) at the level of the bodies of the lateral ventricles. B. Ultrasound scan of the fourth coronal plane (C4) Inter hem is phericf is sure, 8.Temporal lobe, 9.Sylvianfissure, 14.Bodyoflateralventricle, 15. Choroidpexus (*:plexusinthirdventricle), 16.Thal mus, 17Hippocampalfissure, 18 Mesencephalicaqueduct, 19.Brainstem, 20.Parietl from (neonatal cranial ultrasonography 2007) Slowly angle the transducer toward the face. Scan through the frontal horns into the frontal lobes of the brain

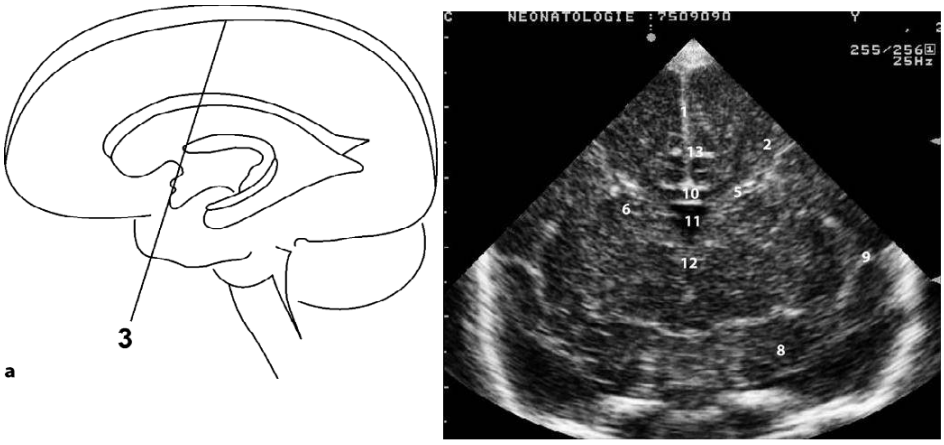


Figure 2-13 show a Third coronal plane (C3) at the level of the foramen of Monro and the third ventricle. b Ultrasound scan of the third coronal plane (C3) at the level of the foramen of Monro and the third ventricle terhemisphericfissure, 2.Frontallobe, 5.Frontal horn of lateral ventricle, 6. 1.In terhemisphericfissure,2.Frontallobe,5.Frontalhornoflateralventricle,6. Caudatenucleus,8.Temporallobe,9.Sylvianfissure,10.Corpuscallosum,11Cavumseptu mpellucidum,12.Thirdventricle,13.Cingulatesulcus from(neonatal cranial ultrasonography 2007)

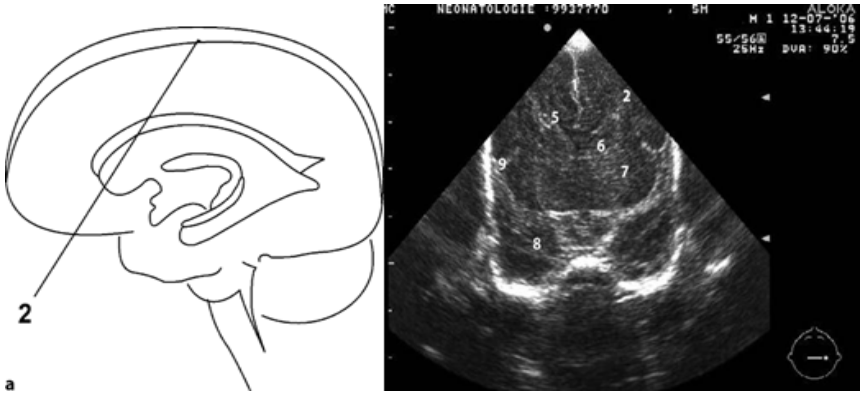


Figure 2-14 show Second coronal plane (C2) at the level of the frontal horns of the lateral ventricles. b Ultrasound scan of the second coronal plane (C2) at the level of the frontal horns of the lateral ventricles 1.in terhemisphericfissure,2. Frontallobe,5. Front al horn of lateral ventricle, 6 Caudatenucleus,7.Basalganglia,8.Temporallobe,9.Sylvianfissurefrom(neonat alcranial ultrasono-graphy 2007)

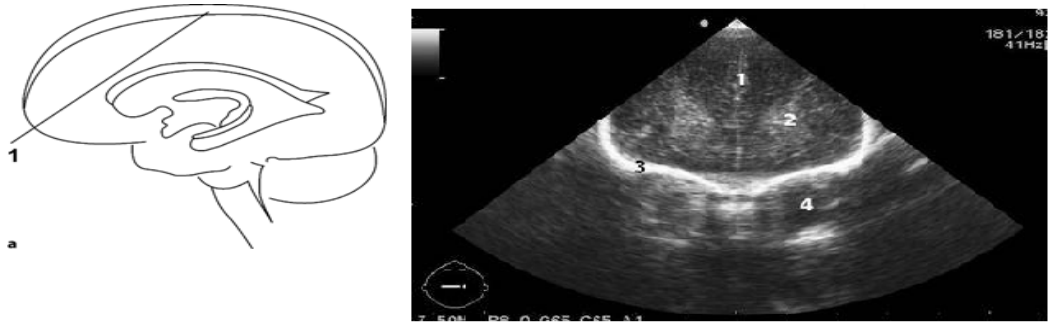
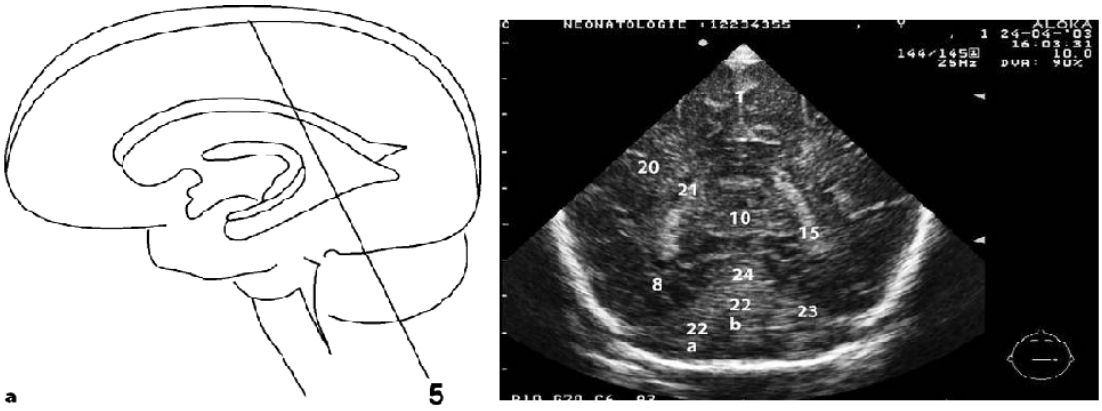


Figure 2-15 show a First coronal plane (C1) at the level of the frontal lobes. b Ultrasound scan of the first coronal plane (C1) at the level of the frontal lobes 1. Interhemispheric fissure, 2. Frontal lobe, 3. Skull, 4. Orbit from(neonatal cranial ultrasonography 2007) Slowly angle the transducer posteriorly. Scan through the occipital horns into the occipital lobes of the brain



Chapter three

3.1.Study design:

This is retrospective longitudinal study , Hospital based study

3.

3.2.Study period:

This study was conducted from June 2013 to janury2014**Research**

Methodology

3.3.Study area :

Khartoum state hospitals .

3.4.Study population:

The target populations of the study are all neonate and infant baby have attending to received brain ultrasonography at the time during and before study conduct

3.5. Sampling and Sample size

3.5.1 Sampling:

Convenience sampling (baby available at the time of researcher coming and previous report if available)

3.5.2.Sample size:

50 baby and above

3.6.Tools of data collection:

by using master sheet check list

3.7.Data analysis:

The data were analysed by using SPSS package version 17 for quantitative data to find out indicators aimed by this study.

3.8.Limitation of the study:

The findings of the study cannot be generalized to other populations as the study was contextual and conducted on only one hospital in one province.

3.9 .Ethical consideration:

- The research is respecting the rights of participants; treat data with confidentiality.
- Verbal consents were obtained from all participants mothers .
- letter to be taken from Sudan University - Faculty of radiology to be taken to targeted hospital.
- Approval from administrative authorities of targeted Hospital to be taken.

Chapter four

Result

4.1 Results:

50 infant and neonate presented to Alshaab & Souba hospital as hydrocephalus patient with CUS reported done inside or outside hospital and collected from archives randomly using collection sheet and the result show ;

Figure 4-1 show distribution of age of cases 36% neonate and 64% infant

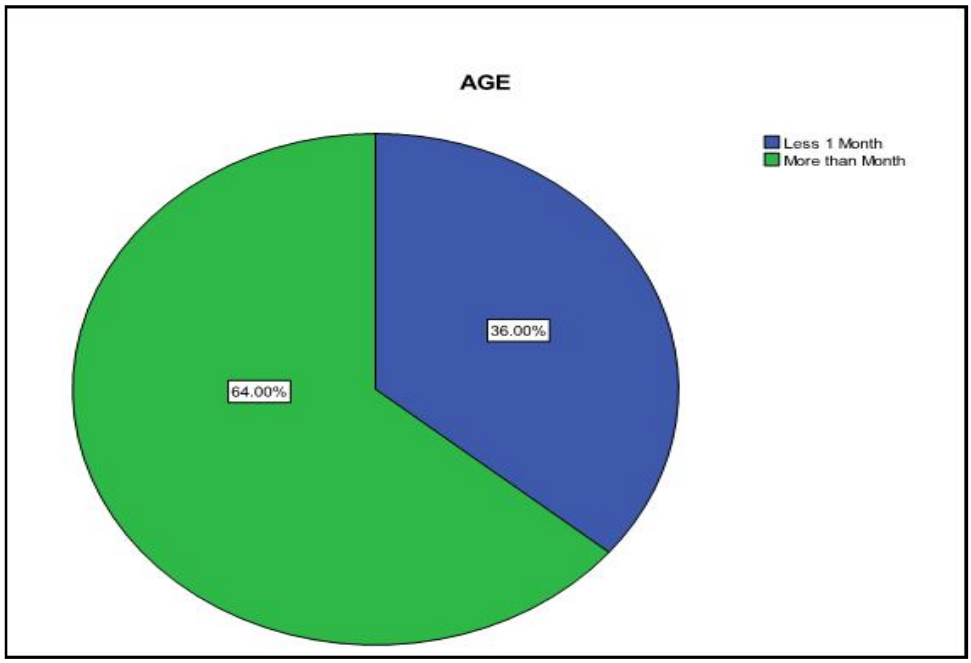


figure 4-2 show gender distribution of cases 52% male and 48% female

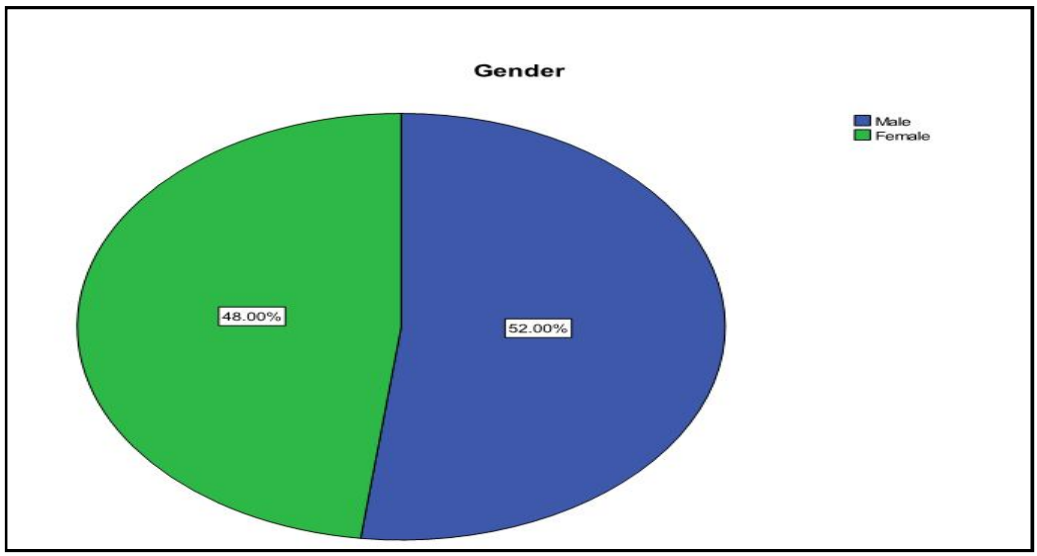


Figure 4-3 show clinical condition of cases 80% symptomatic 20% Asymptomatic

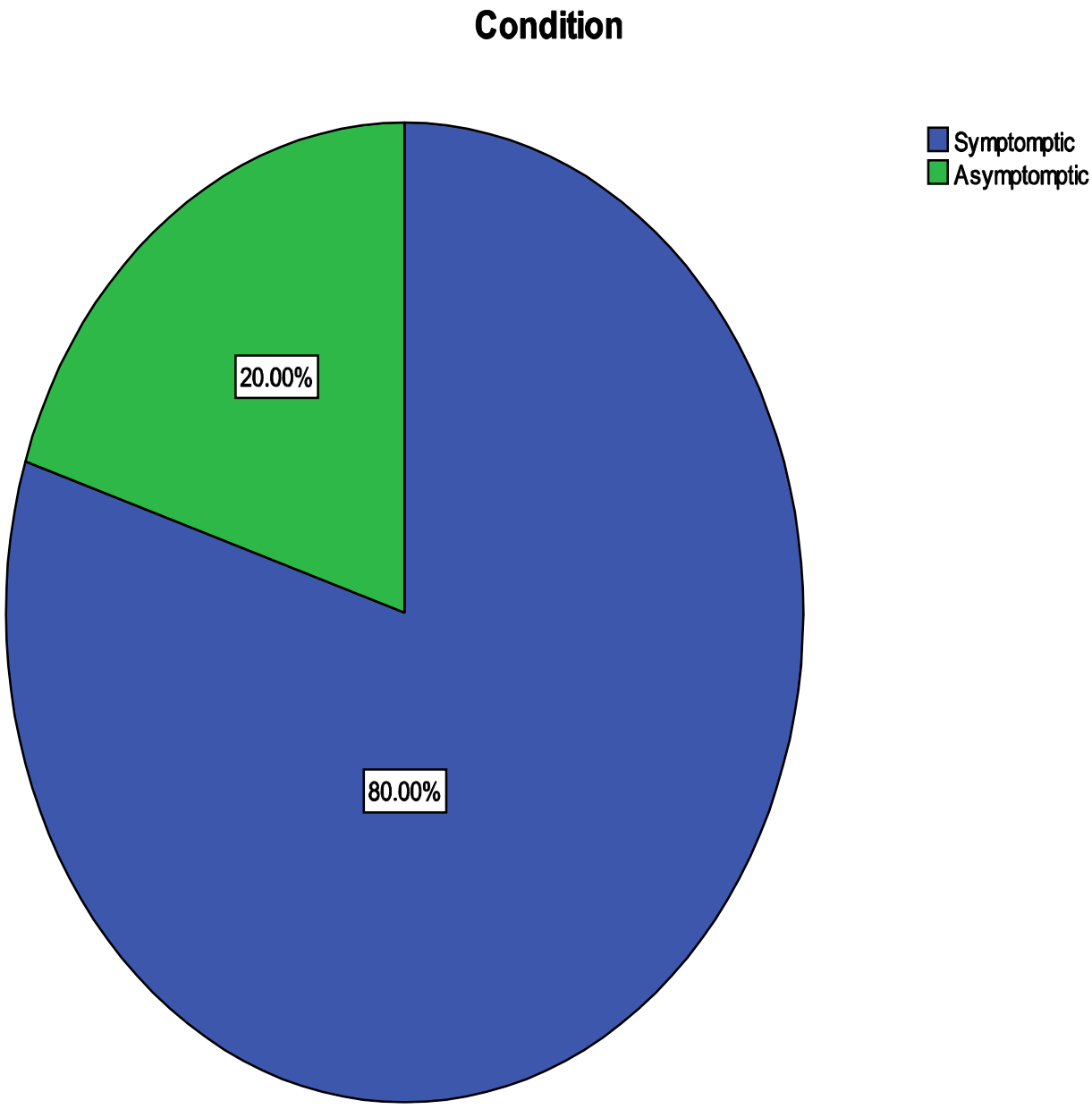
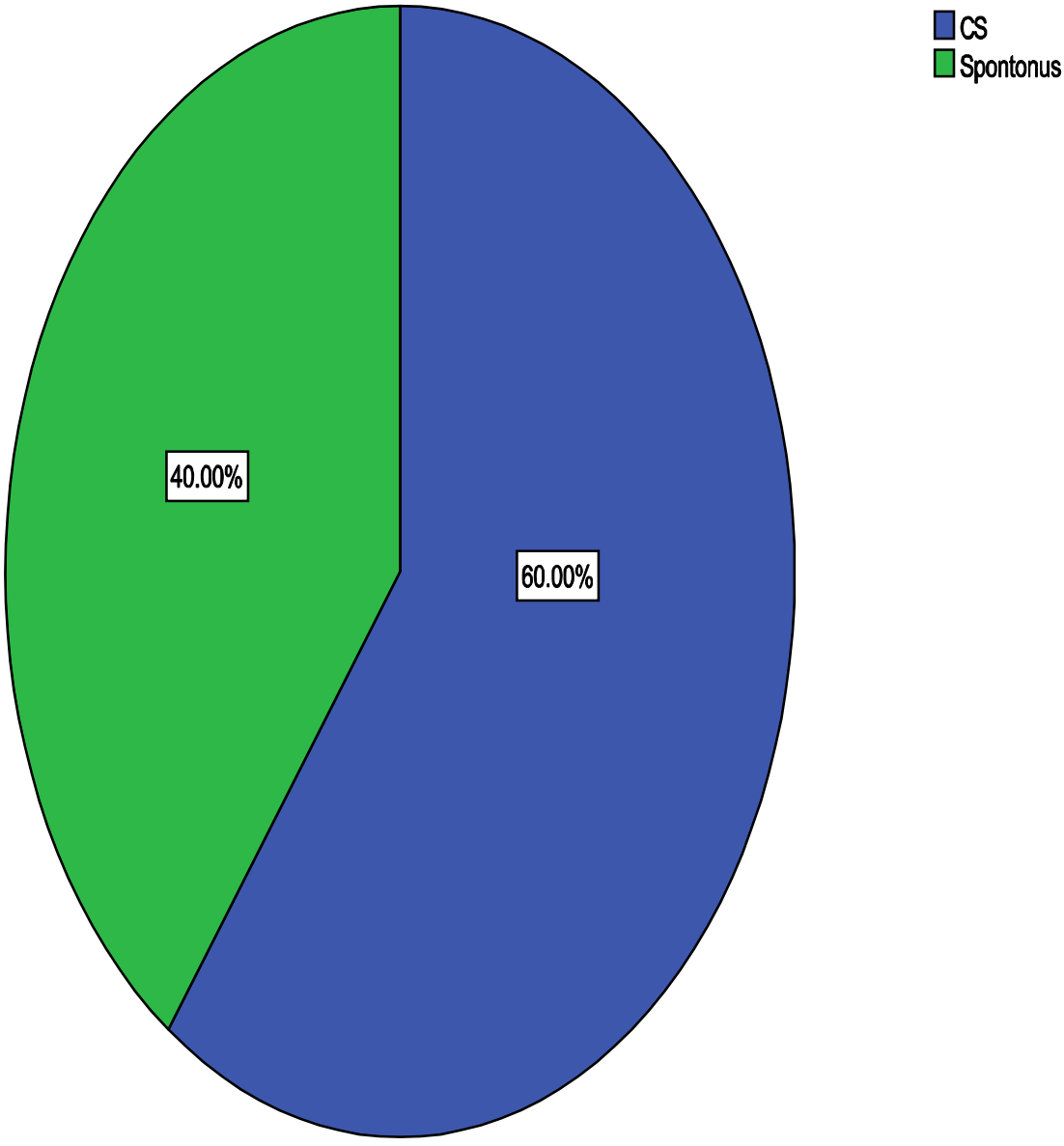


figure 4-4 show mode of delivery 60% caesarean section 40% spontaneous



Lateral Ventricle enlargement

Valid	Frequency	Present	Valid Present	Cumulative present
Yes	50	100.0	100.0	100.0

Table 4-1 show 100% lateral ventricle enlargement

Table 4-2 : 3rd Ventricle Enlargement

Valid	Frequency	Present	Valid Present	Cumulative present
Yes	42	84.0	84.0	84.0
No	8	16.0	16.0	
total	50	100.0	100.0	100.0

Table 4-3: 3rd Ventricle Enlargement

Valid	Frequency	Present	Valid Present	Cumulative present
Yes	42	84.0	84.0	84.0
No	8	16.0	16.0	
total	50	100.0	100.0	100.0

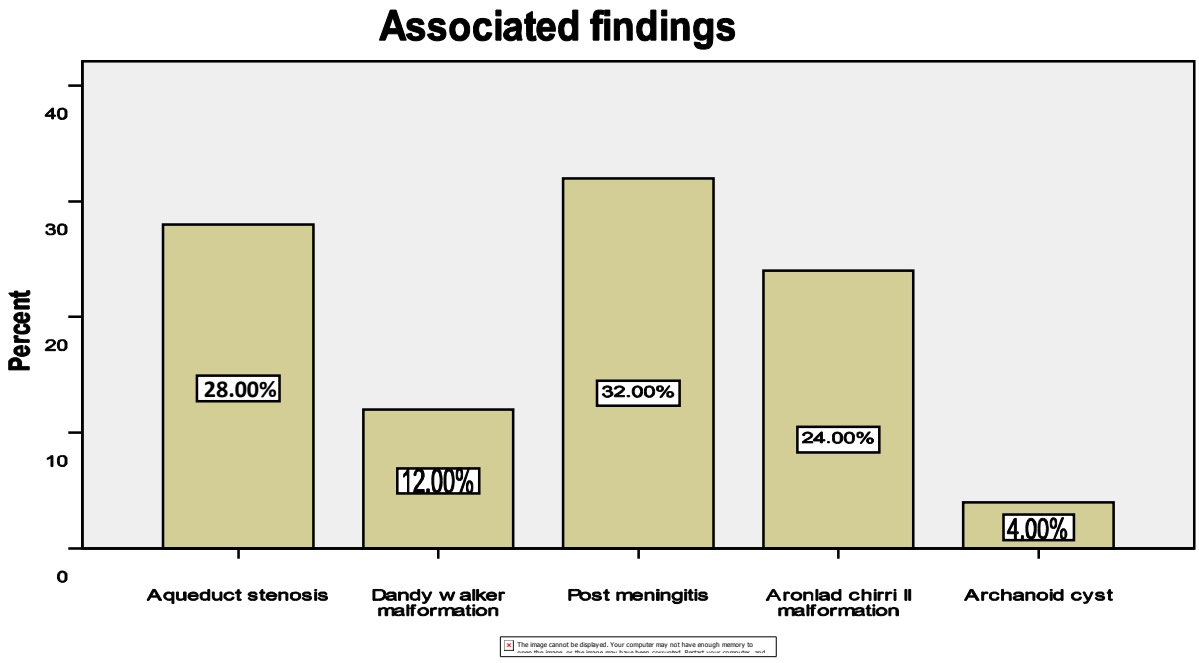
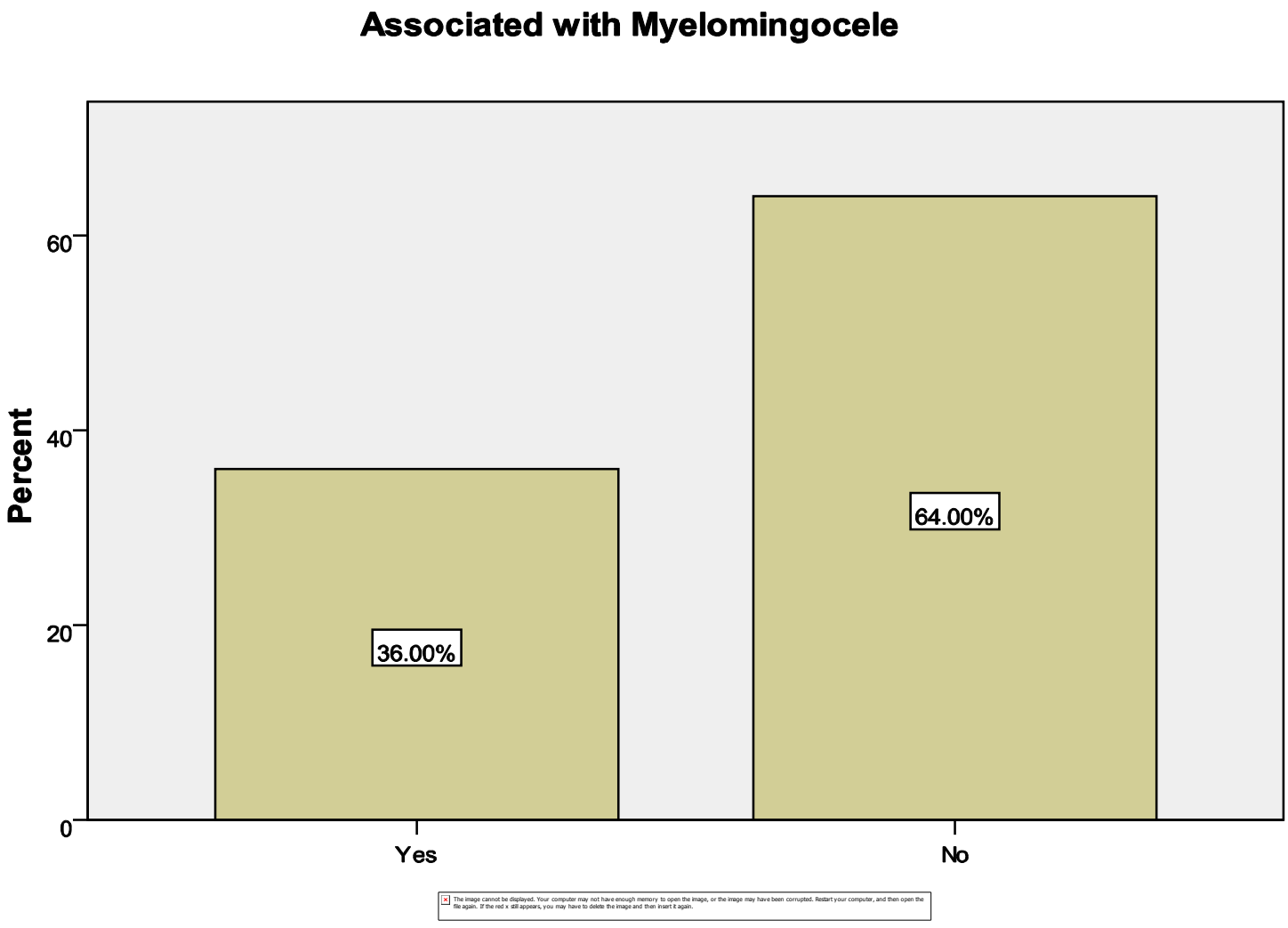


Figure (4-6) show association with myelomingocele 36% and not associated 64%


Associated with Myelomingocele
Percent
60
40
20
0
36.00%
64.00%
Yes
No
The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Associated findings * Type of Hydrocephalus Cross tabulation

Count		Type of Hydrocephalus		Total	
		Congeni Acquire			
		Tal	D		
Associated	Aqueduct stenosis	14	0	14	28
Findings	Dandy walker	6	0	6	12
	Malformation				
	Post meningitis	0	16	16	32
	Arnold chirri ll	12	0	12	24
	Malformation				
	Archanoid cyst	2	0	2	4
Total		34	16	50	100

Table (4-4) show that congenital finding in aqueduct stenosis 28% (14/50) Dandy walker malformation 12% (6/50) Arnold chirr ill malformation 24% (12/50) archanoid cyst 4% (2/50), acquired post meningitis 32% (16/50).

Table 4-5:

Associated finding Associated with meylomingocele cross tabulation

Associated finding			Associated with melomingocele		
	Aqueduct	Count % within associated with myelomingicele	6 33.3%	8 25.0%	14 28.0%
	Dandy walker malformation	Count % within associated with myelomingocele	0 .0%	6 18.8%	6 12.0%
	Post meningitis		4 22.2%	12 37.5%	16 32.0%
	Arnold cirii ll malformation		6 33.3%	6 18.8%	12 24.0%
	Archanoid cyst		2 11.1%	0 .0%	2 4.0%
total		Count % within associated with myelomingocele	18 100.0%	32 100.0%	50 100.0

Chapter five

5.Disscussion Conclusion and recommendation

5.1 Discussion

In spite of the size of the sample which was small because of limitation of the time the age distribution was 64% more than one month and 36% less than one month, the males were majority 52% female 48% in spite of the very close percentage but was close similar to study done by (Howida Mohammed salih 2009) which showed almost the same percentage 54% males 46% females. The patients were symptomatic 80% while only 20% were Asymptomatic which agree with study mentioned above with percentage (72%-28%) symptomatic to Asymptomatic respectively. Regarding to delivery mode 60% of patient was deliver by C/S while 40% delivered spontaneous delivery which was expected due to head enlargement in HC patient see figure (2-22) .100% of sample showed lateral ventricles enlargement, 40% showed 3rd ventricle enlargement 52% are 4th ventricle enlargement. The type of HC in 68% of patient has showed that is congenital type while 32% was acquired type which agreed with previous done by (àRVRZVND-Kaniewska 2007) which showed 55% has congenital origin. The communicating was 60% of the cases while non-communicating 40% and that similar to finding of (Raya Elsayed El-khaleel 2007) who found the 68% were communicating HC and only 32% none communicating.

Associated finding:

100% percentage of cases has associated finding as represented by figure (4-

5) and table (4-5) the majority of the cases as mentioned early 68% were associated congenital abnormalities and distributed as follow 28% aqueducts stenosis , 24% Arnold chirri II malformation 12% dandy 50 walker malformations 4%Archanoid cyst ,while whole 32% acquired HC were post meningitis.

Figure (4-6) and table (4-6) represented the percentage of the cases associated with Myelomingocele which was only 36% of all cases .

5.2 Conclusion

After analysing the data collected, the researcher reached the followingconclusion:

•The incidence of hydrocephalus in the selected sample was more inmale infants (54%), compared with female infants (46%).

•The mostdetectedultrasound findingswere: dilated lateralventricle in all sample (100%).

•The most detected associated congenital anomalies were: aqueduct stenosis 28%, followed by Arnold chiari malformation 24%.

•All acquired hydrocephalus cases were noted to be post meningitis.

•The majority of the cases were symptomatic patients 80%.

5.3 Recommendation

• Patient neonate or infant with HC associated with myelomingocele need care to prevent meningitis.

• Neonate and infant with HC with symptomatic condition should be scanned early to prevent any complication according to development of hydrocephalus.

• Neonates and infants hospital should be provided with excellent US

machine to provide high quality Images.

• The researcher recommends that future studies in the topic be conducted, taking into consideration ventricle measurements using CUS, and compare computed tomography with CUS sensitivity in HC diagnosis.

List of reference

-Carsten Krüger, MD, FRCPCH (UK), MIH et Naftali Naman, AMO SAJCH SEPTEMBER 2010 VOL. 4 NO. 3

- FKXPP\ V. VLQQDWDPE\ )5&6 /DVW¶V $QDWRP\ UHJLRQDO DQG DSSOLHG 8. Churchill livingstone ,1999 p 31.

-Elaine Nicpon-Marieb Basic Anatomy and Physiology of the Human Brain(1991) 25-31.

-Howida Mohammed salih ,the role of ultrasound in scanning of infant brain 2007-2009

-HydrocephalusWritten by Amanda Delgado | Medically Reviewed by George Krucik, MD Published on August 15, 2012 as seen from

-www.ask.com/health/adamcontent/hydrocephalus#definition

-Paul Kremer, Bahram Hashemi, Stefan Kunze (October 1999). "The scientific history of hydrocephalus and its treatment". Neurosurgical Review (Springer) 22 (2±3): 67±93 [67]. seen from

-http://en.wikipedia.org/wiki/Hydrocephalus

-Raya Elsayed El-khaleel ,ultrasound pattern in Sudanese neonate 2007

-Spina bifida herocephalus ireland ass seen from

-http://www.sbhi.ie/hydrocephalus.html#15

-Statistics about Hydrocephalus as seen from

-http://www.rightdiagnosis.com/h/hydrocephalus/stats.htm

-Steggerda S, Leijser L, Walther FJ, Van Wezel-Meijler G. Neonatal cranial ultrasonography: How to optimize its performance. Early Human Development 85 (2009) 93±99.

-Susan Riordan, RN, RDMS et Jonathan Weeks, M.D. Congenital

Hydrocephalus / Ventriculomegaly

-Van Wezel-Meijler G. Neonatal cranial ultrasonography: guidelines for the procedure and atlas of normal ultrasound anatomy. Berlin: Springer;2007 Heidelberg.

Appendix:

-Collected Data:

Associated findings	Discription	Type	Ventricle Enlargment	Mode of delivery	Clinical Condition	Gender (M/F)	Age day	
Post manengitis	Com	***acquired***	Lateral,4^{th}, $3^{rd,}$ ventricle	CS	***A sympt***	F	14d	1
Aquaduct Stenosis	Non-com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	normal	Sympt	F	10d	2
Post manengitis	Com	***acquired***	Lateral ventricle	CS	Sympt	M	33d	3
Aquaduct Stenosis	Com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	CS	Sympt	F	35d	4
Aquaduct Stenosis	Non-com	congenital	Lateral ventricle	normal	***A sympt***	M	7d	5
Aquaduct Stenosis	Com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	CS	Sympt	F	30d	6
DWM	Non-com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	normal	Sympt	F	5d	7

Post manengitis	Com	***acquired***	Lateral ventricle	CS	Sympt	M	40d	8
ACM	Com	congenital	Lateral, 4^{th},3^{rd} ventricle	normal	Sympt	M	35d	9
Aquaduct Stenosis	Non-com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	CS	Sympt	F	4d	10
Aquaduct Stenosis	Com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	Cs	***A sympt***	F	31d	11
Post manengitis	Com	***acquired***	Lateral ventricle	normal	Sympt	F	34d	12
Aquaduct Stenosis	Non-com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	CS	Sympt	M	42d	13
DWM	Com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	normal	Sympt	F	6d	14
Aquaduct Stenosis	Com	congenital	Lateral, 4^{th}, 3^{rd} ventricle	normal	***A sympt***	M	45d	15
Post manengitis	Com	***acquired***	Lateral ventricle	CS	Sympt	M	8d	16

ACM	Com	congenital	Lateral, 4th, 3rd ventricle	CS	Sympt	F	9d	17
Aquaduct Stenosis	Non-com	congenital	Lateral, 4th, 3rd ventricle	normal	Sympt	M	43d	18
Aquaduct Stenosis	Com	congenital	Lateral, 4th, 3rd ventricle	CS	Sympt	M	42d	19
ACM	Non-com	congenital	Lateral, 4th, 3rd ventricle	normal	***A sympt***	F	7d	20
Aquaduct Stenosis	Com	congenital	Lateral, 4th, 3rd ventricle	CS	Sympt	F	39d	21
DWM	Com	congenital	Lateral ventricle	normal	Sympt	M	3d	22
Aquaduct Stenosis	Non-com	congenital	Lateral, 4th, 3rd ventricle	normal	Sympt	M	37d	23
Post manengitis	Com	***acquired***	Lateral, 4th, 3rd ventricle	CS	Sympt	F	35d	24

DWM	Non-com	congenital	Lateral, 4th, 3rd ventricle	normal	Sympt	M	1d	25
Post manengitis	Com	***acquired***	Lateral, 4th, 3rd ventricle	CS	***A sympt***	F	33d	26
ACM	Com	congenital	Lateral, 4th, 3rd ventricle	CS	Sympt	M	31d	27
DWM	Non-com	congenital	Lateral, 4th, 3rd ventricle	CS	Sympt	M	2d	28
Aquaduct Stenosis	Com	congenital	Lateral ventricle	normal	Sympt	F	49d	29
ACM	Com	congenital	Lateral, 4th, 3rd ventricle	CS	Sympt	M	11d	30
Post manengitis	Non-com	***acquired***	Lateral, 4th, 3rd ventricle	normal	Sympt	F	47d	31
ACM	Com	congenital	Lateral, 4th,3rd ventricle	Cs	Sympt	F	45d	32

ACM	Com	congenital	Lateral ventricle	Cs	***A sympt***	M	4d	33
Post manengitis	Non-com	***acquired***	Lateral, 4^{th},3^{rd} ventricle	normal	Sympt	F	43d	34
ACM	Com	congenital	Lateral, 4^{th},3^{rd} ventricle	Cs	Sympt	M	5d	35
Aquaduct Stenosis	Com	congenital	Lateral, 3^{rd} ventricle	normal	Sympt	F	41d	36
Archanoidc	Non-com	congenital	Lateral, 3^{rd} ventricle	Cs	***A sympt***	M	60d	37
Post manengitis	Com	***acquired***	Lateral, 3^{rd} ventricle	normal	Sympt	F	32d	38
ACM	Non-com	congenital	Lateral, 3^{rd} ventricle	CS	Sympt	F	34d	39
Post manengitis	Non-com	***acquired***	Lateral, 3^{rd} ventricle	Cs	Sympt	M	36d	40
Aquaduct Stenosis	Com	congenital	Lateral, 3^{rd} ventricle	normal	***A sympt***	M	43d	41
ACM	Com	congenital	Lateral, 3^{rd} ventricle	Cs	Sympt	F	6d	42
Post manengitis	Com	***acquired***	Lateral, 3^{rd} ventricle	normal	Sympt	M	41d	43

Post manengitis	Non-com	***acquired***	Lateral, 3rd ventricle	Cs	Sympt	M	1d	44
ACM	Com	congenital	Lateral, 3rd ventricle	CS	Sympt	F	35d	45
ACM	Non-com	congenital	Lateral, 3rd ventricle	normal	Sympt	M	49d	46
Post manengitis	Com	***acquired***	Lateral, 3rd ventricle	Cs	Sympt	M	55d	47
Archanoidc	Non-com	congenital	Lateral, 3rd ventricle	Cs	Sympt	M	38d	48
DWM	Non-com	congenital	Lateral, 3rd ventricle	Cs	Sympt	M	1d	49
Post manengitis	Com	**acquired**	Lateral, 3rd ventricle	CS	***A sympt***	f	38d	50

- Images: