Morphohistological Architecture of Human Neonate Cerebral Cortex Autopsy

Bader Khtlan Hameed(PhD) [1], **Samira Abdulhussain Abdullah** (PhD) [2], **Saad Kadhum Kareem** (PhD) [3] and **Ayad Hameed Ibrahim** (PhD) [4]

Abstract

Background: The brain gyri and sulci development, its characterization and timing is one manifestation of the complex orchestration of human brain.

Objective: To present work was aimed to illustrate the morphometry and the histological architecture of the human neonate cerebral cortex.

Patients and Methods: In this study four brains from neonates at day 1, 5, 6 and 7 day were taken as well as other 4 samples at 28 days of age were collected from the medico-legal directorate in Baghdad. This work was done to describe the morphometry and thickness measurements of human neonate cerebral cortex of different ages. Brain samples were fixed in 10% neutral buffer formalin and slides from various regions f cerebral cortex were prepared and stained with H&E.

Results: The present investigation was resulted that, the mean measurements of the brain from the frontal to occipital pole was 125.0- 191.3 mm to the neonate aged 1-28 days. While the mean cortices thickness measurements of the frontal, parietal, temporal and occipital were 3.468, 3.483, 3.097 and 3.290 mm respectively. The histological results revealed that, the human neonate cortex formed by six layers, which were varied in the numbers, size and type of nerve cells, glial cells and nerve fibers.

Conclusion: The present study concluded that the morphometry of the brain from day one until day 28 were varied to that of adult and the histological study of the neonate brain from day one until day 28 were resemble to that of the adult.

Keywords: Braindevelopment; Braincortex; Gyrification; Brainarchitecture.

Corresponding Author: drsaad_kareem@yahoo.com

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[1,4] Department of Anatomy - College of Veterinary Medicine – University of Tikrit- Iraq.

[٢] Department of Anatomy - College of Medicine – University of Tikrit- Iraq

[3]Department of Forensic pathology - College of Medicine - Al-Nahrain University- Baghdad - Iraq.

Introduction

The cerebral cortex is the outer covering of the gray matter over the brain hemispheres. This is typically 2-3 mm thick, covering the gyri and sulci. Cerebral cortex is the most highly developed part of human brain, and the most recent structure in the brain evolution history [1]. The character and timing of gyral development is one of the manifestation and complex orchestration of human brain development. The ability to quantify these changes would not only allow for deeper understanding of cortical development, but also conceivably allow for pathology improved detection [2]. The white matter provides the bulk of the brain volume and hence brain growth over the first two years (Dietrich, 1988) [3]. The

cortical measurements might point towards a structural abnormalities, and represent an early markers for the later appearance of functional disturbance and may be in part responsible for the lower measurements in children born with intrauterine growth restriction (Richa, et al) [4]. Meyer (2007) described the cerebral cortex layers post-natal and pointed out that the marginal zone is sparely cellular in most areas and the layers are well established [5]. Meyer also illustrated that the sub plate continues to decrease in the thickness and disappears by the first post-natal month [5].

Patients and Methods

Four neonate brains of age at first 7 days(day 1,5,6,and 7 days) and others four samples at age of(10,20,and 28days) were collected from Medico-Legal directorate in Baghdad. The brain was removed out carefully. The whole brain samples were fixed in 10% neutral buffer formalin for 48 hrs, and were washed with tap water for 2 hrs to remove the excess formalin. Measurements of samples were made using electronic digital caliber.

Brain samples were passed through graded alcohol solution, followed by clearing in xylene and infiltrated in paraffin wax for 24 hrs. Samples were then blocked in paraffin wax and sectioned at 6µm thickness. Measuring the size of cells were done by application of the ocular and stage micrometers after the, sections stained by using routine haematoxylin and eosin, and then were photographed. Data were recorded in the SPSS for window 11.0.

Results

A-Morphometric measurements

Human neonate brain consisted of two cerebral hemispheres which was indicated by the longitudinal cerebral fissure [Fig.1] and was extended from the frontal lobe pole to the occipital pole. The frontal lobe was recognized and indicated by the presence of inferior, middle, and superior gyri [Fig. 2]. This was tortuous and covered by the pia matter which passed into the shallow sulci. The parietal lobe occupied the superio-laterally, and was indicated by the gyri and the more deep sulci, and was laterally extended to the temporal lobe fissure. The occipital lobe was located superio-posteriorly. The temporal lobe and its superior, middle and inferior gyri and superior and inferior sulci were located laterally. The insular gyri was located in the longitudinal cerebral fissure floor of the posterior halve figure 3 and 4.

The present study demonstrated that, the measurement of the neonate brain from the frontal to the occipital poles ranged [125-181] mm and [181.3- 191.3] mm during the period from 1-10 and 10- 28days after birth respectively.

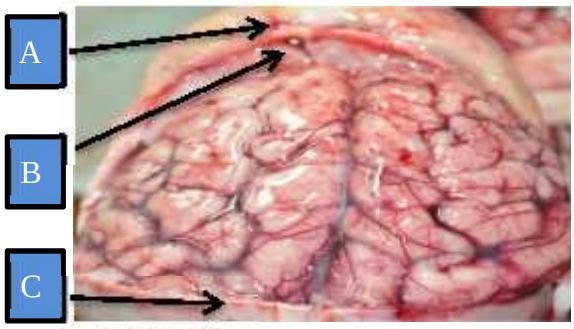

Figure (1): The brain in insitu. The parietal bone was removed to show; Anterior flap A; Frontal bone B; occipital bone C.

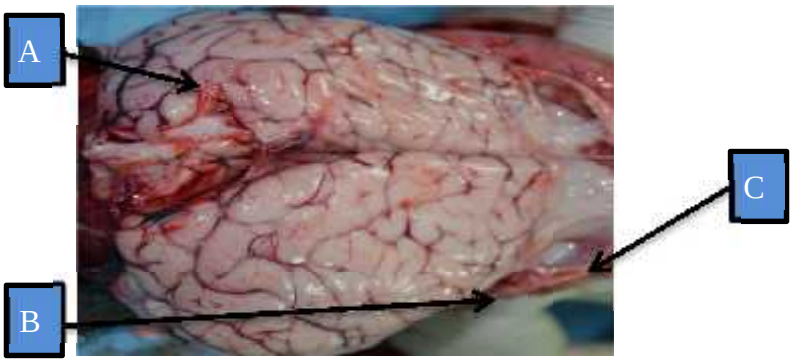

Figure (2): Top superior view of the brain shows; Occipital lobe(A); Middle cerebral fissure(B); Frontal bone (C).

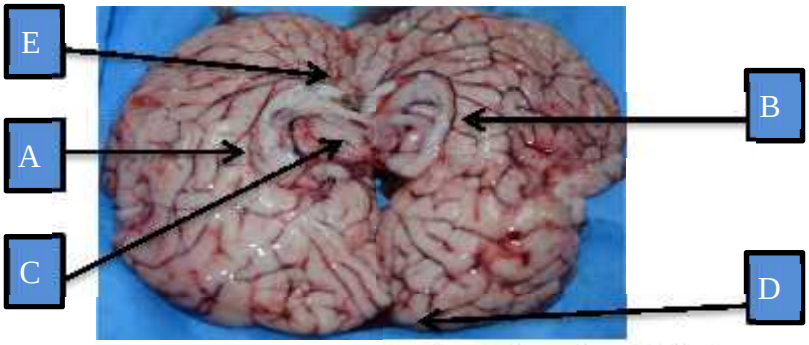

Figure (3): Medial view of a brain in situ at age one day, two hemispheres dissected to show: Cingulate gyrusA; Fornix B;interthalamic adhesion C; Inferior frontal gyrusD; corpus callosum E.

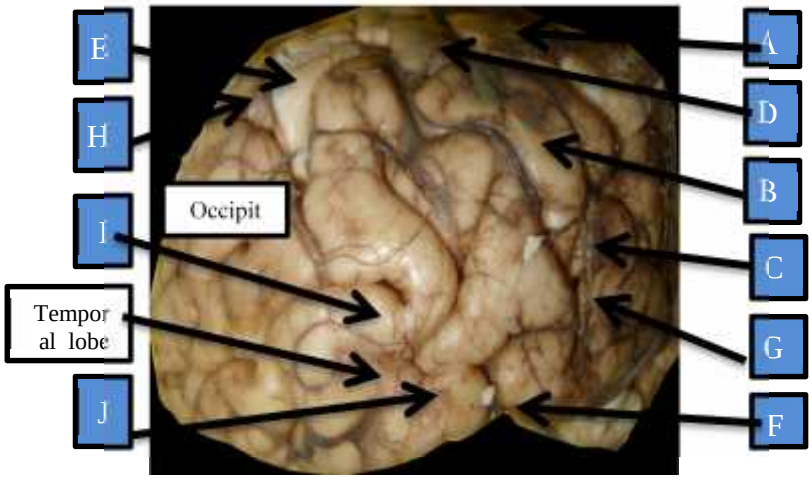

Figure (4): Lateral view of right hemisphere of male brain at one day show the Frontal, Parietal, Temporal and Occipital lobes: superior frontal gyrus **A;** middle frontal gyrus **B;** inferior frontal gyrus **C;**precentralgyrus **D**;postcentralgyrus **E;** lateral sulcus **F;** anterior ascending ramus **G**;parieto-occipital sulcus **H;** Superior temporal lobe **I;** inferior temporal lobe.

The morphometry and thickness measurement of various neonate brain parts were shown in table (1).

Table (1): Measurements f human neonate brain cortex at the frontal, parietal, temporal and occipital lobes of different ages.

Neonatal brain age (day)	Measurement of brain from frontal to occipital pole (mm)	Frontal cortex (mm)	Parietal cortex (mm)	Temporal cortex (mm)	Occipital cortex (mm)
1	125.0± 1.562	2.977±0.124	4.125±1.242	4.107±1.002	3.170±0.1022
5	181.4±2.461	2.580±0.3360	3.635±1.350	3.888±1.204	3.045±1.060
10	183.3±4.835	3.355±1.802	3.545±1.202	4.135±1.602	3.285±1.820
20	190.0±5.862	3.540±1.620	3.275±0.825	3.150±1.402	3.430±1.204
28	191.3±6.184	3.468±1.452	3.483±1.602	3.097±1.252	3.290±1.622

Histological results:

1- The pia matter:-The pia matter was formed by two layers, and was delicate, detached and separated from each other. The inner layer was adhered to the cortex, while the second one was separated. Large number of blood vessels was seen in between the detached pia matter layers. Some blood vessels were empty and the others were engorged with blood.

2-Cerebral cortex:- The following table (2) and figures (5) summarize the histological characterization of the cerebral cortex layers:

Table (2): Histological characterization of the cerebral cortex layer

Cortical layers	Frontal lobe			Occipital lobe		
	Day. 1	Day. 5	Day. 6	Day. 1	Day. 5	Day. 6
Molecular layer I	Network of nerve fiber, neuronal and glial cells	Many neuronal cells surrounded by white colour zone	Large vacuoles associated with glial cells and pyramidal cells and longitudinal sections of blood vessels	Various types of neuronal and glial cells	Smooth surface scanty neuron and glial cells	Large vacuoles associated with glial and pyramidal cells and lngitudinal section of blood vessels
External granular II	Small size pyramidal cells	Large number f cells some are clumped surrounded by cavities of white zone and glial cells	Large number of glial cells and some small and medium size pyramidal cells	Individual undifferentiated cells	Pyramidal and glial cells and microblood vessels close t the third layer	Small and medium size pyramidal cells and large number of glial cells
External pyramidal III	Small and medium size pyramidal cells	Medium and large pyramidal cells with larg nuclei surrounded by large zone and network of nerve fiber and glial cells	Pyramidal cells associated nuclei and vacuoles and glial cells in between	Small and medium size pyramidal cells	Large and medium size pyramidal cells surrounded by white large zone	Pyramidal cells associated with large vacuoles containing nuclei and glial cells
Internal granular**IV**	Small pyramidal and glial cells	Large number of neurons and glial cells , micrglial cells and nerve fiber	Glial cells and medium and large size pyramidal cells	Large number of pyramidal and glial cells	Small and medium size pyramidal cells and a single large pyramidal cells	Medium size pyramidal cells and glial cells associated with blood vessels
Internal Pyramidal **V**	Medium size pyramidal cells, glial cells and micrglial cells	Large pyramidal cells surrounded by large white zone , glial cells and nerve fiber	Small and medium size pyramidal cells and number f glial cells	Small and medium size pyramidal cells with spherical nuclei, vacuoles and microglial cells	Large size pyramidal cells and glial cells	Large and medium size pyramidal cells and a number of glial cells
Multiform layer **VI**	Different size of pyramidal, glial cells and nerve fibers , and spaces surrounded by glial cells	Large number of nerve fibers and varius cell shapes and size , small blood vessels , and large pyramidal and glial cells	Large glial and pyramidal cells	Medium and large pyramidal cells and microglial cells	Pyramidal cells of varius size and glial cells with nerve fibers	Glial cells of different size with many blood vessels

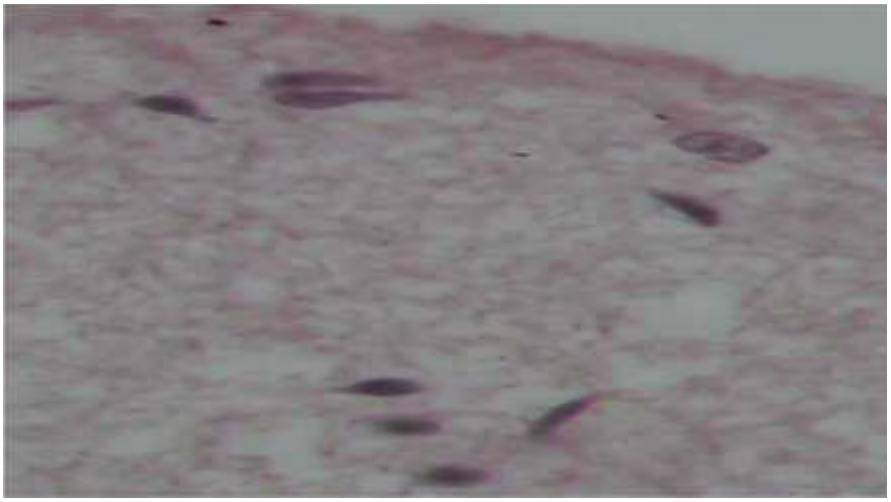

Figure (5): Male at day 1, frontal lobe, surface of cerebral cortex with molecular layer , Pyramidal cells A; Glial cells B (H&E X125).

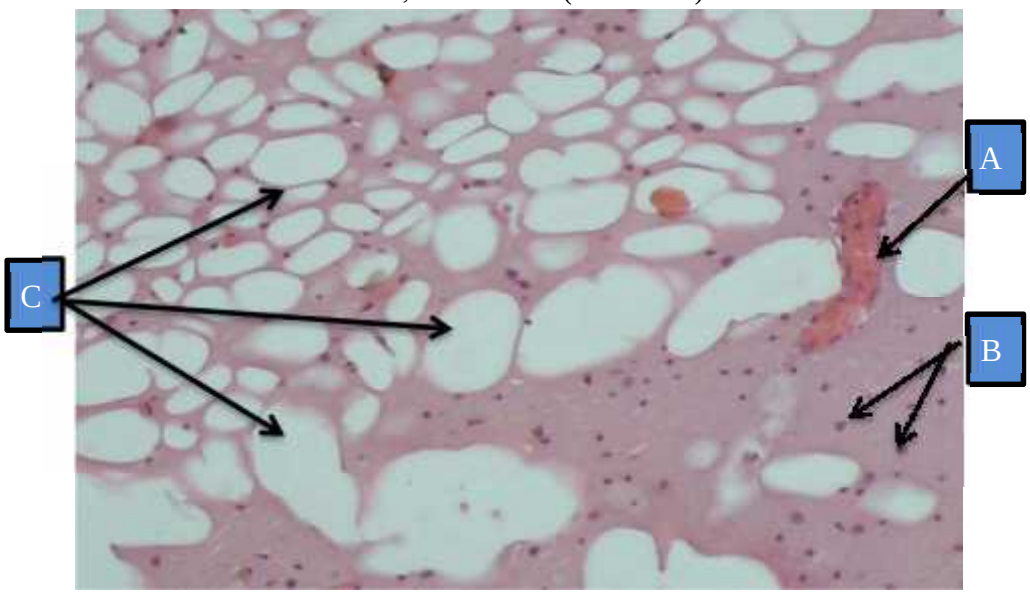

Figure (6): Male at day 1,parietal lobe , multiform layer with white matter indicate; Blood vessels A; Glial cells B; Vacuoles C (H&E X20).

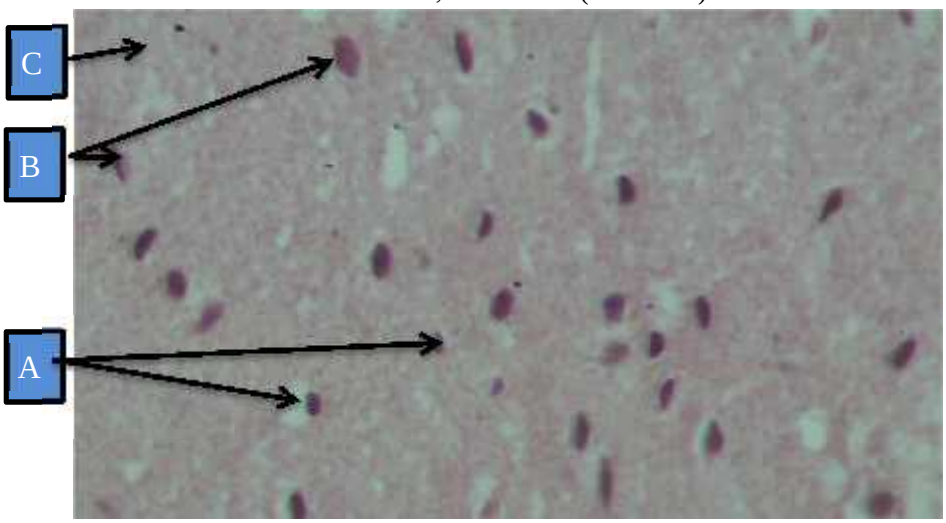

Figure (7): Male at day 5, frontal lobe, internal pyramidal layer indicate; Glial cell A; Pyramidal cell B; Microglial cell C.

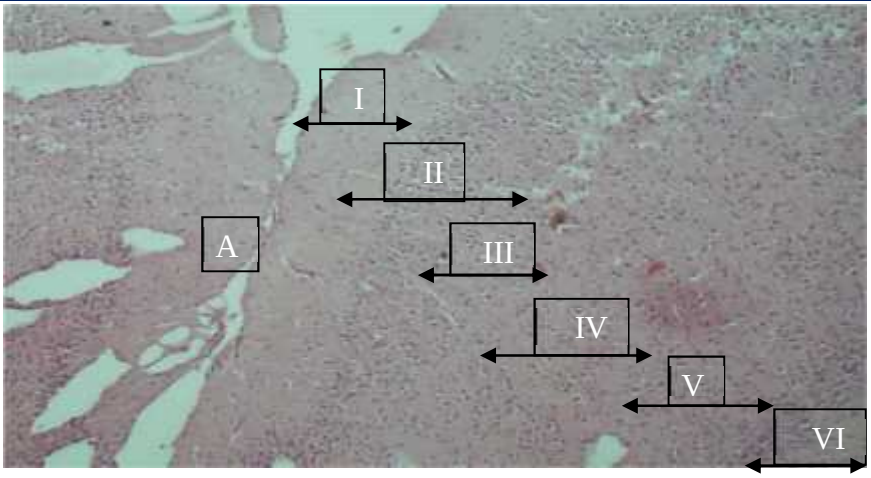

Figure (8): Occipital lobe of male at day 5, layers cerebral cortex: molecular layer **I;** External granular layer **II;** External pyramidal layer **III;** internal granular layer **IV;** internal pyramidal layer **V;** multiform layer **VI;** sulcus **A** (H & E. X10).

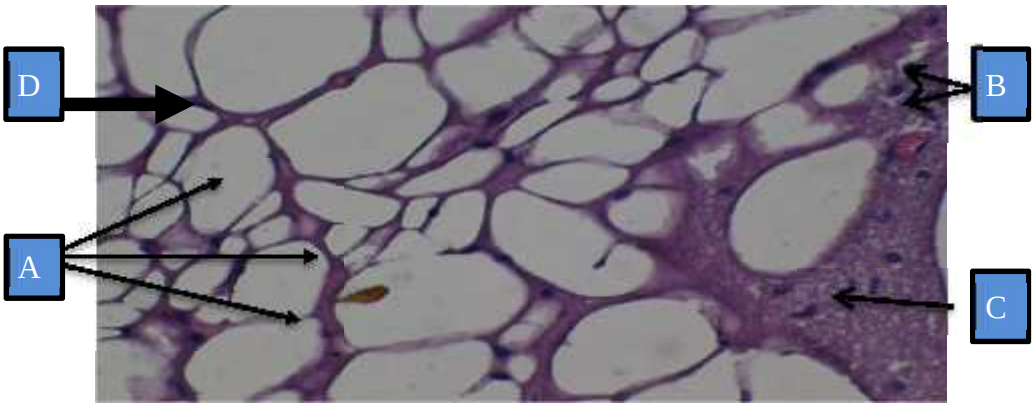

Figure (9): Occipital lobe of male Gray and white mater at day 6: White matter A; glial cells B; multiform layer of gray matter C; blood vessels D (H & E X40).

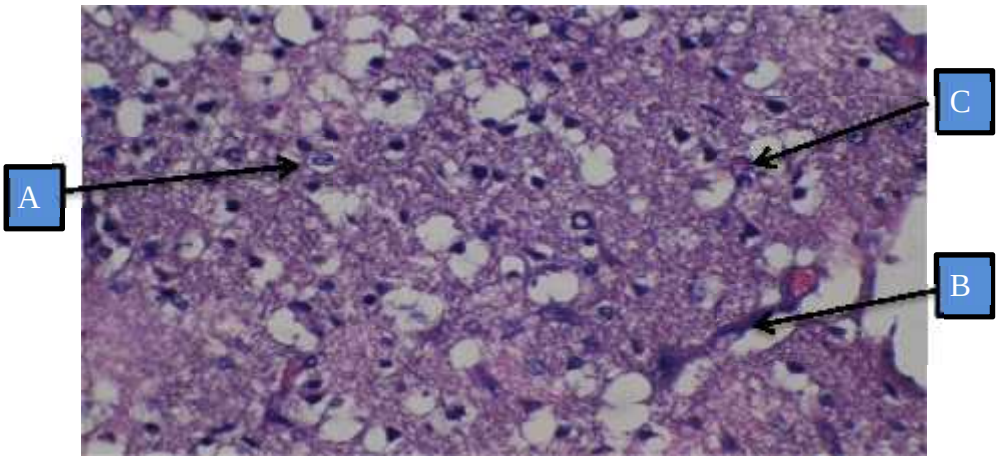

Figure (10): Frontal lobe of male cerebral cortex at day 6, external pyramidal layer:pyramidal cells A; Dendrite of pyramidal cells B; blood vessels C (H & E X40).

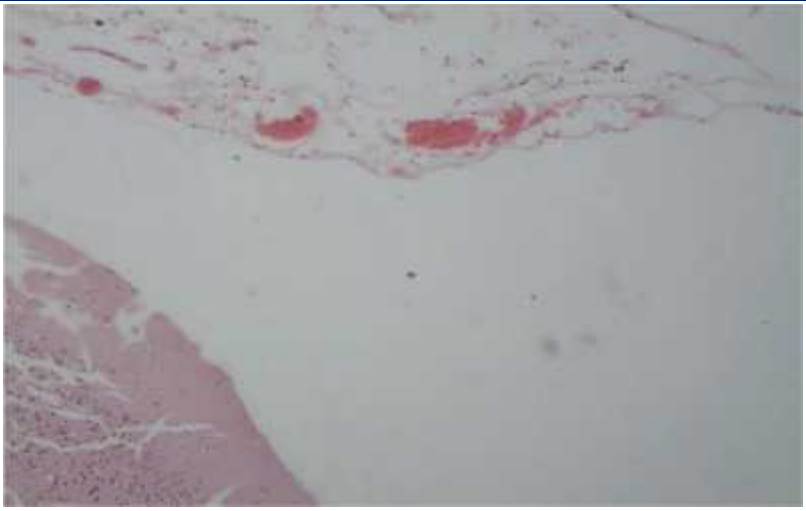

Figure (11): Female at day 5, frontal lobe, surface of cerebral cortex with layers shows; Arachnoids A; Blood vessels B; I Layer C; II layer D (H&E X20).

Discussion

The present results clarify that, the superior and inferior gyri of parietal lobe were highly convoluted, but Most of the sulci were shallow. The occipital lobe was determined by a prominent parieto – occipital sulcus and the occipital pole was recognized. The lingual gyrus appeared less convoluted in comparison with previous gyri of parietal lobe. This is agreed with Regis *et al* who demonstrated sulci and hig light inter individual variability in the time of appearance and inter – hemispherical a symmetrical with a large right superior temporal sulcus than the left side [6]. Hilgetag and Barbas they demonstrated the division of the brain into four regions[7][8].

The frontal, parietal, temporal and occipital lobes. This is what the present result refers to it.

Peterson (2003) who demonstrated that, the gray matter grows in the parietal and occipital cortices during the first weeks of life. The present results also demonstrated two areas, one is dark colored (gray matter) and the other was lighter color (white matter). The gray matter becomes harder than the white matter during the first [1-28] days of age and this in agreement with the study of Peterson 2003 [9].

Rand 2006 demonstrated that the cerebral cortex is the outer covering of the gray matter measuring 2-3 mm in thickness. This result disagrees with the result of the present work. The thickness of cerebral cortex in the present work was approximately 2-4 mm. Amaral in 2000 [10]. And Uyling in 2008 [11]. Also in their studies measured the human neocortex to be approximately [2-4] mm. so these results are in agreement with the present results.

The results of the present work showed that, the white matter contains large cavities surrounded by glial cells associated with the delicate brain tissue stroma. These cavities were empty compartment and surrounded by fine network of nerve fibers and this is in agreement with a study by (Dietrch, 1988) [3].

Histological studies proved that the cerebral cortex continues after infancy, the gray matter continues to increase in volume Levitt, 2003 [12].The present work clarify that, the molecular layer was seen as a narrow zone of cells with a uniform size which agrees with the previous work.

The development of the neocortex from inside – out manner as mitotic ally dividing progenitor outward cells migrate and then become the multiform layer (Calegari, 2005)[13] . The results o f the present study

disagree with Landing *et al* 2002 [14] .They described thickening of the external granular layer (Layer II), which characterized by short range connections with other cortical region, precedes thickening of the external pyramidal layer (Layer III) which makes longer connections with other cortical region. In the present work pyramidal cells were less in number and were rarely seen.

The meningeal tissue is located transiently between the pial surface of the brain and the adjacent dural membrane. The pia matter was seen adherent early to the neural tissue and consisted of reticulum and elastic fibers network (Ladher and Schoenwlf, 2005) [15] .The results of the present work showed that, the pia matter was investing cerebral cortex and had branches of cerebral vessels engorged with red blood cells, which was located in the peripheral cortex, just beneath the pia matter figure [11]. While the pia matter in some samples appeared detached from brain surface. This means, the present work disagrees with the study of Ladher and Schoenwlf in 2005[15].

The present work clarify that, the surface of cerebral cortex is smooth completely and associated with the molecular layer. A reduction in the sub plate thickness begins in the sulci depth and then in the gyricrown. The present study identified layer II in the temporal lobe containing small pyramidal cells and others were spherical, with spaces surrounding some. The external granular layer in the parietal lobe contained some neurologic cell surrounded by spaces and individual glial cells. The external pyramidal in the temporal lobe contained large pyramidal cells associated with neurological cells mass, which were small and spherical, while the external pyramidal of the parietal lobe contained condensed pyramidal cell mixed with glial cells, these findings in agreement with a study done by Meyer 2007 [5].

In conclusion, From the results of study we may achieve the following conclusion. The morphometric measurement from frontal to the occipital lobes measured (125.0-191.3mm). The neonatal cortex consisted of six layers which were; molecular, external granular, external pyramidal, internal granular, internal pyramidal and multiform layer. These layers were varied in the type, size and number of cells and nerve fibers.

The early characterization of the cerebral cortex and gyrification opens up the possibility to study the environmental effects on the cortical folding process in human, and many help as early markers for the appearance of developmental disorders.

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