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Morphometry and Cytoarchitecture of Superior Colliculus in Human Fetal Brains

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Abstract: **Development of superior colliculus in Human Fetuses aged from CRL 9.5 cm to 43.5 cm in length showed various stages of development. In fetuses of CRL 9.5 cm TD and APD are 2604 and 1624 micrometers respectively. In fetus CRL 43.5 cm TD and APD 4200 and 2100 micrometers respectively. The cell size is increased on average 4.88 micrometers at CRL 9.5 cm to 8.78 micrometers at CRL 43.5 cm. There has been reduction in the number of cells from (9.5 cm CRL) from 11,880 to 4554 per mm^2 cells. In 43.5 CRL the cell have been reduced in number from 3168 to 1980 per mm^2 cells.**

Keywords: **Superior colliculus, morphogenesis, histogenesis and lamination.**

I. INTRODUCTION

The midbrain develops from mesencephalon. The mesencephalon persists for time as a thin walled tube enclosing a cavity of some size, separated from that of the prosencephalon by a slight constriction and from the rombencephalon by the rhombencephlic isthmus. Histogenesis of optic tectum is not separately described. It is mentioned that it is similar to histogenesis of neural tube and various parts of brain especially the cerebral and cerebellar cortices. The tectum has been described to be a derivative of exclusively of the cells of alar laminae of the mesencephalon. The neuroblasts of alar laminae proliferate and invade the roof plate of mesencephalon which thickens forming the quadrigeminal plate. This plate later is divided into corpora bigemina by a median grove. The corpora bigemina are later subdivided into superior and inferior colliculi by a transverse furrow. Willims P.L. et al., 1999).

Keibel and Mall (1912**):** described that differentiation between ependylmal and mantle layers in mesencephalon is completed in basal plates by about the end of 1st month and is considerably later i.e., about the 3rd month in alar plates. Neuroblast migrate to dorsal surface of midbrain from alar plates. These neuroblasts proliferate and develop into stratified ganglionic masses which together with deeper lying cells form the superior and inferior colliculi.

Keith A (1948): stated that in 3rd month quadrigeminal plate (tectum) develops on the dorsal part of alar laminae.

Arey L.B. (1966): stated that colliculi (superior and inferior) appear in 4th month. Neuroblasts migrate towards the surface of colliculi and there organize into stratified layers. **Patten (1968) described that** there is a recognible proliferation centre of neuroblasts in alar plate region of mesencephalon by 6th week of fertilization age which will take part in the formation of paired superior and inferior colliculi.

According to Hamilton, Mossman and Boyd (1976): tectum is present as a pair of longitudinal elevations separated by a median depression representing corpora bigemina at 3.8 cm CRL and at 8.1 cm stage a transverse depression appears making four elevations. Cells of mantle zone of mesencephalic alar laminae partly migrate into marginal zone, become arranged into stratified layers typical of the adult colliculi. According to Moore and Persaud (1999): neuroblasts migrate from alar plate of mid brain into tectum (roof) and aggregate to form four large groups, the paired superior and inferior colliculi.

II. MATERIAL AND METHODS

The present study has been undertaken on mid brain specimens of 38 fetuses of different age groups starting from 9.5 cm to CRL to 43.5 cm, of these 18 fetuses have been subjected to morphemetry and 20 fetuses have been subjected to histometry. The fetuses were preserved by perfusing 200 ml of 10% formalin through the umbilical vein. In addition 25 ml of 10% formalin was directly injected into cranial cavity through the anterior fontenelle. These were kept in 10% formalin. Brains were taken out by dissection of skull. The tectum in these brains was measured with a divider and then embedded in paraffin. Sections of 3-5 micrometers were stained with H & E and Holme's silver nitrate methods.

III. RESULTS

Morphology:

(1) At CRL 9.5 cm the tectum in divided into corpora bigemina by a vertical sulcus (Fig.1). At CRL-13.4 cm a faint horizontal sulcus appeared dividing corpora bigemina into corpora quadrigemina (Fig.2).

(2) Average volume of superior colliculus is calculated as follows. Transverse Diameter (TD), Vertical Diameter (VD) and Anteroposterior Diameters (APD) were taken

Volume = TD × VD × APD in Cubic Millimetres

The volume is calculated by considering the superior colliculus as a Cube. Hence volume is a rough estimate.

Average volume of superior colliculus had gradually increased with age of fetus.

CRL	-	**volume of Superior colleculi**
11.2 cm	-	24 cubic millimeters
33.5 cm	-	130.99 cubic millimeters
Adult	-	208.49 cubic millimeters

Histological observations:

(1) The Lowest age in our study is CRL 9.5 cm (13 weeks / 18.5 cm). All layers of superior colleculi were formed. Matrix, mantle and marginal layers were observed in neural tube cells were migrating from alar lamina. Marginal layer was observed showing four layers from surface. These layers were (stratum zonale (SZ), stratum cinerium (SC), stratum opticum (SO) and stratum lemnisci. Matrix layer was several cells thick.

(2) There is increase in thickness of each layer of superior colliculus with advancement of age of fetus.

Increase in thickness of layers (micrometers)

CRL	-	TD	-	APD
9.5 cm	-	2604	-	1624
43.5 cm	-	4200	-	2100
Adult	-	6328	-	4200

(3) Migration of cells is observed from CRL 9.5 cm (13 weeks/ 18.5 weeks) (Fig.3). At CRL 24 cm (25 weeks/ 26.8 weeks) migration is reduced. At CRL 29. cm (30 weeks) the migration of cells ceased.

(4) At CRL 20.5 cm (22 weeks/ 24.4 weeks) has few large cells amongst many small cells (Fig.4, Fig.5).

(5) At CRL 24 cm (25 to 26 weeks) cells in SZ were beginning to be oriented parallel to the surface. At CRL 29 cm (30 weeks) most of the cells in SZ were oriented parallel to the surface (Fig.6).

(6) Average largest diameter of cells has increased from SZ to SL in Micrometers

CRL	SZ	SC	SD	SL
9.5 cm	4.28	4.5	5.33	5.6
43.5 cm	6.82	7.78	10.32	10.76
Adult	4.9	9.36	11.02	10.32

(7) Number of cells in each layer is reduced with advancing age of fetus.

CRL	SZ	SC	SO	SL
9.5 cm	11880	6336	8574	4554
43.5 cm	3168	2178	2316	1980
Adult	1980	2178	1980	1980

(8) The matrix layer of neural tube is converted into ependymal layer lining the aquduct of sylvius.

(9) The mantle layer of neural tube is converted into periaquaductal grey matter.

(10) The marginal layer of neural tube in the dorsal part is developed into various layers of superior colliculus.

(11) In adults SO and SL layers have few large neurons amongst many small cells.

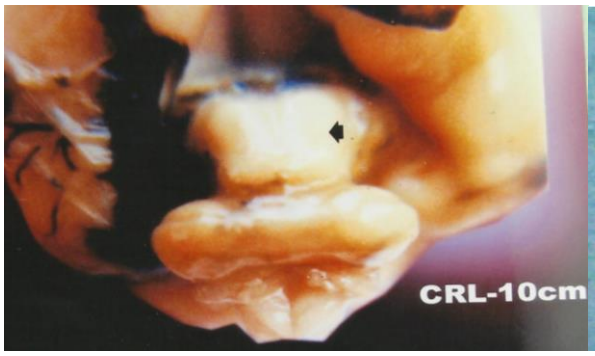

Fig. 1

Fig. 2

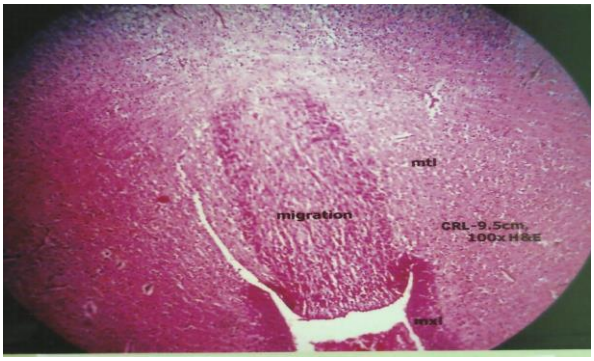

Fig. 3

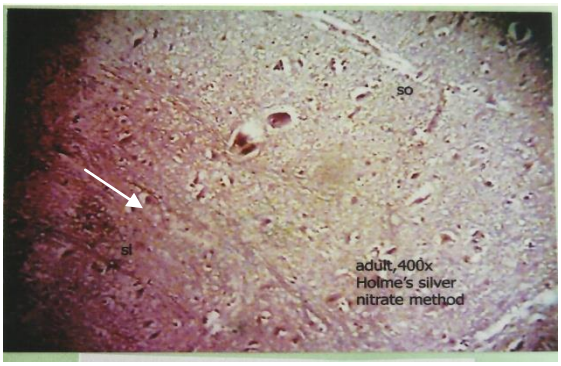

Fig. 4

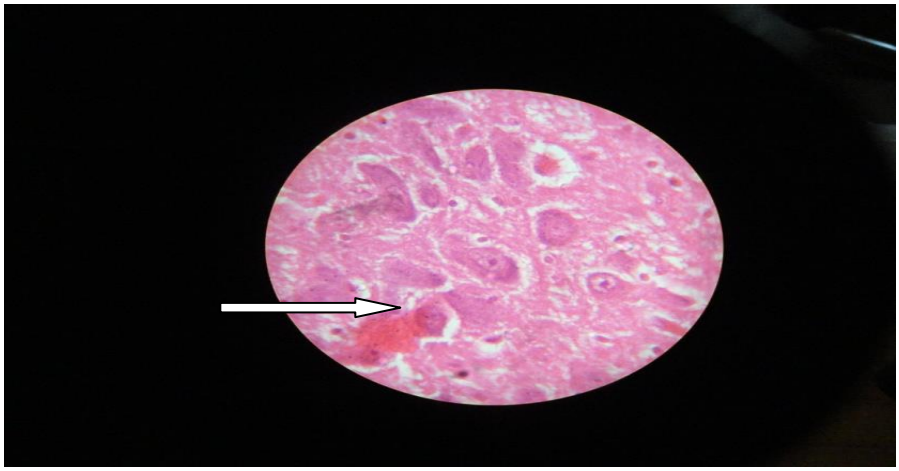

Fig. 5 Oil Immersion

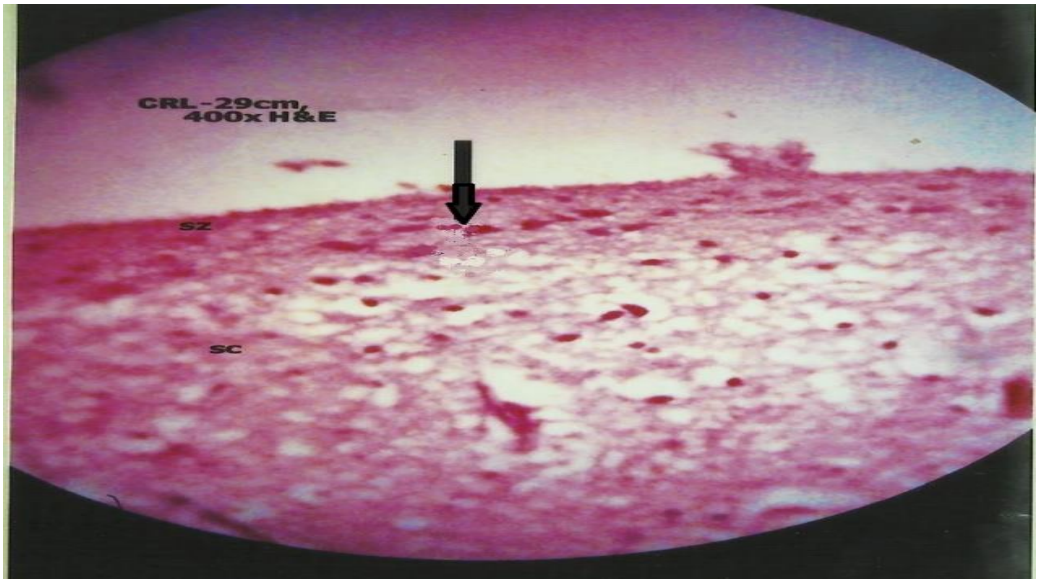

Fig. 6 Cells Parallel to Surface

IV. DISCUSSION AND CONCLUSIONS

The superior colliculi of a 35 cm CRL fetus in the present study is 5.5 mm x 7.0 mm and this size compares with that of aves. It is much more in size than that in reptiles, amphibians and fish. The superior colliculi in man grow very little with age to reach the adult size of 6.6 x 8.1 mm. The difference between colliculi of full term fetus and the superior colliculi in adult brain is only about 1.0 mm. Its size is very close to that of an adult compared to the rest of the brain especially the cerebrum which grows very extensively to attain the adult size. (Dodds, 1946)

In the present study the weight of fetal brain at various stages of fetal development and its percentage to the weight of fetus ranged from 25 gm/ 102 gm.(24.5%) at 9.5 cm CRL to 412 gms./ 3000gms. (13.73%) at 43.5 cm CRL. This percentage is very similar to what has been described by Arey L.B (1966). Arey L.B. has described the fetal CNS weight as percentage of fetal body weight which is 25% at 2 month and 15% at term. In the present study the weight of brain only has been assessed. It excludes the spinal cord.

Morphogenesis:

Morphogenesis may be described as the assumption of form by the whole, or part, of a developing embryo. As a term it is used to denote the movement of cell populations and the changing shape of an embryo particularly during early development. (Williams P L et al. 1999)

The tectum of midbrain has appeared in a fetus of 9.5 cm CRL (13/15.5 wks) as a bilateral longitudinal elevations (Corpora bigemina). The anteroposterior thickness in this fetus is 1.6 mm. From this earliest stage the optic tectum has grown to a maximum size of TD x VD x APD - 5.5 x 7 x 3 9 mm in a 33.5 cm CRL fetus.

The tectum is distinctly present in the brain at quite an early stage i.e., 9.5 cm CRL (13/15.5 wks) as two bilateral swellings. The morphological division of tectum into superior and inferior colliculi by cruciform sulcus has occurred at 13.4 cm CRL (16/18.8 wks). (Fig.14)

Hamilton, Boyd and Mossman (1976) have described the stage of corpora bigemina in 3.8 cm CRL stage (Fig.4) and their division into superior and inferior colliculi in a fetus 8.1 cm CRL and complete division by 19 cm CRL.

Paterson A.M. (1915) has described the formation of corpora bigemina during third months and their division into four colliculi during 5th month. The present findings are more similar to what has been described by Paterson A.M.,(1915). They are at slight variance with the description of Hamilton, Boyd and Mossman (1976).

Histogenesis:

Histogenesis of neural tube in general has been exhaustively studied using various techniques starting with simple histological techniques with light microscope to recent immunohistochemical and computer analysis technique by the earlier workers, Wilhelm His (1890) to recent workers Rakic and Goldman - Rackic (1982). Smart (1982, 1983). attempts have been made to identify the appearance, proliferation and migration of cells of the earliest stage to the development of both neuroblasts, neurons, glioblasts, glial cells and formation of different zones and layers.

The presently accepted view of histogenesis is that the pseudostratified epithelium of the neural tube contains two distinct cell varieties namely Glial Fibrillary Acidic Protein positive and Glial Fibrillary Acidic Protein negative. The positive cells form radial glioblasts, glial cells and ependymal cells. The negative cells form migratory neuroblasts and then neurons of different types.

The present study has demonstrated all the processes namely proliferation, migration, formation of layers, differentiation by increase in cell size, nuclei getting converted from heterochromatic to euchromatic, apoptosis. Some of these processes are clearly identifiable at various stages of development of superior colliculi starting from CRL 9.5 cms to CRL 43.5 cms. Apoptosis could not be clearly identified except for the diminution in the cell population. It has not been possible to clearly identify the neuron cell bodies from those of glial cells.

In the present study 9.5 cms CRL (13 wks / 15 ½ wks) fetus showed all four layers.

There has been increase in thickness of TD and APD. At 9.5 cms CRL (13 wks / 15½ wks) TD and APD are 2604 and 1624 micrometres whereas at 43.5 CRL (38/37.6 wks) they are 4200 and 2100 micrometres respectively.

In a fetus of CRL 24 cm (25 wks/ 26.8 wks) cells in stratum zonale are beginning to be oriented horizontally. In fetus of 29 cms CRL (30 wks), most of the cells in stratum zonale are oriented horizontally. This is in concurrence with the description given by Williams P L et al 1999 who has described that stratum zonale is having few small neurons, arrayed horizontally. (Williams P Let al. 1999)

There is an increase in the diameter of cells from stratum zonale to stratum lemnisci in each age group.

There is gradual increase in the diameter of cells with increasing age of the fetus. This indicates differentiation and maturation.

There is gradual reduction of number of cells from stratum zonate to stratum lemnisci i.e., stratum lemnisci is more mature than stratum zonale.

There is gradual reduction in number of cells as age of fetuses increased. This indicates apoptosis which is a part of differentiation and maturation of cells. This is in concurrence with Williams P L et al 1999.

In a fetus of CRL 20.5 ems (22 wks/ 24 wks) a few large neurons have appeared amongst many small cells in stratum opticum which is in concurrence with Williams P L et al 1999, which states that stratum opticum has some large multipolar neurons.

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