

Research Article

Morphometric analysis of corpus callosum in relation to brain size in fetuses of South Indian population

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ABSTRACT

Background: The corpus callosum (CC) comprises axons connecting the cortices of the two cerebral hemispheres and is the principal white matter fiber bundle in the brain. Morphological characteristics of fetal corpus callosum are of value from embryologic and diagnostic points of view. Knowledge of fetal callosal size is an essential prerequisite for the study of its changes during infancy and childhood.

Methods: The study included twenty four formalin fixed fetuses ranging from 25 to 40 weeks obtained from department of Anatomy, Kasturba Medical College. The measurements taken were; frontal pole to occipital pole, anterior most point to posterior most point of CC, frontal pole of brain to anterior most point of CC, occipital pole of brain to posterior most point of CC, anterior edge of splenium to superior most point of superior colliculus and thickness of body of CC.

Results: Spearman's correlation test was used to determine the correlation between different parameters. A strong positive correlation was found between the length and gestational age ($r=0.69$), between thickness and gestational age ($r=0.4$) and between length and thickness of corpus callosum ($r=0.5$).

Conclusions: Length and thickness of corpus callosum was found to increase proportionally to gestational age but it was not statistically significant. The growth of CC was proportional to the growth of brain. The precise anatomical knowledge regarding the morphology and growth of corpus callosum will provide baseline data for the diagnosis and assessment of progression of a disease affecting it.

Keywords: Corpus callosum, Fetuses, Splenium, Length, Thickness

INTRODUCTION

The corpus callosum (CC) comprises axons connecting the cortices of the two cerebral hemispheres and is the principal white matter fiber bundle in the brain. As recently as the mid-20th century, the CC was thought to serve no other purpose than preventing the two hemispheres from collapsing on one another.¹ CC is the main fiber tract connecting the two cerebral hemispheres.² There is a topographic organization of callosal fibers, which represents the cortical regions to be connected.³ Topographically, fibers connecting frontal

regions travel through the front of CC and those connecting occipital cortices travel through the posterior part of CC. Total corpus callosotomy represent the therapy of choice for patients with intractable epilepsy. Each hemisphere contains neurons which project callosal axons not only to homologous areas in the contralateral hemisphere but also to heterologous areas.⁴

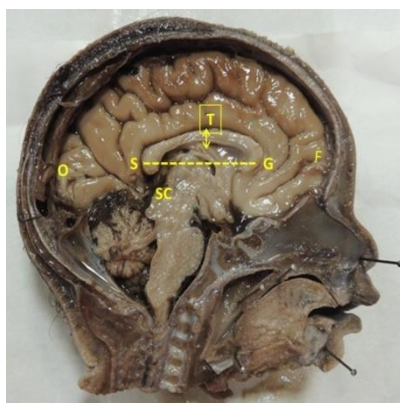
Morphological characteristics of fetal corpus callosum (CC) are of value from embryologic and diagnostic points of view. Knowledge of fetal callosal size is an essential prerequisite for the study of its changes during infancy.⁵

There have been two main theories regarding the progression of callosal development in utero. For many years, the prevalent theory maintained that callosal axons first cross the midline toward the anterior end and callosal development proceeds posteriorly, with the rostrum added last.⁶ Despite its significance, little is known regarding the morphology and the anatomical dimensions of the corpus callosum. Hence, this study was carried out to elucidate the gross anatomical features and development of CC in fetuses of different gestational ages and is compared with the growth of the brain. Understanding this normal growth pattern may enhance detection of subtle growth abnormalities.

METHODS

The study included twenty four formalin fixed fetuses obtained from Department of Anatomy, Kasturba Medical College, Manipal in 2013. The gestational age of the fetuses ranged from 25 to 40 weeks. In present observational study the crown rump length (CRL) was measured, gestational age was computed according to Hamilton et al, 1972.⁷ The brain specimens of fetus with recorded brain pathology were excluded from the study. Only those brains with no visible gross abnormalities were included in the study. Sagittal sections of brain through the septum pellucidum using band saw were taken. Straight distances between the following structures were measured as shown in Figure 1:

1. Frontal pole to occipital pole (F-O).
2. Anterior most point to posterior most point of corpus callosum (Length).
3. Frontal pole of brain to anterior most point of corpus callosum (F-CC).
4. Occipital pole of brain to posterior most point of corpus callosum (O-CC).
5. Anterior edge of splenium to superior most point of superior colliculus (S-SC).
6. Thickness of body was measured by a graduated vernier calliper.



F- Frontal pole, O- Most posterior point of occipital lobe, SC- Superior colliculus, SG- Length of corpus callosum, T- Thickness of body of corpus callosum.

The fetuses were divided into 4 groups as follows. Group 1: 25- 28weeks, group 2: 29- 32 weeks, group 3: 33- 36 weeks and group 4: 37- 40 weeks.

The measurements were tabulated and appropriate statistical tests were applied using SPSS version 16.

RESULTS

Brains of 20 male and 4 female fetuses, ranging from 25 to 40 weeks of gestation, were studied. Mean and standard deviations length and thickness of CC are shown in Table 1. The distance of CC in relation various points of brain were calculated and tabulated in Table 2. Spearman’s correlation test was used to determine the correlation between different parameters. A strong positive correlation was found between the length and gestational age (r=0.69), between thickness and gestational age (r=0.4) and between length and thickness of corpus callosum (r=0.5). The correlation between various parameters and corpus callosum are shown in Table 3. As the number of female fetuses was less, the gender difference was not taken into consideration.

Table 1: Mean and standard deviation of length and thickness of corpus callosum.

Groups (According to GA)	N	Length of CC in cm	Thickness of CC in cm
25 - 28 weeks	8	3.48 ± 0.29	0.2 ± 0.08
29 - 32 weeks	2	4.3 ± 0.14	0.25 ± 0.07
33 - 36 weeks	10	4.36 ± 0.26	0.25 ± 0.07
37 - 40 weeks	4	4.6 ± 0.42	0.3 ± 0.08

Table 2: Mean and standard deviation of distances of CC from frontal pole, occipital pole and superior colliculus in centimetres.

Groups (According to GA)	N	F - O	F - CC	O - CC	S - SC
25 - 28 weeks	8	8.38 ± 0.38	2.08 ± 0.15	2.88 ± 0.13	0.55 ± 0.13
29 - 32 weeks	2	9.38 ± 0.1	2.13 ± 0.04	3.11 ± 0.14	0.51 ± 0.01
33 - 36 weeks	10	9.88 ± 0.34	2.34 ± 0.27	3.26 ± 0.11	0.58 ± 0.13
37 - 40 weeks	4	11.1 ± 1.13	2.65 ± 0.49	3.4 ± 0.28	0.7 ± 0.14

- F - O: Frontal to occipital pole
- F - CC: Frontal pole to corpus callosum
- O - CC: Occipital pole to corpus callosum
- S - CC: Splenium to superior colliculus

Table 3: Spearman's correlation coefficient of various brain parameters measured.

	F - O	F - CC	O - CC	S - SC
Length of CC	0.1	0.1	0.2	0.3 ^x
Thickness of CC	0.3 ^x	0.1	0.4 ^x	0.3 ^x

^x r value with positive correlation.

F - O: Frontal to occipital pole

F - CC: Frontal pole to corpus callosum

O - CC: Occipital pole to corpus callosum

S - CC: Splenium to superior colliculus

DISCUSSION

Corpus callosum being the major structural connection between the hemispheres is likely to be affected by physiological as well as pathological changes in the cortical and sub-cortical regions of the brain. The fiber system that connects the corresponding cerebral hemispheres travels through specific regions of the corpus callosum. Hence, any morphological changes in corpus callosum may give a clue which will help diagnosis of specific pathological condition.⁸

A study done by Koshi et al. showed that the distance between genu and splenium and maximum dorsoventral width of splenium seemed to increase with GA but no statistical significance was found. These results suggest that corpus callosum, particularly its rostral part, is progressively enlarged by addition of commissural fibers through the ages (second half of gestation) investigated. The genu grows faster than body and splenium. No gender differences in the callosal length or widths were found.⁹ In present study the length and thickness of CC increased proportionally to GA but was not statistically significant.

Bishop and Wahlsten (1997) indicated that, on an average, males have larger brains than females and that the average size of their corpus callosum is larger.¹⁰ The findings of a study done by M. P. Padmini & B. N. Rao (2012) showed that the average length of the corpus callosum was 42.55mm in males which was more as compared to females (35.78mm). The thickness of splenium is more in females than males.¹¹ In the present study as the number of female foetuses was less, gender difference was not assessed.

Anagnostopoulou et al., Estruch et al. analysed the growth of CC in foetuses and concluded that there is a positive correlation between the size of brain and respective size of CC.^{12,13} The present study also showed a positive correlation between various brain parameters and CC indicating the growth of CC proportionate to the size of the brain.

The precise anatomical knowledge regarding the morphology and growth of corpus callosum structure in a certain ethnic population will provide baseline data for the diagnosis and assessment of progression of a disease affecting it.

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