Morphometric Assessment of Human Corpus Callosum on Cadaveric Brain Specimens

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ABSTRACT

BACKGROUND
Corpus callosum is the main commissural tract between the two halves of the brain and assumes an essential job in transferring sensory, motor, and cognitive data from identical regions in the two brain hemispheres. Literature on the issue of the human corpus callosum sexual dimorphism is not universal. Similarly, age related change in corpus callosum measurements is also not consistent.

METHODS
Different diameters of brain and corpus callosum like longitudinal and vertical diameters of brain and length, height, widths of corpus callosum etc. were measured with digital vernier caliper.

RESULTS
37 brains were collected, out of which 24 were male & 13 were female brains of various ages between 20 years and 70 years of age. Average longitudinal & vertical diameters of brain specimens under study were 158.29 mm and 102.41 mm respectively and average length of corpus callosum was 72.19 mm. Change in length of corpus callosum in relation to gender is not significant with p value >0.05. There is decrease in length of corpus callosum after 65 years of age.

CONCLUSIONS
Positive linear correlation was observed between length of corpus callosum and the length & vertical diameters of brain. The study has failed to establish statistically significant gender differentiation in the diameters of corpus callosum. Also, there was decrease in the length of corpus callosum (EZ) in 65 years and above age group with decrease in height and width of body as well as splenium of corpus callosum between 50 - 60 years age group.

KEY WORDS
Corpus Callosum, Age, Sexual Dimorphism

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BACKGROUND

Corpus callosum (CC) is the main commissural tract between the two halves of the brain and assumes an essential job in transferring sensory, motor, and cognitive data from identical regions in the two brain hemispheres.[1] Corpus callosum consists of 200-350 million nerve fibers in man.[2] Corpus callosum is viewed as crucial in the assimilation and connection of top level data, for example, the accurate data that is required to recognize an object.[3] Investigators have been interested in size diversity of corpus callosum, as estimated by area, because of the anatomical and functional implication of the corpus callosum. The territory of the corpus callosum is normally estimated at the mid sagittal cut of the brain.[4] Due to the rise in number of callosotomies conducted to treat intraventricular injuries and to cure certain types of generalized epilepsy, the anatomy of the corpus callosum has revived attention in recent years.[5] As corpus callosum connects identical areas of two cerebral hemispheres, thus corpus callosum is an inter-hemispheric fibres. Other commissural fibres are: anterior commissure, posterior commissure, hippocampal commissure and habenular commissure. Corpus callosum is largest of all the commissural fibres and is about 10 cm in length. The parts of corpus callosum from posterior to anterior are splenium, body, genu and rostrum.[6] Report recommended that the size of the posterior sub-areas of the corpus callosum might be diminished in autistic people.[7] Additionally, for autism, expanded mid-sagittal regions are also related with diminished autism symptom intensity, improved intellect, and higher processing speed. These outcomes propose that people with autism advantage practically from expanded corpus callosum region.[8]

As indicated by different investigators, IQ representing a variety of cognitive capabilities and requiring cautious processes has been demonstrated to be impaired by corpus callosum compromise.[9,10,11,12,13] Moreover, according to Tiffany M. Chaim et al,[14] atrophy of corpus callosum occurs in Alzheimer's disease. Literature on the issue of the human corpus callosum's sexual dimorphism is not universal. Some investigations have discovered noteworthy gender differences in the length, shape and regions of the corpus callosum; with females having bigger splenial width than males.[15,16,17,18,19] On the other hand, many researchers reported non-existence of sexual dimorphism in the size and other measurements of corpus callosum. Also, according to various studies, the change in the measurements of corpus callosum with change in age is not consistent.[20,21,22-28] Age changes in particular areas of corpus callosum have been mentioned and this may point out change in inter-hemispheric fiber frameworks. The majority of the studies on morphometry of corpus callosum have been performed on Caucasian population but few studies are documented in Indian population.[29,30] Moreover, studies of corpus callosum measurements are carried more on MRI imaging than on formalin fixed brain.[31]

The present study was conducted using formalin fixed preserved brains to get comprehensive data regarding gender, age related differences and normal range of size of corpus callosum with different measurements of brain in normal adult population in this part of northeast region of India.

METHODS

This is a descriptive study. Brain specimens were obtained from the cadavers given for dissection to the first year undergraduate medical students of Silchar Medical College and Hospital, Silchar and also from the dead bodies subjected to post-mortem examinations in the Department of Forensic Medicine, Silchar Medical College and Hospital, Silchar. The brains were removed from the cranial cavity and were preserved in 10% formalin solutions. The brain specimens from people with intracranial lesions, head injury or recorded brain pathology were excluded from the study. Only those brains with no visible gross abnormalities were included in the study. Brains were sagittaly sectioned from front to back through the septum pellucidum. The study was approved by the Institutional Ethical Committee.

Measurements Recorded Using Digital Sliding Caliper

- Anterior most point of frontal pole to posterior most point of occipital pole (AB) i.e. longitudinal diameter of brain.
- Anterior most point to posterior most point of corpus callosum (EZ) i.e. longitudinal diameter of corpus callosum.
- Anterior most point of frontal pole of brain to anterior most point of corpus callosum (AE).
- Posterior most point of occipital pole of brain to posterior most point of corpus callosum (BZ).
- Lower most point on the inferior surface and upper most point on the superior surface of the brain (CD) i.e. vertical diameter of brain.

For study purposes, corpus callosum length were divided with the method proposed by Witelson,[21] in which corpus callosum has been arbitrarily divided into three regions according to maximal straight length: the anterior third (genu), the mid-third (mid-body) and the posterior third, which is divided into the posterior fifth (splenium).

Measuring Height (H) of Corpus Callosum

- T, highest point on the superior border of corpus callosum.
- R, inferior most point on the rostrum.
- S, inferior most point on the splenium.

A horizontal line was taken through the inferior-most points of rostrum (R) and splenium (S); another line parallel to this was taken through the highest point (T) of corpus callosum; distance between these two lines was recorded as height of corpus callosum.

Recording Widths of Corpus Callosum

- WM, width of body at the midpoint of corpus callosum. Midpoint will be taken at half the longitudinal diameter of corpus callosum.
- WR, maximum width of rostrum of corpus callosum.
- WS, maximum width of splenium of corpus callosum.

Statistical Analysis

Statistical analysis of the data was carried out by using SPSS version 18. For all parameters, mean, standard deviation was calculated for males, females and total subjects studied. Student t- test was used to compare the means of different parameters. For p value, level of significance was taken as 0.05.

RESULTS

37 brains were collected, out of which 24 were male & 13 were female brains of various ages between 20 years to less than 70 years of ages. Average longitudinal & vertical diameters of brain specimens under study were 158.29 mm (standard deviation 11.02) and 102.41 mm (standard deviation 7.88) respectively and average length of corpus callosum was 72.19 mm (standard deviation 5.67). Mean length of genu & body of corpus callosum was 24.07 mm (i.e. EZ/3) and that of splenium was 14.44 mm (i.e. EZ/5). Average height of corpus callosum was 23.34 mm (standard deviation 2.42) and its average width at mid-body was 5.22 mm (standard deviation 0.68). Average width of rostrum and splenium of corpus callosum were 5.71 mm and 8.48 mm respectively. Average length of AE and BZ diameters were 36.06 mm and 60.73 mm respectively. The Pearson's coefficient of correlation between AB & CD, AB & AE, AB & BZ, AB & EZ (figure no.4) were found to be 0.75, 0.78, 0.92 and 0.57 respectively. Again, Pearson's coefficient of correlation between CD &AE, CD & BZ, CD & EZ were 0.73, 0.62 and 0.59 respectively. Also, Pearson's coefficient of correlation between AE & BZ, AE & EZ, BZ & EZ were 0.71, 0.56 and 0.45 respectively. All these correlation values showed that all the brain diameters were positively correlated with each other and also with the length of corpus callosum. Thus, the growth of one diameter was related with growth of another diameter and occurred in coordinated manner, so that the symmetry could be maintained. From the table no. 1, it is evident that gender differentiation for the diameters of brain & length of corpus callosum, is not significant with p value >0.05. Also, gender differentiation for the height & width of corpus callosum, is not significant with p value >0.05. There is decrease in height, width of body & splenium of corpus callosum in between 50 years to less than 60 years of ages (Table. 2).

Para-meters		Male			Female			t	p
		Min (mm)	Max (mm)	Mean ± SD (mm)	Min (mm)	Max (mm)	Mean ± SD (mm)		
Brain	AB	140.48	170.01	159.83 ± 9.17	140.53	178.22	155.46 ± 13.78	1.158	0.255
	CD	88.73	111.83	102.04 ± 6.90	94.05	125.81	103.10 ± 9.71	0.384	0.703
	AE	30.23	44.12	36.35 ± 4.06	30.29	42.74	35.51 ± 5.25	0.541	0.592
	BZ	51.37	65.38	61.61 ± 4.12	50.63	65.22	59.10 ± 5.55	1.562	27
CC	EZ	61.63	78.59	71.80 ± 5.24	61.49	85.51	72.93 ± 6.53	0.572	0.571
	H	17.61	26.04	22.95 ± 2.54	20.81	26.92	23.99 ± 1.68	1.317	0.196
	WM	4.37	6.44	5.24 ± 0.63	4.08	6.51	5.18 ± 0.66	0.272	0.787
	WR	5.11	6.83	5.73 ± 0.51	4.62	6.56	5.69 ± 0.55	0.192	0.849
	WS	6.72	11.61	8.26 ± 1.16	8.13	10.68	8.90 ± 0.69	1.835	0.075

Table 1. Showing Different Statistical Values of Diameters of Brain and Corpus Callosum According to Gender

Age Groups	Parameters of Corpus Callosum			
	H	WM	WR	WS
20 to <30 yrs.	23.06 ± 0.39	4.86 ± 0.04	5.46 ± 1.21	8.49 ± 0.24
30 to <40 yrs.	23.1 ± 0.23	5.29 ± 0.50	5.22 ± 0.68	8.69 ± 0.33
40 to <50 yrs.	23.24 ± 2.29	5.55 ± 0.73	5.82 ± 0.49	8.47 ± 1.29
50 to <60 yrs.	22.79 ± 3.13	4.81 ± 0.48	5.66 ± 0.52	8.03 ± 0.82
60 to <70 yrs.	23.94 ± 2.31	5.26 ± 0.58	5.51 ± 0.22	8.79 ± 1.21

Table 2. Height & Width of Corpus Callosum According to Different Age Groups

Age Groups	Parameters of Brain and Length of Corpus Callosum				
	AB	CD	AE	BZ	EZ
<65 yrs.	158.34 ± 11.07	102.52 ± 8.06	35.85 ± 4.29	60.86 ± 4.73	72.34 ± 5.59
≥65 yrs.	157.94 ± 12.25	101.58 ± 7.19	37.76 ± 6.13	59.63 ± 5.53	70.96 ± 7.00

Table 3. Diameters of Brain & Length of Corpus Callosum According to Age Groups

There is decrease in length of corpus callosum (EZ) in 65+ years of age groups (Table. 3).

DISCUSSION

Corpus callosum has been the focal point of considerable lot of research and discussion, particularly its morphology in connection to age and sex.[31] Anagnostopoulou S et al. published similar study & found positive correlation between lengths of corpus callosum with longitudinal diameter of brain. They also proposed that by applying their analogies & quotes on MRI images, it could be easier to define anterior corpus callosum & perform anterior callosotomy.[32] There is a positive correlation between the size of corpus callosum and the size of brain, a finding which is consistent with the findings of the study of Estruch et al.[33] From the clinical perspective, these findings recommend that corpus callosum can be found in a specific area in brain hemisphere, contingent upon the size itself and that of the brain, a knowledge that is significant in callosotomy operations for epilepsy cases.[34,35] The first research of the corpus callosum in connection to sexual differentiation was by Bean RB, a Philadelphia anatomist, who recommended in 1906 that "exceptional size of the corpus callosum may mean exceptional intellectual activity" and that there were quantifiable contrasts among male and female.[36] In almost all studies on sexual dimorphism, splenium has received more attention than any other part of the corpus callosum. Some studies have reported greater splenial width and area in females.[15,16,17,19] In Bishop and Wahlstein[36] research, based on 19 independent human corpus callosum studies, it was concluded that there is insufficient evidence to support the existence of gender-related variations in the size or shape of splenium, regardless of the disparity in the average brain size of both sexes.

Luders et al[22] additionally recommended that impact of individual varieties in callosal size was enormous enough to out range any impact of splenial size differentiation among men and women. Witelson[21] also did not report any sex related differences in splenial areas, either in absolute size or size proportional to brain weight. Similarly, the Japanese[37] and Indian[29,30] studies also failed to find gender related difference in splenium. Corpus Callosum size changes in relation to aging adults are controversial. Although many studies have concluded that age related corpus callosal thinning is moderate,[20,27] on the other hand, some studies have reported that it is statistically significant.[26,28] Most cross sectional MRI studies of the corpus callosum fail to show age related thinning in adults from 3rd-7th decade.[27] In contrast some studies[26,28] have shown senile effects over 3rd-8th decades. Others[19] have found age related changes in elderly population especially individuals having more than 55 years of age. Several studies[28] found a greater susceptibility to aging in the anterior regions of the corpus callosum than in the posterior regions.

CONCLUSIONS

Positive linear correlation was observed between length of corpus callosum and the length & vertical diameters of brain. The study has failed to establish statistically significant gender

differentiation in the diameters of corpus callosum. Also, there was decrease in the length of corpus callosum (EZ) in 65 years and above age group with decrease in height and width of body as well as splenium of corpus callosum between 50 - 60 years age group.

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