A Digital Photogrammetric Study of the Corpus Callosum Using MRI in Sulaimani Normal Individuals

*Shilan H. Karim** *MSc.*
*Imad G. Qasim*** *FICMS*
*Sameh S. Akkila**** *MSc.*

Abstract

Background: Corpus callosal anatomy and physiology have been the interest of many studies due to the influence of this commissural structure on the performance of the brain in patients with intractable epilepsy undergoing callosotomy. Numerous conflicting studies have been published with respect to variations in the size of the corpus callosum relative to handedness, gender and age.

Aim: This cross sectional study was carried out to examine the morphometric influence of these factors (sex, age and handedness) on the corpus callosum in normal adults.

Subjects and methods: One hundred normal individuals, 36 males and 64 females, divided into 3 age groups were subjected to magnetic resonance imaging study of the brain. Of the 100 subjects, 7 females and 1 male were left handed. The brain magnetic resonance images of all subjects were digitalized using Auto CAD computer software to estimate the statistical correlation and ratio between the surface area of the corpus callosum and the medial surface of the cerebral hemisphere.

Results and Discussion: The results showed no statistical significance of the effect of sex, age or handedness on the surface area of the corpus callosum but there was a statistically significant sexual dimorphism in the medial surface of the cerebral hemisphere, being larger in males. We attributed these results to the fact that cerebral cortical atrophy starts earlier in females while the surface area of the corpus callosum remains normal leading to a relative increase in surface area of the corpus callosum / medial surface of the cerebral hemisphere ratio in females and a proportionally larger medial surface of the cerebral hemisphere area in males. We, however, recommend future studies to include a larger sample size, greater number of left handed subjects and probably other influencing physiological or pathological factors.

Key words: Magnetic resonance imaging, Photogrammetry, Corpus callosum, Handedness.

Introduction

The corpus callosum is the largest commissure of the brain whose fibers provide abundant bidirectional neural connections between most of the respective cortical areas of the two cerebral hemispheres and also serve as a path for storing information in the cortex of one hemisphere to be available for the corresponding cortical areas of the opposite hemisphere [1].

The absolute sizes of many neural structures [e.g. amygdala, cerebellum and thalamus] are usually significantly larger in males but the sexual dimorphism for the corpus callosal size appears to be reversed showing a statistically larger set of relative measures in females [2]. Sexual differences are also reported in the shape of the corpus, the splenium being more bulbous in females but more tubular in males [3].

Age-related thinning of the corpus callosum is a controversial subject. While many studies concluded the change to be modest [4,5], others indicated the presence of a significant thinning of the corpus with increasing age, particularly in women, during the 3rd to the 8th decades that may be contributed to the age-related expansion of the adjacent lateral ventricle[6,7]. The surface area of mid-sagittal sections of the corpus callosum also appeared to decrease with age in females but not in males [3]. Longitudinal dimensions of the corpus, examined by MRI also appear to decrease after the age of 45 years [8].

Handedness, a reflection of the anatomical asymmetry of the human cerebral hemispheres, is probably related to the development and function of the corpus callosum which plays an important role in the interhemispheric communication and cerebral dominance by affecting the interhemispheric exchange of sensory, motor and higher order cerebral functions [9].

Postmortem examination of the mid-sagittal area of the corpus callosum revealed a larger size in left handed individuals [10].

The current study was performed to examine the effect of age, sex and handedness on the corpus callosum morphology in normal adults in Sulaimani City (Northern Iraq) using a new digital technology (digital photogrammetry). Digital photogrammetry is a method of measurement applied to digital images instead of hard copies with the advantage of preserving the research material and allowing repeated measurements to be taken over time with the possibility of adding new parameters to later measurements [11].

Subjects and Methods

The study was carried out in the MRI department of Sulaimani Teaching Hospital with 100 randomly selected healthy adults: 36 males and 64 females. The subjects fell in the age range of 20 to 81 years and were divided into three age groups:

- Group 1 [**G1**]: 53 subjects aged 20-39 years, 15 males and 38 females.
- Group 2 [**G2**]: 34 subjects aged 40-59 years, 22 males and 12 females.
- Group 3 [**G3**]: 13 subjects aged ≥ 60 years, 4 males and 9 females.

On interview and examination, 8 subjects were found to be consistently left-handed: 7 females and 1 male.

Mid-sagittal view of the corpus callosum were obtained from each subject using 0.2 Tesla MGNETOM Siemens machine with T1-weighted echo sequence, 5 mm slice thickness and 213X240 field view. No brain abnormalities were detected on examination of the scans.

The slices were then converted to digital images using Canon D30 8MB Pix digital camera and the images were then examined using AUTOCAD 2009 computer software for the following parameters:

- The surface area of the corpus callosum (**CCA**).
- The surface area of the medial surface of the cerebral hemisphere (**CHA**).
- The ratio of **CCA/CHA**.

Statistical analysis of the data was performed using SPSS 15 for windows. A P-value of <0.05 was considered statistically significant.

Results

Age-related Changes and Sexual Dimorphism

One-way ANOVA test was used to study the statistical significance of changes in CCA, CHA and CCA/CHA ratios among different age groups of male and females. There were no significant differences between any age groups of either sex as shown in table 1.

To study the sexual differences in each age group, Student's t-test was utilized to examine the differences between CCA, CHA and CCA/CHA ratio among the male and female subjects of each group. As shown in table 1, there was a statistically significant difference between the CHA measurements of males and females in the G1 and G2 age groups only. Other measurements (CCA and CCA/CHA ratio) were not statistically different among males and females in any age group. The CHA data also did not show significant difference between males and females in G3 age group.

Table 1: The CCA, CHA and CCA/CHA ratios of different age groups of males and females.

Age Group [years]	CCA [cm^2]		P
	Males	Females	
20-39	7.6±1.5	7.2±1.2	0.3142
40-59	7.2±1.1	6.7±1.1	0.2302
>60	6.8±1.1	6.5±0.8	0.6408
ANOVA	0.404	0.233	---
Age Group [years]	**CHA [cm^2]**		**P**
	Males	**Females**	
20-39	80.4±7.2	74.9±7.4	0.0174*
40-59	80.8±11.1	72.5±6.4	0.0316*
>60	77.1±7.6	71.9±6.5	0.2610
ANOVA	0.594	0.394	---
Age Group [years]	**CCA/CHA ratio**		**P**
	Males	**Females**	
20-39	0.095±0.023	0.096±0.017	0.7889
40-59	0.091±0.019	0.093±0.018	0.7528
≥60	0.089±0.016	0.092±0.015	0.8194
ANOVA	0.789	0.717	---

(Data expressed as Mean ± S.D., P= P-value for t-test, ANOVA= P-value for one way ANOVA test, * is statistically significant).

Handedness related differences

Student t-testing of data of CCA, CHA and CCA/CHA ratios among right handed and left handed subjects regardless of sex and age revealed no statistical differences.

Discussion

The study showed that there was no sexual dimorphism of the corpus callosum at different age groups. Although the mean male CCA areas were insignificantly larger and the mean female CHA areas were significantly larger, the male/female CCA/CHA ratios remained insignificantly different. This may be explained by the fact that cerebral cortical atrophy begins at an earlier time in females (G2) leading to a proportional rise in the CCA/CHA ratio while the CCA remains larger in males causing a proportional decrease in the CCA/CHA ratio.

The net effect is that the CCA/CHA ratio remains constant for all age groups, as the atrophic process affects the cerebral cortex rather than the callosal commissural fibers.

Some studies suggest the presence of sex differences among different parts of the corpus callosum rather than a total area difference [12], others suggest that smaller brains have larger callosal areas and that women have a larger callosum-to-brain volume ratio [13]. So the subject remains controversial.

Although the mean values of CCA, CHA and CCA/CHA ratio decreased with increasing age, but the decrease was not statistically significant. The absence of statistically significant change in callosal size with increasing age is concordant with several studies by Tuncer *et al* and others [14, 15]. Again, age-related thinning of the corpus callosum may be confined to a small area that does not significantly affect the whole CCA or CCA/CHA [16].

The absence of significant differences in the parameters among right and left handed individuals may be attributed to 2 reasons: first; the small size of the left handed subjects relative to the sample size (only 8%) and secondly; handedness is usually associated with neuroanatomical variations in men more than in women [10] (in our study only 1 male was left handed). Handedness related differences that were described in other studies may be related to other factors like race and ethnicity.

We recommend studying this factor on a more appropriate sample size with elimination of other factors of difference (sex, age and ethnicity).

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* *Lecturer, Anatomy Dept., College of Medicine, University of Sulaimani.*

** *Assist. Professor, Dept. Anatomy, Histology and Embryology College of Medicine/ Al-Mustansiriya University*

*** *Assist. Lecturer, Dept. Anatomy, Histology and Embryology, College of Medicine/ Al-Mustansiriya University [samakkila@gmail.com]*