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CEREBRAL ASYMMETRY: A CADAVERIC STUDY

Archana Rani[1], Rakesh Kumar Verma[2], Arvind Kumar Pankaj[2], Rakesh Kumar Diwan[3], Anita Rani[1], Deepshikha Kori[4]

[1]Professor, Department of Anatomy, King George's Medical University, Lucknow-226003, Uttar Pradesh, India; [2]Assistant Professor, Department of Anatomy, King George's Medical University, Lucknow-226003, Uttar Pradesh, India; [3]Associate Professor, Department of Anatomy, King George's Medical University, Lucknow-226003, Uttar Pradesh, India; [4]JuniorResident, Department of Anatomy, King George's Medical University, Lucknow-226003, Uttar Pradesh, India.

ABSTRACT

Objectives: Anatomical brain asymmetries in cadaveric human brains are not well defined in the literature. Therefore, the present study was undertaken to observe the variations in right and left cerebral hemispheres using various parameters.

Methods: Twenty eight adult human brains irrespective of sex were taken for the present study. Various measurements of cerebral hemisphere including fronto-occipital length, cerebral width, Sylvian fissure length and distance between anterior Sylvian point to inferior Rolandic point were taken. These measurements were taken by Vernier calipers. Different configuration of the anterior ascending and anterior horizontal ramus of the Sylvian fissure were also examined as U-shaped, V-shaped and Y-shaped. The presence or absence of triangular sulcus located within pars triangularis was also observed.

Results: The fronto-occipital length was longer on right side while the cerebral width and Sylvian fissure length were more on left side. These values were significant statistically. The configuration of the anterior ascending and anterior horizontal ramus of the Sylvian fissure was V-shaped in maximum number of hemispheres followed by U-shaped. The triangular sulcus was noted in thirty hemispheres i.e. 16 right and 14 left.

Conclusions: Hemispheres of the brain are not identical and functional asymmetries have an underlying anatomical basis.

Key Words: Cerebrum, Morphometry, Sylvian fissure, Triangular sulcus

INTRODUCTION

Anatomical brain asymmetries are understated and still little studied in humans. The Sylvian fissure (SF) has long been shown to be an important indicator of the leftward cerebral asymmetry present in human language reception regions. The language ability and handedness are localized on the left side.

The two human cerebral hemispheres are not simply mirror image of each-other. Brain asymmetry has been observed in animals and humans in terms of structure, function and behavior. The evidence of lateralization was first provided in 1861, by Broca who described a case of expressive aphasia resulting from an infarction of the left posterior inferior frontal lobe, which became to be known as Broca's area. The later discovery of Wernicke's area in the left posterior temporal and inferior parietal lobes also provided unequivocal evidence of another lateralized function and demonstrated an asymmetry for language comprehension as well as for speech production. Association of language impairment with left hemisphere lesions led to the more general concept of a dominant left hemisphere and a minor right hemisphere.[1]

Speech and language are one of the most lateralized of all cerebral functions.[2] Their cortical areas are also some of the most asymmetrical in the brain.[3] These areas are located within pars opercularis and pars triangularis in the frontal lobe. They are bounded anatomically by the anterior horizontal and anterior ascending ramus of the SF. Sylvian fissure is a most commonly used landmark for neurosurgical interventions. The triangular sulcus, also known as the incisura capitis, separates the pars triangularis into an anterior and a posterior part.[4]

The present study was undertaken to note the morphometry, asymmetry and variations of the right and left cerebrum and SF using various parameters.

Corresponding Author:
Dr. Archana Rani, Department of Anatomy, King George's Medical University, Lucknow-226003, Uttar Pradesh, India;
E-mail: archana71gupta@yahoo.co.in

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MATERIAL AND METHODS

28 adult human brains with no gross deformity preserved in formalin irrespective of sexes were obtained from the Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh, India. The various measurements including fronto-occipital (FO) length, cerebral width, Sylvian fissure (SF) length and distance from anterior Sylvian point (ASP) to inferior Rolandic point (IRP) were taken. The sulcus (if present) located within the pars triangularis (PT) and pars opercularis (PO) was also evaluated. Identification of various sulci and gyri was done according to standard anatomy books. Confirmation was further strengthened by consensus of two authors. A tag with a specific number was attached to each specimen to avoid intermingling of brains.

Measurements were done by Vernier calipers. The fronto-occipital length was the maximum distance between the frontal and occipital poles measured from the inferior aspect of cerebrum (Figure 1). On superolateral surface of cerebral hemisphere, the lowermost point of central sulcus (Rolandic sulcus)which intersects with SF was referred as inferior Rolandic point (IRP). Lateral sulcus (Sylvian fissure) length was measured on the superolateral surface from anterior Sylvian point (ASP) i.e. most anterior point of SF where it divides into three rami (anterior horizontal, anterior ascending and posterior) to posterior Sylvian point (PSP) i.e. where the SF separates into ascending and descending posterior ramus (Figure 2). Width of cerebrum was measured by putting the two arms of Vernier calipers at the superomedial and inferolateral borders respectively at the level of IRP in midline. ASP to IRP distance and presence of the triangular sulcus (if present) located within the PT was also evaluated (Figure 3). Various pattern of division at ASP into anterior horizontal ramus (AHR) and anterior ascending ramus (AAR) of the Sylvian fissure as U, V and Y-shaped was also noted and analyzed (Figure 4).

Statistical Analysis was done using Statistical Package for Social Sciences (SPSS), version 15.0. Continuous data was compared using paired 't'-test. Categorical data was compared using chi-square test. A 'p' value less than 0.05 (<0.05) indicated a statistically significant difference.

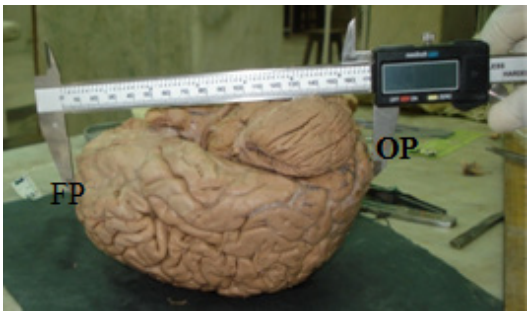

Figure 1: Photograph showing measurement of Fronto-occipital length (FP-Frontal pole, OP-Occipital pole).

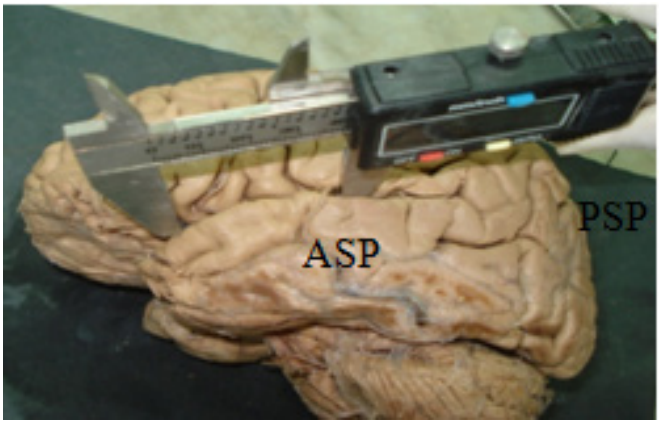

Figure 2: Photograph showing measurement of Sylvian fissure length(ASP-Anterior Sylvian point, PSP-Posterior Sylvian point).

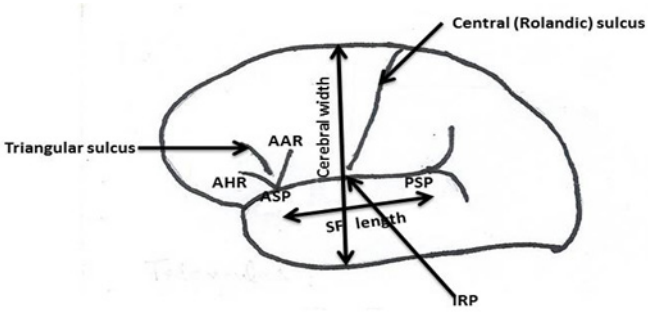

Figure 3: Photograph showing various points on superolateral surface of brain and measurement of different parameters (ASP-Anterior Sylvian point, IRP-Inferior Rolandic point, PSP-Posterior Sylvian point, AHR- Anterior horizontal ramus, AAR-Anterior ascending ramus, SF- Sylvian fissure).

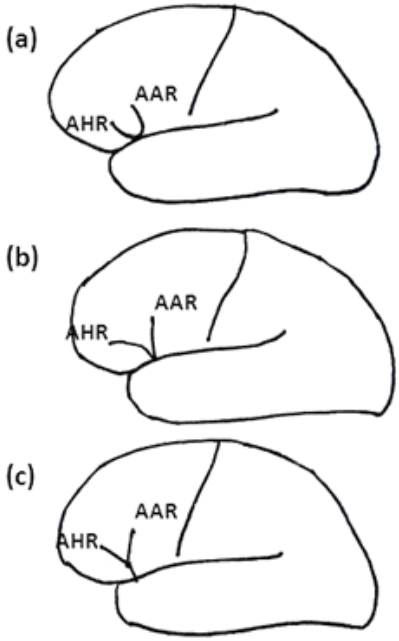

Figure 4: Various configuration of the anterior horizontal ramus (AHR) and anterior ascending ramus (AAR) of the Sylvian fissure as (a) U-shaped, (b) V-shaped and (c) Y-shaped.

RESULTS

Mean fronto-occipital length of right side (19.62 cm) was significantly greater than left side (18.83 cm). Mean cerebral width was significantly greater on left side (13.04 cm) as compared to right side (12.51 cm). Mean Sylvian fissure length of left side (6.43 cm) was more than that of right side (5.64 cm) and was statistically significant. Distance between anterior Sylvian point and inferior Rolandic point was greater on left side (3.36 cm) than right side (3.28 cm) but not significant. Triangular sulcus was present in 30 hemispheres (16 right and 14 left) out of 52 (26 right and 26 left). It was not well appreciated in one brain on right side, one brain on left side and bilaterally in one brain. It was noted more on right side (61.5%) as compared to left (53.8%). Out of 50 hemispheres (25 right and 25 left), V- shaped configuration of anterior ascending and anterior horizontal ramus was present in highest number of hemispheres i.e. 52% on right and 48% on left side followed by U and Y shaped. The various patterns of shapes were not properly demarcated bilaterally in two brains and unilaterally right and unilaterally left in one brain each (Table 1).

DISCUSSION

The gross anatomy and functional layout of the brain are organized asymmetrically, with hemispheric specializations for key aspects of language and motor function. These asymmetries are first observed around 29-31 weeks gestation. Various developmental programmes structure the two hemispheres well into childhood and beyond, leading to lateralized differences in maturational rates, dendritic arborization, metabolism, and functional activation.[5] In humans, inbreeding (Markow & Martin, 1993)[6], poor health conditions, and various neurological disorders, such as schizophrenia, attention deficit disorder, developmental delays in childhood and Down syndrome are positively associated with fluctuating asymmetries.[7-11] Asymmetric areas have been reported to have less interhemispheric connections.[12]

The lateral sulcus (also called Sylvian fissure or lateral fissure) is one of the most prominent structures of the human brain. It begins on the inferior aspect of the cerebral hemisphere and runs laterally to reach the superolateral surface. There it divides into three rami i.e. anterior, ascending and posterior. The anterior and ascending rami are short and run into the frontal lobe while the posterior ramus begins near the temporal pole and runs backwards and slightly upwards. Its posterior most part curves sharply upwards. The sulcus divides both the frontal lobe and parietal lobe above from the temporal lobe below. It is present in both hemispheres of the brain but is longer in the left hemisphere in most people. It is one of the earliest-developing sulci of the human brain. It first appears around the fourteenth gestational week.[13]

Eberstaller (1890) reported that the posterior horizontal ramus of the left lateral fissure was longer than the right in 63% of a large series of adult brains. The difference averaged 0.64 cm.[14] This asymmetry was confirmed by Cunningham (1892) who also pointed out that the right lateral fissure (the posterior horizontal portion) courses posteriorly at a slightly greater upward angle than the left with a mean difference of 4 degrees.[15] Rubens et al. (1976) noted a characteristic pattern of divergence of posterior regions of the lateral fissures in 25 of 36 adult brains. He found that after pursuing similar courses, the right lateral fissure angulated sharply upward into the inferior parietal area while the left one continued posteriorly.[16] Sylvian fissure was significantly longer on the left side as compared to right in our study. In a study done by Boni et al. (2007) on 42 postmortem

Table 1: Comparison of different parameters between right and left cerebral hemispheres

Parameters	Right (n=28)		Left (n=28)		t'	p'
	Mean	SD	Mean	SD		
Fronto-occipital length (cm)	**19.62**	1.92	18.83	1.79	4.191	**<0.001***
Cerebral width (cm)	12.51	1.22	**13.04**	1.52	-3.583	**0.001***
Sylvian fissure length (cm)	5.64	0.99	**6.43**	1.26	-5.147	**<0.001***
ASP-IRP distance (cm)	3.28	0.86	**3.36**	0.94	-0.508	0.616
Presence of Triangular sulcus	**16**/26 (61.5%)		**14**/26 (53.8%)		χ^2=0.315; p=0.575	
Various configuration of AAR / AHR of SF	**Right (n=25)**		**Left (n=25)**			
U-shaped	10 (40%)		7 (28%)		χ^2=2.57; p=0.277	
V-shaped	13 (52%)		12 (48%)			
Y-shaped	2 (8%)		6 (24%)			

p value<0.05* is highly significant

adult brains, the lateral sulcus in the right hemisphere had a median of 65.11 mm and in left hemisphere 79.94 mm (16.6% higher in left hemisphere).[17] The left SF was significantly longer than the right and both were positively correlated in various other studies.[18-20] Ono et al. (1990) detected the absence of anterior ascending rami in 86.66% (13/15) of the right hemispheres and in 93.33% of the (14/15) left hemispheres.[21] In our study and the study conducted on 62 hemispheres by Idowu et al. (2014),[19] the anterior ascending ramus was present in all the hemispheres. The anterior horizontal and anterior ascending rami of the SF had three major configurations. In a study done by Idowu et al. (2014), the U and V-shaped configuration of branching of anterior ascending and anterior horizontal ramus was seen in 70%. According to him, the anterior ascending and anterior horizontal rami of the SF was U-shaped in 37.1% (23/62), V-shaped in 32.3% (20/62) and Y-shaped in 30.65% (19/62) hemispheres.[19] Chakrabarti & Vijayalakshmi (2015) also found the U-shaped configuration in maximum number of specimens.[20] While in the present study, maximum hemispheres 50% (25/50) depicted V-shaped configuration followed by U-shaped 34% (17/50) and Y-shaped 16% (8/50). In six hemispheres, the shape could not be appreciated well. Ayberk et al. (2012) observed Y-shaped configuration in 39.3% (11/28) and 28.6% (8/28) each with V-shaped and U-shaped configuration which is again contradictory to the findings of our study.[22] He noted the triangularis sulcus in 49 hemispheres (79%) i.e. 26 right and 23 left side while we observed it in 30 hemispheres (57.69%) i.e. 16 right and 14 left side. Fronto-occipital length of right side was significantly greater on right side (19.62 cm) than left (18.83 cm) in our study. Cerebral width of left side was significantly greater on left side (13.04 cm) as compared to right (12.51 cm) in the present study. While Idowu et al. (2014) found the mean value of FO length to be similar on both sides and the mean value of cerebral width to be 6.71 cm and 6.99 cm respectively on right and left side.[19] ASP-IRP distance was more on left side but the values was not significant in the present study. This finding is in concordance with the study of Idowu et al. (2014).[19]

Anatomical asymmetries may help to explain the range of human talents, recovery from acquired disorders of language function, certain childhood learning disabilities, and some dementing illnesses of middle life (Galaburda et al., 1978).[23]

The surgeon's knowledge of the structure and a better appreciation of the range of their variation in the human brain, is vital to interpret functional imaging studies and during intraoperative dissection.[24,25]

CONCLUSION

Significant difference in fronto-occipital length, cerebral width and Sylvian fissure length indicates that the two brain hemispheres differ structurally and it can be speculated that some morphological asymmetries could be related to other functional hemispheric specialization. To correlate this anatomical asymmetry with the functional aspects, further studies are required.

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ABBREVIATIONS USED: SF- Sylvian fissure, PO- Pars opercularis, PO- Pars triangularis, FO- Fronto-occipital, ASP- Anterior Sylvian point, PSP- Posterior Sylvian point, IRP- Inferior Rolandic point, SPSS- Statistical Package for Social Sciences, AHR- Anterior horizontal ramus, AAR- Anterior ascending ramus

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