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Digital Subtraction Angiography of Anterior Cerebral Artery Complex in Indian Population at Two Tertiary Super-Specialty Hospitals

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Abstract

Background: Cerebral circulation has different variations in blood supply. Anterior cerebral artery is an important terminal branch of internal carotid artery. It forms the anterior component of circle of Willis along with the anterior communicating artery. The knowledge of anatomical variations in anterior cerebral artery is of considerable help to clinicians. **Objective:** The purpose of the study is to find out common anatomical variations of anterior cerebral artery complex by digital subtraction angiography in Indian population. **Methodology:** This descriptive cross-sectional study was conducted in the Neurointervention department of Max Super-specialty Hospital, New Delhi and Neo Multi-specialty Hospital, Noida, India during July 2016 to December 2016 for a period of six (06) months. Patients admitted in the Neurointervention department for digital subtraction angiography (DSA) were included in this study. Sampling technique was purposive. The angiogram machine was SIEMENS Artis Zee system and framing rate was 4f/sec. Morphology and variations of the anterior cerebral arteries and the anterior communicating artery were studied in 75 patients undergone cerebral DSA. **Results:** Variations were found in 48% (n=36). Variations of the segments in relation with size, course, communications and terminations of the anterior cerebral artery (ACA) were noted. These were divided into different groups like hypoplasia, aplasia, duplication and fenestrations. Hypoplasia/Aplasia of proximal anterior cerebral artery (A1) was 13.3% in right side and 5.3% in left side. Anterior communicating artery (AComA) was found absent in 10.7% and fenestration in 12%. Callosomarginal artery was found absent in 1.3% in right side and 5.3% in left side. In right callosomarginal artery 6.8% had abnormal origin and 4.2% abnormal in left side. Pericallosal artery was present 100% on both sides. **Conclusion:** Variations of anterior cerebral artery complex anatomy is found common in Indian population. Among them hypoplasia/aplasia is most common. *[Journal of National Institute of Neurosciences Bangladesh, 2018;4(1): 12-17]*

Keywords: Anterior cerebral artery complex; variations; hypoplasia; aplasia; fenestration

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Introduction

The cerebral cortex is primarily supplied by the anterior, middle and posterior cerebral arteries. The anterior communicating artery complex consists of two anterior cerebral arteries (ACA), one anterior communicating artery (AComA) and two recurrent arteries of Heubner[1-2]. The anatomy of the anterior cerebral artery (ACA) is variable and the description of the ACA and its branches is complicated. Different authors have described the segments of the ACA differently. It can be divided into proximal or pre-communicating and distal or post-communicating segments[3-4]. The pericallosal artery is distal to the A1 segment and consists of several segments that can be divided according to its relationship with the corpus callosum. The A2 segment (infracallosal section) runs vertically from the AComA to the genu of the corpus callosum. The A3 segment (precallosal part) curves around the genu, and the A4 segment (supracallosal section) usually runs in the callosal sulcus and almost reaches the splenium[5-6].

The A5 segment (cortical branches) varies considerably; for this reason it is difficult to describe a standard arterial pattern. The two basic configurations of the ACA are determined by the presence or absence of the CmA[6-7]. Some authors refer to the A1 segment as the ACA and the artery distal to the AComA as the pericallosal artery[8]. The ACA complex has a strong clinical importance. It is the most common site of intracranial aneurysm. Despite its considerable significance, little is known about the anatomical variations of the ACA complex. Many anomalies such as aplasia, hypoplasia, duplication or fenestration of ACA segments and AComA have been described. Authors used various methods such as digital subtraction angiography (DSA), computed tomography angiography (CTA), magnetic resonance angiography (MRA), cadaveric dissection or intraoperative observations to study the anterior cerebral circulation of brain. However those studies have a number of limitations. Firstly, they are focused on patients with intracranial aneurysms, and not healthy subjects[9]. Secondly, the authors base their conclusions on a relatively small study group, rarely exceeding 100 patients. Thirdly, their observations are often limited to the anomalies of the A1 segment (most commonly associated with AComA aneurysms) regardless of AComA and A2 and other segment anomalies. Complete study of anterior cerebral artery complex is lacking in the population of Indian subcontinent. Digital subtraction angiography is now-a-days becoming popular minimally invasive angiographic study method for cerebral vessels. Most of the pathologies of cerebral vasculature can be explored and treated by Neurointervention methods[10]. The development of Neurointervention is progressively increasing in the field of management of vascular pathologies in brain.

So complete understanding by the help of digital subtraction angiography of ACA complex is very important for the population of Indian subcontinent. The results of such studies would be useful to make plan in neurointerventional procedures and surgical approaches, and would allow avoiding any unexpected anatomical variations during treatment of AComA aneurysms. The aim of this study was to see the common variations of ACA complex configurations by using digital subtraction angiography (DSA).

Methodology

This descriptive cross-sectional study was conducted in the Department of Neurointervention of Max Super-specialty Hospital, New Delhi, India and Neo Multi-specialty Hospital, Noida, Uttar Pradesh, India during July 2016 to December 2016 for a period of six (06) months. Patients admitted in the Neurointervention department for digital subtraction angiography (DSA) were included in this study. Sampling technique was purposive. The angiogram machine was SIEMENS Artis Zee system and framing rate was 4f/sec. Angiograms with gross pathology like arteriovenous malformations (AVM) in anterior circulation were excluded from this study. Anterior part of the circle of Willis was studied. Morphological variations, branching pattern and course of the ACA and AComA were observed. Variations of the size, course, segments, communications and terminations of the anterior cerebral artery complex were noted. These variations were divided into different groups like hypoplasia, aplasia, and duplication of pre-communicating segment of ACA (A1), double AComA, fenestrations, azygos ACA and variation in the A2 segment of ACA in its terminal branches. Origin of callosomarginal artery and the course of pericallosal artery were noted and pictures were drawn in data collection sheet. All collected data were checked, edited and analyzed by using computer based SPSS software version 16.0. Data were presented by frequency distribution and percentage.

Results

A total of 75 patients admitted in the Neurointervention department for digital subtraction angiography (DSA) included in this study. Out of the 75 patients, majority were belonged to over the age 40 years which was

Table 1: Socio-demographic characteristics of the study patients (n=75)

Characteristics		Frequency	Percent
Sex	Male	53	70.7
	Female	22	29.3
Age	≤40	17	22.7
	>40	58	77.3

58(77.3%) cases and 40 or less than 40 years were 17(22.7%) cases. It was observed that 53(70.7%) cases were male and 22(29.3%) cases were female. Male to female ratio was 2.4:1 (Table 1).

Morphologic variations like Aplasia/hypoplasia/ fenestration in A1 or AcomA or absent/abnormal origin of callosomarginal artery were present in 36 (48%) of cases. Variations related with the A1 segment of ACA are agenesis, hypoplasia and duplication. Hypo- plastic/ under-developed A1/Aplastic segment were present in 14 cases. It was seen in 10 (13.3%) on the right and 4 (5.3%) on the left A1 segment Azygos anterior cerebral artery was found in 2 (2.7%) cases. Triple A2 segment was found in 1 (1.3%) case (Table 2).

Table 2: Morphologic variation of A1 segment of ACA on both sides (n=75)

Right A1	**Frequency**	**Percent**
Normal	65	86.7
Hypoplasia/Aplasia	10	13.3
Left A1		
Normal	71	94.7
Hypoplasia/Aplasia	4	5.3

All possible forms of abnormalities of AComA were present in 19 (25.4%) of cases and normal in 56 (74.6%) cases. Fenestration of AcomA was seen in 9 (12%) cases, Hypoplastic/Absent AComA was seen in 8 (10.7%) cases. Other abnormalities like duplication were present 2 (2.7%) cases (Table 3).

Table 3: Morphologic variation of AComA of ACA complexes (n=75)

AComA	**Frequency**	**Percent**
Normal	56	74.6
Fenestration	9	12
Hypoplasia/Aplasia	8	10.7
Others	2	2.7

Callosomarginal artery was absent in 1 (1.3%) in right side and 4 (5.3%) in left side. Out of them 5 (6.8%) in right side and 3 (4.2%) in left side were abnormal in origin. Pericallosal artery was found in all cases on both sides in this study (Table 4A, 4B).

Table 4A: Morphologic variation of origin of Right Callosomarginal artery (n=75)

Right CmA Artery	**Frequency**	**Percent**
Present	74	98.7
Absent	1	1.3
Origin		
Normal	69	93.2
Abnormal	5	6.8

callosomarginal arteries=CmA

Table 4B: Morphologic variation of origin of Left Callosomarginal artery (n=75)

Left CmA Artery	**Frequency**	**Percent**
Present	71	94.7
Absent	4	5.3
Origin		
Normal	68	95.8
Abnormal	3	4.2

callosomarginal arteries=CmA

Discussion

Multiple variations in anatomy of anterior cerebral artery complex like agenesis, hypoplasia, fenestrations resulting in defective circulation has been reported in the different publications[11]. If the artery on one side is narrowed, the vascular insufficiency is compensated by crossing over by opposite side artery, or by giving branches that cross over to the other side. It indicates that the circle of Willis offers a potential shunt in abnormal conditions such as occlusions and spasms. In normal circumstances it is not an equalizer and distributer of blood from different sources[12].

Majority (77.3%) of the study subject was over 40 years of age, and less than 40 years is 22.7%. Among them male were 70.7% and female were 29.3%, and male to female ratio were 2.4:1. Morphological variations like Aplasia/hypoplasia/fenestration in A1 or AcomA or absent/abnormal origin of callosomarginal artery was present in 36(48%) of cases. In Text book of Practical Neuroangiography by Pearse Morris, third edition showed the range of variation between 11.0% to 43.0%[2]. In a cadaveric study Gunnal et al[13] found total variation up to 31.3% cases.

Variations related with the A1 segment of ACA are agenesis, hypoplasia and duplication[14]. Hypoplastic/ under-developed A1/Aplastic segment were present in 14 cases. It was seen in 10(13.3%) on the right and 4(5.3%) on the left A1 segment. In previous cadaveric study by Riggs and Rup[4] showed 7.0% A1 hypoplasia. Pai et al[5] found no hypoplasia or aplasia. But Piganiol et al[6] found 2.1% and Macchi et al[7] found it 0.7%. 3DCTA study showed 10% hypoplasia/apasia in a series[15]. In general, our study shows a higher percentage of variations. Hypoplasia/Aplasia is more common in right side than the left side (13.3% vs 5.3%).

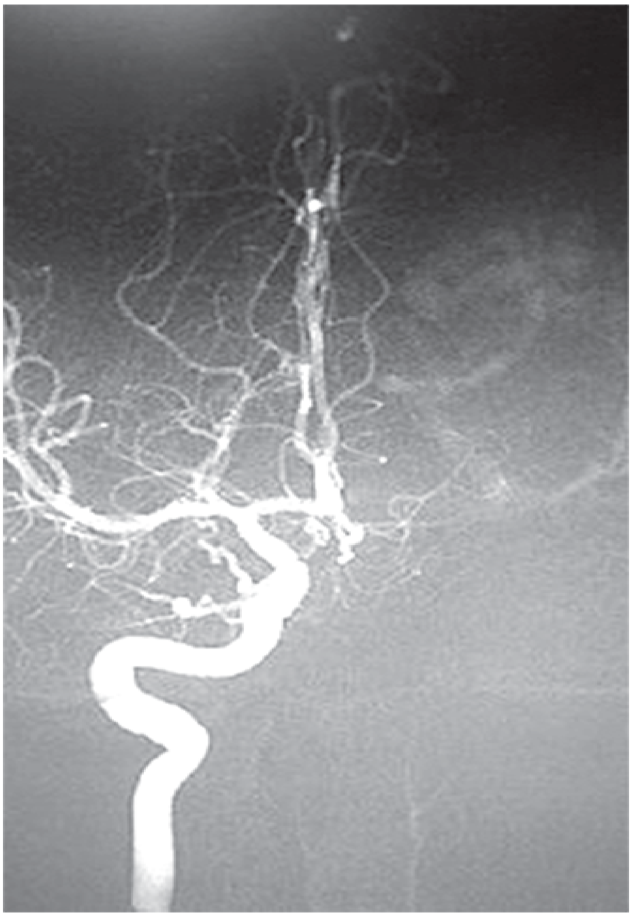

Figure 1: Azygous A2 with left hypoplastic A1

All possible forms of abnormalities of AComA were present in 19(25.4%) of cases and normal in 56(74.6%) cases. Fenestration of AcomA was seen in 9 (12%) cases, Hypoplastic/ Absent AComA was seen in 8(10.7%) cases. Other abnormalities like duplication were present 2(2.7%) cases. Autopsy studies described the frequency of fenestrations in the anterior circulation in up to 64.4%. Investigations that used three-dimensional digital subtraction angiography (DSA) found a greater incidence of fenestrations in the anterior cerebral circulation, which was 27% for aneurysm patients and 22% for patients without aneurysm[15-16]. On the other hand, Sanders et al[16] studying 5,190 cerebral angiograms found only 3 fenestrations in the AComA complex. A study by Boz˙ek et al[3] using CTA described the incidence of AComA complex fenestrations to be 1.75 %. Zhao et al[14], Saidi et al[17] in cadaveric study found fenestration 0,8%, 1.2% and 26% respectively. These findings emphasis the fact that two-dimensional imaging is not a suitable tool for detecting intracranial arterial fenestrations. So, the most common anomaly of the anterior cerebral circulation was fenestrated AComA.

Again Cadaveric studies show a vast range of AComA hypoplasia frequency from 9.15 to 30.0%[12]. In addition, aplastic AComA is a rare autopsy finding, found only in 1.8 % of studied subjects[13-18]. This phenomenon can be explained by the fact that hypoplastic arteries may not be hemodynamically efficient, therefore are not visible in angiographic studies and thus are considered to be aplastic[19,15]. On the other hand, autopsy findings always visualize the artery trunk, even when contrast flow would not be possible. Li et al[8] using CTA found aplastic AComA's in 9.38 % of study subjects. AComA 3D imaging provides the excellent quality data, but unfortunately it is rarely available in everyday clinical practice[20,16]. Pai et al[5] showed 20% aplastic/hypoplastic AComA.

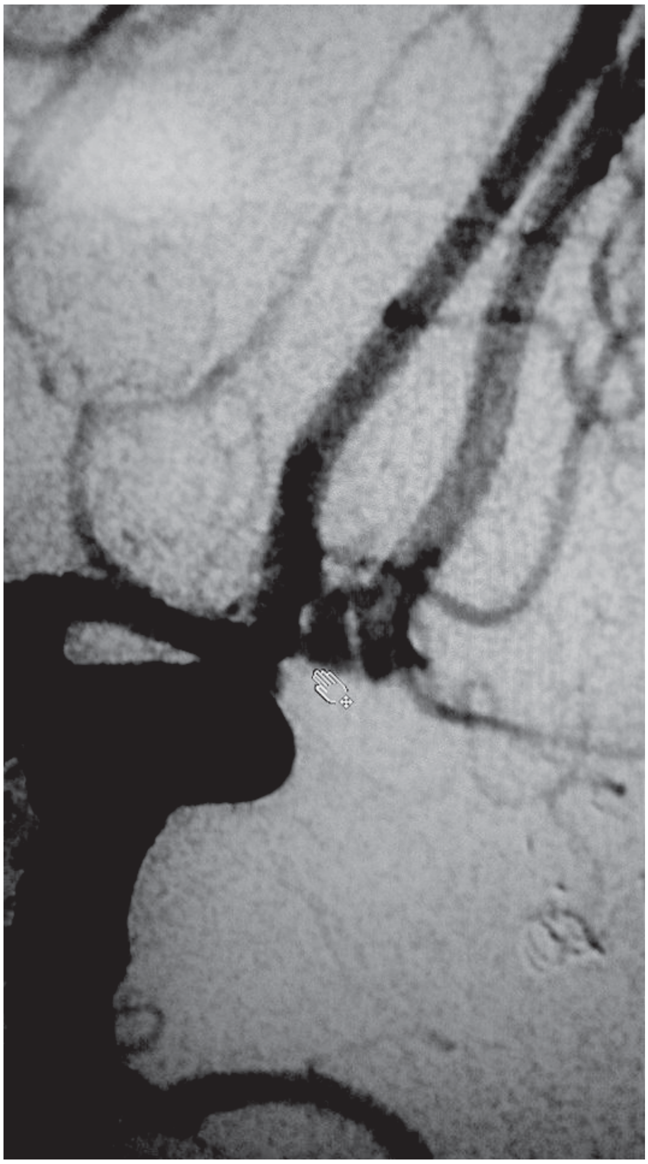

Figure 2: Fenestration of AComA

Azygos anterior cerebral artery was found in 2 (2.7%) cases. In text book Practical Neuroangiography by Pearse Morris showed that incidence of azygos ACA is only 0.3%2. Schik et al[17], Dietrich et al18 and Baptista et al[22] found 1.1%, 0.5-5%, 0-5% and 0.1-5% respectively. But some study like Osborn et al[24] showed this value very high (10%). In this study we found one (1.3%) case of a triple A2 segment. Most authors identify the triple A2 segment as a persistent median artery of corpus callosum, a remnant of embryological cerebral circulation[11]. MRA studies show that the frequency of a triple A2 segment ranges between 0.4 and 3.03%[23-25]. Usually a triple A2 is an incidental finding. Sun et al[16] reported a very interesting case of a triple A2 segment associated with the presence of an aneurysm. We have not found such pathology in our study.

Callosomarginal artery was absent in 1(1.3%) in right side and 4(5.3%) in left side. Out of them 5(6.8%) from right side and 3(4.2%) from left side were abnormal in origin. Callosomarginal artery usually originates at the top of the knee of corpus callosum. But very early origin or late origin are also seen. Abnormal origin may be associated with aneurysm formation. The CmA is also not always present and therefore it is preferable to classify the pericallosal artery as the segment distal to the AComA[25,17]. The CmA has been observed in 40.0% to 93.4% of specimens[21- 29]. The variability of the absence or presence of the CmA is due to the different definitions used for this artery by different authors[26-30]. The CmA is the largest branch of the pericallosal artery that has been defined as the artery that runs near the cingulate sulcus and gives off two or more cortical branches. But this is problematic since there can occasionally be more than one artery that arises from the pericallosal artery, run in the cingulate sulcus and give rise to a number of cortical branches[30]. Ugur et al[30] proposed a new classification system. The CmA was either defined as typical, atypical or absent. An atypical CmA was observed when there was only a very short artery coursing in the cingulate sulcus. Two symmetrical callosomarginal arteries can also be present in the same hemisphere. A typical CmA has a longer course compared to the two symmetrical atypical callosomarginal arteries and usually originates from the A3 segment. Ugur et al[30] observed typical, atypical or absent CmA's in 49.0%, 34.0% and 17.0% respectively.

Conclusion

Anterior cerebral artery complex is a common place for anatomical variations and this has a relation with aneurysm formations. Morphology and variations of the anterior cerebral artery complex were studied in Indian patients who had undergone digital subtraction angiography (DSA). Among them a large number had different forms of variations. Hypoplasia/Aplasia of proximal anterior cerebral artery (A1) was most common anatomical variation and that was most common in right side. Other variations were also present. This study was performed in a small number of subjects. Multicenter studies are necessary to reach a satisfactory conclusion about the complete understanding of anatomy of anterior cerebral artery complex in this population.

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