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# Anatomical Variations in Anterior Cerebral Circulation - Cadaveric Study in Indian Population

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**Abstract:** ***Aim of the Study: To study the microsurgical anatomy and variations of the anterior cerebral circulation and to discuss its implications with respect to anatomical, pathophysiological and neurosurgical perspectives. Introduction: Micro dissection of cadaver is the base on which our knowledge of the human brain is built. Thorough knowledge of the microsurgical anatomy and its variations are mandatory to adopt the best possible techniques and to have good functional outcome. Materials And Methods : This study was conducted with dissection of 60 brains in the autopsy theatre of Coimbatore Medical College. After injecting red colour to the anterior circulation vessels, magnifying loupes and Vernier callipers were used to take measurements. Results: Mean outer diameter of A1 segment was 2.53 mm. Most Right &Left A1 segments had equal length with an average length of 13.7mm. ACom artery measurements revealed a mean diameter of 1.63mm. The mean length of ACom artery was found to be 2.1 mm.In 63% of cases Recurrent artery of Heubner had arisen from A2. Conclusion: Understanding the microvascular anatomy of anterior circulation in cadavers will pave the way for better surgical outcome.***

**Keywords:** Anterior cerebral artery, microvascular anatomy

## 1. Introduction

Microneurosurgery has evolved over the years with the better understanding of the normal and myriads of variation that occur in the miniature structures of the brain. Micro dissection of cadaver specimens is the base on which our knowledge of the intricacies of the human brain is built.

Neurovascular anatomy of the brain is most complex and the variations encountered are as distinct as a finger print. Most neurovascular surgeons in the pre microscopic era, were handicapped with a poor knowledge of the minute vessels that supplied the vital regions of the brain. They were not able to explain the unexpected deficits patient suffered after apparently uneventful surgery.

The advent of microneurosurgery and the knowledge of the tiny perforating vessels and their arrangements along the base of the brain in relation to neurovascular structures has made much awaited changes in the outcome of patients undergoing surgery [1].

Anterior cerebral artery is a complex arterial system and anterior half of Circle of Willis of the brain [2,3].Thorough knowledge of the microsurgical anatomy and the anatomical variations are mandatory for the neurosurgeons to adopt the best possible technique to avoid disaster during surgery and to have good functional outcome in patients.

Various authors have studied, the ACA A1-ACOM-A2 in detail and have explained their variations in other countries [4,5] .No large study of this nature has been done in our population, though few small Indian studies have been done. This study is done to improve the knowledge of the variations in micro surgical anatomy of anterior cerebral artery in our population [6] .

## 2. Materials and Methods

This study was conducted in the autopsy theatre, Department of Forensic medicine, Madras Medical College and Coimbatore Medical College.

A total number of 60 brains were dissected. Brains of head injury patients, intra cranial pathology patients were excluded from the study. The brains of only those who died due to other causes were taken up for study.

Entire dissection was carried out under 4x magnification using Carl Zeiss magnifying loupe.

Standard Vernier calliper with accuracy of 0.2 mm was used for measurements.

Other Instruments used are Toothed forceps, needle, syringe, cannula , poster colour, cotton, scissors, 11 blade knife, curved and straight artery forceps. 5 mega pixel digital camera was used for taking photographs .

## 3. Method of Dissection

During autopsy, after removal of the skull vault carefully, taking care not to damage the dura.The dura in the frontal region was incised and 15 ml of 20% formaldehyde was injected into the subdural space. After 10 minutes dura was opened transversely and the anterior limit of falx cerebri cut. The two frontal lobes were retracted slowly and carefully to expose and cut the optic nerve and ICA entry into the cranial cavity.

Both the cerebral hemispheres are progressively lifted after cutting cranial nerves one by one at their exit. The brain stem and basilar artery were cut at the level of tentorial


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hiatus. The falx cerebri posterior attachment was cut to completely remove both cerebral hemispheres. The entire specimen was soaked in 10% formaldehyde solution for about 10-15 minutes.

Further dissections were done under 4x magnification.

The anterior inter hemispheric fissure was injected with 5 ml saline to ease dissection while opening it. The anterior inter hemispheric fissure was opened by standard micro neurosurgical technique.

ICA was traced to bifurcation, then the ACA, A1-acom-A2 and its branches coursing over the medial surface of frontal lobe, over the corpus callosum and the cortical areas, were carefully dissected.

The ICA at its origin was tied and injected with red poster colour solution to make the vessel prominent and to ease the dissection of perforators.

Length of Right A1 segment and Left A1 segment and Acom Artery were noted. Number of Acom arteries and its course noted.

Diameter of Rt A1, LA1, ACom, Rt A2, Lt A2 noted .Site of origin of Recurrent artery of Heubner noted. Number and location of basal perforators noted. Branching pattern of A2 was noted .

## 4. Results

Diameter of A1 segment of ACA measured just distal to bifurcation revealed an average outer diameter of 2.53 mm for Right A1 and 2.46 for Left A1. The maximum outer diameter was 3.5mm and minimum 1.0 mm for Right A1. For Left it ranges from 1.5 to 3.5 mm. When one side A1 diameter decreases the other side correspondingly increases. Most Right A1 and Left A1 segments had equal length with an average length of 13.7mm.

Right A2 segment of ACA had a maximum outer diameter of 3.5 mm and minimum diameter of 2 mm with an average outer diameter of 2.58 mm. Left A2 segment had a maximum outer diameter of 3.5 mm and minimum diameter of 1 mm with an average outer diameter of 2.39mm.When diameter of A1 increases the diameter of A2 also increases , implying a positive correlation between outer diameters of A1 and A2.

ACom artery measurements revealed a minimum outer diameter of 1mm and maximum of 2.5mm with a mean diameter of 1.63mm. The mean length of ACom artery was found to be 2.1mm.

In a total of 54 cadavers, a single ACom was present accounting to 90% of cases, whereas 5 cadavers (8%) had 2 Acom and 1 case (2%) had 3 ACom arteries.

In 63% of cadavers, recurrent artery of Heubner had arisen from A2, in 24% from ACom junction and in 13% from A1. Also in 62% of cadavers, Heubners artery runs in a superior course to A1.

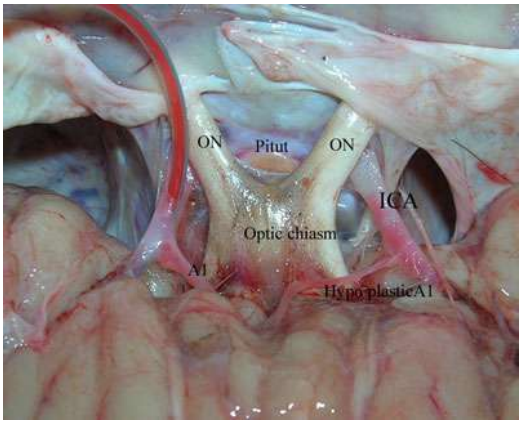



**Figure 1:** Hypoplastic Right A1

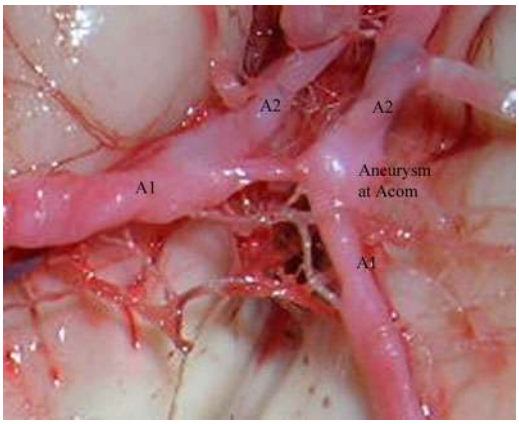



**Figure 2:** Aneurysm at Acom Junction

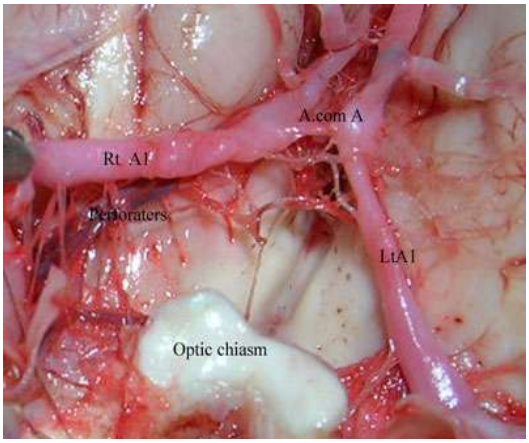



**Figure 3:** Perforator branches of A1

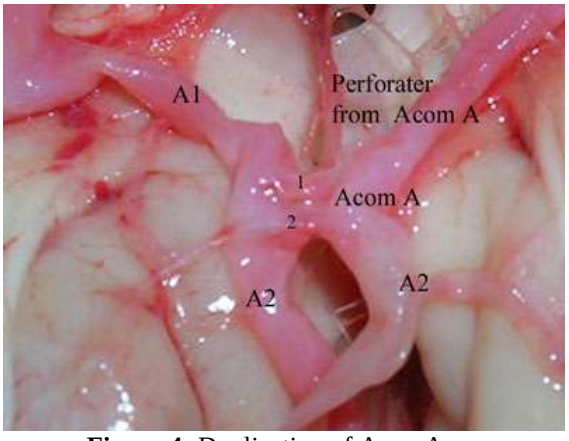



**Figure 4:** Duplication of AcomA


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## 5. Discussion

Most of the A1 -Acom artery junction lies over the optic chiasm[1],when the A1 segment is longer it lies over the optic nerves; when it is shorter, it lies over the optic chiasm.A1 diameter less than 1.5mm is very rare. When it is less than 1.5mm then it is called hypoplastic [Figure 1]. 6.5% of A1 were hypoplastic in our study. Hypoplastic A1 segment is associated with aneurysm at the junction of A1 with Acom artery [7] [Figure 2]. Most of the perforators from A1 arises from the proximal segment of the A1[Figure 3].

The length of A1 was comparatively larger in the present study when compared to the western population. The difference is minimal when compared to the other Indian study(SB Bai et al study)[18]. The outer diameter is almost equal when compared to SB Bai et al study. Duplication of Acom were noted in five cadavers constituting about 8% of our study[Figure 4].The Acom length is slightly short when compared to other studies. The Acom outer diameter is slightly less when compared to SB Bai et al study [Table1].

**Table 1:** Comparison of A1 Outer Diameter, A1 Length, Acom length and diameter (in mm)

| Parameter | Our Study | Perlmutter et al[8] | SB Bai et al[18] | Smitha et al[19] | Sande et al[20] |
|---|---|---|---|---|---|
| Rt A1OD | 2.53 | 2.6 | 2.8 | 2.05 | 2.6 |
| Lt A1 OD | 2.46 | 2.6 | 2.8 | 2.8 | 2.4 |
| Lt A1 Length | 13.7 | 12.7 | 14.6 | 13 | 14.7 |
| ACom Length | 2.1 | 2.6 | 2.45 | 2.3 | 1.8 |
| Acom Diameter | 1.63 | 1.5 | 2.80 | 1.9 | 2.1 |

Most of the recurrent artery of the Heubner arises from A2 segment and also most of them from initial 3 mm of A2. RAH runs in the superior course to A1 in 50% of brain. Recurrent artery of the Heubner arises from lateral aspect of the parent vessel [3]. AComA cross sectional area increases when there is hypoplasia of any one of the H limb [9]. This favours the cross circulation between right and left side. Anterior communicating artery perforators supply the lamina terminalis, hypothalamus, optic chiasm and septal nucleus [10] .Occlusion of this vessels may lead to unconsciousness, memory disturbances and visual deficit. Recurrent artery of Heubner supply anterior limb of the internal capsule, caudate nucleus, lentiform nucleus. Occlusion of this vessel leads to weakness of upper limb and face and emotional disturbances. When compared to MCA, A1 arises at an angle from ICA[11].So the territory supplied by the ACA is likely to suffer from hypotension-more often and earlier than MCA. This effect is compensated by nature to some extent by ACom artery and its duplication as well as by equal total cross sectional area of Rt A1+Lt A1 and Rt A2 + Lt A2 [12,13].

In view of multiple anatomic variations in the A1-ACom-A2 complex region and in view of important perforators supplying the vital structures, detailed angiographic evaluation is mandatory to get the three dimensional vision of A1- ACom- A2 complex and to know the direction of dome of the aneurysm and to know the dominant A1[14] .Cautious inspection for recurrent artery of Heubner is essential because most of the RAH runs through superior course and maybe adherent to the A1 segment [15]. Irrespective of the length of A1, it is not freely mobile as the perforators hamper its mobility. Most of the A1 perforators arises from the proximal segment of A1 ,so temporary clipping may be safely applied on distal A1. If the recurrent artery of Heubner arises from A1 segment ,it is least likely to be damaged during ACom Aneurysmal Surgery[16]. In the transcallosal approach ,the A2 segment variability of position should be considered. But it can be mobilised from either side. It is usually safer to resect gyrus rectus for aneurysm surgery[17].

## 6. Conclusion

The study of microsurgical anatomyof anterior cerebral artery clearly shows the differences between dimensions of A1, Acom and A2 in Indian and western studies.Flow dynamics of the anterior circulation depends on the diameter of bilateral A1 and Acom vessels. Knowledge about the various anomalies will provide crucial information during intraoperative dissection.

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