AN ANATOMICAL STUDY OF THE ANTERIOR COMMUNICATING ARTERY IN SOUTH INDIAN POPULATION

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CERTIFICATE

This is to certify that this dissertation titled **"AN ANATOMICAL STUDY OF THE ANTERIOR COMMUNICATING ARTERY IN SOUTH INDIAN POPULATION"** submitted by **DR. A. PREM PRAKASH** to the faculty of Neuro Surgery, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement in the award of degree of **MASTER OF CHIRURGIE IN NEURO SURGERY,** for the **August 2011** examination is a bonafide research work carried out by him under our direct supervision and guidance.

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DECLARATION

I, **Dr. A. PREM PRAKASH** solemnly declare that this dissertation **"AN ANATOMICAL STUDY OF THE ANTERIOR COMMUNICATING ARTERY IN SOUTH INDIAN POPULATION"** were prepared by me under the guidance of supervision of Professor and HOD, Department of Neurosurgery, Madurai Medical College and Government Rajaji Hospital, Madurai between **2008 and 2011.**

This is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of **MASTER OF CHIRURGIE, in NEURO SURGERY,** degree Examination to be held in **AUGUST 2011.**

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CONTENTS

INTRODUCTION

The Circle of Willis and its branches with their disorders which were once considered most inaccessible and dangerously lethal if manipulated have now become the neurosurgeon's most favorite area of interest after the advent of advanced microsurgery and through understanding of their anatomy and physiology.

More and more research and clinical work in the field of microanatomy, microneurosurgery, endoscopic and endovascular surgery have led us far in the understanding of the behavior of their pathology.

The microanatomical knowledge of the Anterior cerebral-Anterior communication artery complex, their orientation and branches is indispensible for guiding the neurosurgeon in treating the aneurysms and other pathological processes which occur in this area, without causing harm to the vital areas which receive their blood supply from this area.

Anterior communicating artery (ACoA) is the most preferable site for aneurysm formation (31.7%)[3] of all aneurysms, and nearly 91.2% of all anterior cerebral artery aneurysms. Therefore, it is the most studied blood vessel among all the cerebral circulation. Appropriate selection of surgical approach and retraction of adjacent anatomic structures are crucial in creating the clear view during surgical interventions. But the presence of giant aneurysms or hematoma owing to the rupture of aneurysms would blur the surgical view. In such cases, it would be difficult to recognize the surrounding anatomic structures including the blood vessels, thus increasing the risk of damaging the perforators.

These necessitate the knowledge of the microsurgical anatomy of the AComA for young neurosurgeons.

EMBRYOLOGY OF ANTERIOR CIRCULATION OF BRAIN

The third aortic arch forms the common carotid artery and the first part of the internal carotid artery. The remainder of the internal carotid is formed by the cranial portion of the dorsal aorta. The external carotid artery is a sprout of the third aortic arch.[1]

Upon reaching the forebrain the internal carotid artery gives a large branch, the primitive maxillary artery, which passes ventral to the optic stalk and forms the main blood supply to the cranial pole of the brain. The internal carotid then divides into its cranial and caudal rami. The cranial ramus passes forwards, dorsal to the optic stalk, and its first branch is the anterior choroid artery which disappears from view behind the rapidly expanding telencephalic vesicle. It next supplies several branches to the telencephalon, one of which will later enlarge to form the middle cerebral artery, and then gives a recurrent branch which passes ventrally and caudally to join up with the primitive maxillary artery so that the optic stalk is now completely surrounded by a peri-optic arterial ring. The continuation of the cranial ramus is known as the primitive olfactory artery since it is mainly concerned in the supply of the developing nasal region. The ventral portion of the optic ring formed by the primitive maxillary artery and the recurrent branch of the primitive olfactory artery. The proximal part of the anterior cerebral artery is formed from the primitive olfactory artery, its recurrent branch and one of the cranially directed branches of the latter. The remainder of the recurrent branch becomes a chiasmal branch of the anterior cerebral artery.

The AComA will not yet be formed in one embryo of 21–24 mm stage; it is a single large canal in embryos of 21 and 23 mm, and is large, but still rather plexiform of 24 mm[2]. Incomplete fusion of this plexiform anastomosis may lead to a fenestration or a doubling or tripling of the AComA, explaining the high incidence of variations found in the adult brain.[2,16] The most frequent anomalies of the AComA were duplication, triplication and fenestration[13].

MICRO ANATOMY

ANTERIOR CEREBRAL ARTERY

The ACA, the smaller of the two terminal branches of the internal carotid artery, arises at the medial end of the sylvian fissure, lateral to the optic chiasm and below the anterior perforated substance. It courses anteromedially above the optic nerve or chiasm and below the medial olfactory striate to enter the interhemispheric fissure. Near its entrance into the fissure, it is joined to the opposite ACA by the AComA, and ascends in front of the lamina terminalis to pass into the longitudinal fissure between the cerebral hemispheres.

The shorter A1s are stretched tightly over the chiasm; the longer ones travel anteriorly over the optic nerves. The arteries with a more forward course are often tortuous and elongated, with some resting on the tuberculum sellae or planum sphenoidale.[5]

The arteries from each side are typically not side by side as they enter the interhemispheric fissure and ascend in front of the lamina terminalis. Rather, one distal ACA lies in the concavity of the other.

After giving rise to the cortical branches, the ACA continues around the splenium of the corpus callosum as a fine vessel, often tortuous, and terminates in the choroid plexus in the roof of the third ventricle. The posterior extent of the ACA depends on the extent of supply of the PCA and its splenial branches.

Ten percent of the brains have an A1 of 1.5mm or less in diameter and only 2% have an A1 with a diameter of 1.0 mm or less.[5] A1 hypoplasia has a high rate of association with aneurysms; it is found with 85% of AComA aneurysms.[17]

Segments

The ACA is divided at the Anterior communicating artery (AcomA) into two parts, proximal (precommunicating) and distal (post-communicating). The proximal part, extending from the origin to the AComA, constitutes the A1 segment. The distal part is formed by the A2 (infracallosal), A3 (precallosal), A4 (supracallosal), and A5 (posterocallosal) segments. The relationships of the four distal segments are reviewed below.

A1 Segment and the Anterior Communicating Arteries:

The A1 courses above the optic chiasm or nerves to join the AComA. The junction of the AComA with the right and left A1 is usually above the chiasm (70% of brains) rather than above the optic nerves (30%). Of those passing above the optic nerves, most journey above the nerve near the chiasm rather than distally [5]. The shorter A1s are stretched tightly over the chiasm; the longer ones travel anteriorly over the optic nerves. The arteries with a more forward course are often tortuous and elongated, with some resting on the tuberculum sellae or planum sphenoidale. The A1 varies in length from 7.2 to 18.0 mm (average, 12.7 mm) [5].

Recurrent Artery of Heubner:

The recurrent branch of the ACA, first described by Heubner in 1874, is unique among arteries in that it doubles back on its parent ACA and passes above the carotid bifurcation and MCA into the medial part of the sylvian fissure before entering the anterior perforated substance.

In its journey to the anterior perforated substance, it is often closely applied to the superior or posterior aspect of the A1. It may seem, falsely, to be issuing from the A1 until further dissection clarifies its site of origin at the level of the AComA. The recurrent arteries arising proximally on the A1 follow a more direct path to the anterior perforated substance than those arising distally.

The recurrent branch is the largest artery arising from the A1 or the proximal 0.5 mm of the A2 in the majority of hemispheres. It originated from the A2 in 78%, from the A1 in 14%, and at the A1–A2 junction at the level of the AComA in 8%. In 52%, it arose within 2 mm of the AComA, in 80% within 3 mm, and in 95% within 4 mm. It may infrequently be absent on one side or arise as several branches.

If there were two or more recurrent arteries, both or at least one arose at the level of the junction of the A1 and A2. Rarely does more than a single recurrent artery arise from the A1. If there are two recurrent arteries and one arises on the A1, the second usually arises at the junction of the A1 and A2.

The recurrent artery diameter is usually less the half that of the A1, but it may infrequently be as large as or exceed the A1 diameter if the A1 is hypoplastic.

The recurrent arteries arising near the AComA usually arise from the lateral side of the junction of the A1 and A2 at a right angle to the parent vessel. They may originate either in common with or give rise to the frontopolar artery.

Most recurrent arteries course anterior to the A1 and are seen on elevating the frontal lobe before visualizing the A1.

It courses above the internal carotid bifurcation and the proximal middle cerebral artery in its lateral course.

The recurrent artery may enter the anterior perforated substance as a single stem or divide into many branches (average, four). Of the total branches, approximately 40% terminate in the anterior perforated substance medial to the origin of the ACA, and 40% terminate lateral to the ACA origin. The remaining branches pass to the inferior surface of the frontal lobe adjacent the anterior perforated substance. The recurrent artery supplies the anterior part of the caudate nucleus, anterior third of the putamen, anterior part of the outer segment of the globus pallidus, anteroinferior portion of the anterior limb of the internal capsule, and the uncinate fasciculus and less commonly, the anterior hypothalamus.[5]

Basal Perforating Branches

The A1 and A2 and the AComA give rise to numerous basal perforating arteries. An average of 8 basal perforators (range, 2–15), exclusive of Heubner’s artery, arise from each A1.[26, 27] The lateral half of A1 is a richer source of branches than the medial half. The A1 branches terminate in descending order of frequency, in the anterior perforated substance, the dorsal surface of the optic chiasm or the supra-chiasmatic portion of the hypothalamus, the optic tract, dorsal surface of the optic nerve, and the sylvian fissure between the cerebral hemispheres and the lower surface of the frontal lobe.

Approximately 40% of both A1 branches terminate in the anterior perforated substance medial to the A1 origin, but almost no Heubner’s branches enter the area around the optic chiasm and tract, although 40% of those from A1 terminated there. Approximately 40% of the recurrent artery branches enter the anterior perforated substance lateral to the carotid bifurcation.

The A1, excluding the recurrent artery, most consistently supplies the chiasm and anterior third ventricle and hypothalamic area, but only inconsistently supplies the caudate and globus pallidus.

Heubner’s artery, by contrast, provides a rich supply to the caudate and adjacent internal capsule, but much less to the hypothalamus than the A1.

Involvement of the hypothalamic branches that arise mainly from A1, without implication of the recurrent artery, may result in emotional changes, personality disorders, and intellectual deficits, including anxiety and fear, weak spells, and symptoms referable to disordered mentation, such as dizziness, agitation, and hypokinesis without paralysis or alterations of the conscious or waking state.

The frequent inclusion of recurrent artery ischemia when the A1 branches are involved adds a hemiparesis with brachial predominance to the deficit. This contrasts with the crural weakness of distal ACA occlusion.

The A2 is also the site of origin of perforating branches terminating in the inferior frontal area, anterior perforated substance, dorsal optic chiasm,and the suprachiasmatic area.

Distal Part

The distal or postcommunicating part of the ACA begins at the AComA and extends around the corpus callosum to its termination. The distal ACA is divided into four segments (A2 through A5). The A2 (infracallosal)segment begins at the AComA, passes anterior to the lamina terminalis, and terminates at the junction of the rostrum and genu of the corpus callosum. The A3 (precallosal) segment extends around the genu of the corpus callosum and terminates where the artery turns sharply posterior above the genu.

The A4 (supracallosal) and A5 (postcallosal) segments are located above the corpus callosum and are separated into an anterior (A4) and posterior (A5) portion by a point bisected in the lateral view close behind the coronal suture.

The Pericallosal Artery: (The Distal ACA)

The pericallosal artery is the portion of the ACA distal to the AComA around and on or near the corpus callosum.

The Callosomarginal Artery

The callosomarginal artery, the largest branch of the pericallosal artery, is defined as the artery that courses in or near the cingulate sulcus and gives rise to two or more major cortical branches.

The calloso-marginal artery is present in 80% of hemispheres. Portions of the premotor, motor, and sensory areas are included in its area of perfusion.

The size of the pericallosal artery distal to the callosomarginal origin varies inversely with the size of the callosomarginal artery.

The anterior portion of the falx cerebri is consistently narrower than its posterior part, with the free margin of its anterior portion lying well above the genu of the corpus callosum, whereas the free margin of its posterior portion is more closely applied to the splenium.

Distal ACA Branches

The distal ACA gives origin to two types of branches:

1) Basal perforating branches to basal structures including the optic chiasm, suprachiasmatic area, lamina terminalis, and anterior hypothalamus, structures located below the rostrum of the corpus callosum

2) Cerebral branches divided into cortical branches to the cortex and adjacent white matter and subcortical branches to the deep white and gray matter and the corpus callosum.

Basal Perforating Branches

The A2 segment typically gives rise to 4 or 5 (range, 0–10) basal perforating branches that supply the anterior hypothalamus, septum pellucidum, medial portion of the anterior commissure, pillars of the fornix, and anteroinferior part of the striatum. They commonly take a direct course from the A2 segment to the anterior diencephalon.

Cortical Branches

The cortical branches supply the cortex and adjacent white matter of the medial surface from the frontal pole to the parietal lobe where they intermingle with branches of the PCA.

On the basal surface, the ACA supplies the medial part of the orbital gyri, the gyrus rectus, and the olfactory bulb and tract. On the lateral surface, the ACA supplies the area of the superior frontal gyrus and the superior parts of the precentral, central, and postcentral gyri.

The distal ACA on one side sends branches to the contralateral hemisphere in nearly two-thirds of brains.

Eight cortical branches are typically encountered. They are orbitofrontal, frontopolar, internal frontal, paracentral, and the parietal arteries; the internal frontal group is divided into the anterior, middle, and posterior frontal arteries, and the parietal group is divided into superior and inferior parietal arteries. The smallest cortical branch is the orbitofrontal artery, and the largest is the posterior internal frontal artery. The most frequent ACA segment of origin of the cortical branches is as follows: orbitofrontal and frontopolar arteries, A2; the anterior and middle internal frontal and callosomarginal arteries, A3; the paracentral artery, A4; and the superior and inferior parietal arteries, A5.

1. Orbitofrontal Artery

This artery, the first cortical branch of the distal ACA, is present in nearly all hemispheres. It commonly arises from the A2, but may also arise as a common trunk with the frontopolar artery. It supplies the gyrus rectus, olfactory bulb, and tract, and the medial part of the orbital surface of the frontal lobe.

2. Frontopolar Artery

The next cortical branch, the frontopolar artery, arises from the A2 segment of the pericallosal artery in 90% of hemispheres and from the callosomarginal artery in 10%. It supplies the frontal pole.

3. Internal Frontal Arteries

The internal frontal arteries supply the medial and lateral surfaces of the superior frontal gyrus as far posteriorly as the paracentral lobule. They most commonly arise from the A3 segment of the pericallosal artery or from the callosomarginal artery. The anterior internal frontal artery usually arises as a separate branch of the A2 or A3, but may also arise from the callosomarginal artery; it supplies the anterior portion of the superior frontal gyrus. The middle internal frontal artery arises with nearly equal frequency from the pericallosal and the callosomarginal arteries. It supplies the middle portion of the medial and lateral surfaces of the superior frontal gyrus. It is the cortical branch that arises most frequently from the callosomarginal artery. The posterior internal frontal artery arises with nearly equal frequency from the A3 and A4 and the callosomarginal artery. It supplies the posterior third of the superior frontal gyrus and part of the cingulate gyrus. Its branches frequently reach the anterior portion of the paracentral lobule.

4. Paracentral Artery

This branch usually arises from the A4 or the callosomarginal artery approximately midway between the genu and splenium of the corpus callosum. It supplies a portion of the premotor, motor, and somatic sensory areas.

5. Parietal Arteries

The parietal arteries, named the superior and inferior parietal arteries, supply the ACA distribution posterior to the paracentral lobule. The superior parietal artery arises from the A4 or A5 and from the callosomarginal artery and supplies the superior portion of the precuneus.

The inferior parietal artery

It most commonly arises from the A5 just before the latter courses around the splenium of the corpus callosum and supplies the posteroinferior part of the precuneus and adjacent portions of the cuneus. It is the least frequent cortical branch of the ACA (64% of hemispheres).

Callosal Branches

The ACA is the principal artery supplying the corpus callosum. The pericallosal artery sends branches into the rostrum, genu, body, and splenium and often passes inferiorly around the splenium. The terminal pericallosal branches are joined posteriorly by the splenial branches of the PCA.

The Described variations in ACA – AcomA complex:

A normal ACA-AComA complex is one in which an AComA connects A1s of nearly equal size, and both A1s and the AComA are of sufficient size to allow circulation between the two carotid arteries and through the anterior circle of Willis. [5]

Variations in Diameter:

The AComA diameter averages approximately 1 mm less than the average diameter of the A1. The AComA diameters are the same or larger than their smaller A1 in only 25% of the brains. Ten percent of the brains have an A1 of 1.5mm or less in diameter and only 2% have an A1 with a diameter of 1.0 mm or less. The diameter of the AcomA was 1.5 mm or smaller in 44% of brains and 1.0 mm or smaller in 16%.The A1 is the favorite site on the circle of Willis for hypoplasia. A1 hypoplasia has a high rate of association with aneurysms; it is found with 85% of AComA aneurysms. It is the only anatomic variant that correlates with the location of cerebral aneurysm. [5]

There is a direct correlation between the difference in size of the right and left A1s and the size of the AComA. As the difference in diameter between the A1s increases, so does the size of the

AComA. A difference in diameter of 0.5 mm or more between the right and left A1 is found in half of the brains and a difference of 1mm or more in 12%. The average AComA diameter is 1.2 mm in the group of brains in which the difference in diameter between the right and left A1s is 0.5 mm or less and 2.5 mm if the difference is more than 0.5 mm.[11]

Variations in Length:

The length of the AComA is usually between 2 and 3 mm, but may vary from 0.3 to 7.0 mm. The longer AComAs are commonly curved, kinked, or tortuous.[5]

Variations in Orientation:

Another difficulty in angiographically defining the AComA is that it is frequently not oriented in a strictly transverse plane. The length of the AComA is oriented in an oblique or straight anterior-posterior plane if one ACA passes between the hemispheres behind the other ACA. The ACAs are side by side as they pass between the cerebral hemispheres in approximately one in five hemispheres, and the left is anterior to the right more often than the right is anterior to the left. These variations may explain why angiography in the oblique position is often needed to define the AComA. The

AComA usually has a round appearance, but it may seem flat because of a broad connection with both ACAs, or even triangular with a large base on one ACA and a threadlike connection on the other. [5]

Variations in Number:

One AComA was present in 60%, two in 30%, and three in 10% of the brains we examined. Double AComAs can take a variety of forms; one is simply a hole in the middle of a broad or triangular artery separating arteries. It is rare to find no connection between the two sides, but in some cases, the connection may be tiny as small as 0.2 mm in diameter. [5,6]

An infrequent finding is duplication of a portion of the A1. Another infrequent anomaly consists of a third or median ACA arising from the AComA. The median artery courses upward and backward above the corpus callosum.

Variations in Morphology :

The variation of the structure of AComA was initially classified in 1977 into 13 types according to Ozaki et al.[6] They are single, one point fusion, two point fusion, long fusion, N shaped, H shaped, Y shaped, V shaped, plexiform, triple, presence of the median ACA, fenestrations and aneurysms.

Fenestration is the partial duplication of the artery, whereas parallel extension of the similar artery is termed as duplication.[14]

Branches of the AComA and variations:

The AComA frequently gives rise to perforating arteries that terminate in the superior surface of the optic chiasm and above the chiasm in the anterior hypothalamus. The AComA is frequently the site of origin of one or two, but as many as four branches that terminate, in descending order of frequency, in the suprachiasmatic area(51%), dorsal surface of the optic chiasm (21%), anterior perforated substance(15%), and frontal lobe(5%) ,and perfuse the fornix, corpus callosum, septal region, and anterior cingulum(8%) [5]

In order of greatest frequency, the anterior communicating perforating branches arose from the superior (54%),posterior (36%),anterior(7%) and inferior(3%) aspects of the artery.[5]

Further details regarding the variations of the ACA-AComA complex have been listed in the review section.

Development of ACA-ACOM Complex surgical approaches:

Bifrontal and Interhemispheric Approach:

The first surgical approach to an ACOM artery aneurysm was bifrontal and was performed by Tonnis[30] in 1936. His high craniotomy required the removal of the genu of the corpus callosum to reach the ACom complex. Pool[31] subsequently reported a low bifrontal approach with closure of the violated frontal sinus using a vascularized pericranial flap. French et al.[32] advocated a right unilateral frontal craniotomy with a wedge resection of the mesialfrontal lobe. Suzuki et al [33] reported their experience in treating 603 ACom aneurysms through bifrontal craniotomy. They used a very low frontal craniotomy and meticulously dissected the olfactory tracts from the undersurface of the frontal lobes to preserve olfaction. Yasui et al [34] advocated a basal opening of the interhemispheric fissure, which afforded early access to the A1 segments. The interhemispheric approach has had considerable development and application in Japan.

Pterional Approach:

Walter Dandy [35] performed a lateral subfrontal approach to ACom artery aneurysms via an osteoplastic frontotemporal craniotomy. The modern frontosphenotemporal or pterional craniotomy was described by Yasargil and Fox.[36] Professor Yasargil [37] revolutionized aneurysm surgery with his perfection of the pterional approach (the frontosphenotemporal approach), use of the operating microscope, opening of the sylvian fissure and other basal cisterns, and many other nuances.

Although the ACom complex is located in the interhemispheric fissure and is somewhat distal from the cranial entry site, wide opening of the cisterns and removal of a small area of the gyrus rectus allowed optimal exposure of the ACom complex in most cases. He also emphasized the preservation of small arteries that could be seen better through the microscope, the use of bipolar cautery to shrink aneurysms, and the performance of operations with no brain retraction, and he helped to develop a new generation of aneurysm clips. Many technical improvements developed by him for aneurysm surgery are in popular use today. The resection of the gyrus rectus to expose the ACom area was first reported by Kempe and VanderArk [38].

Keyhole Approach:

Another development in aneurysm surgery was the “keyhole approach,” with the idea that a smaller craniotomy may lead to less morbidity. Brock and Dietz[39] described a small frontolateral approach, also used by Hernesniemi et al.[40] An eyebrow incision with a small supraorbital craniotomy was reported by a number of neuro-surgeons.

Endoscopic-assisted Surgery:

The use of neuroendoscopy may greatly aid in the surgery of intracranial aneurysms, primarily when used as an adjunct to microsurgery. The endoscope allows visualization of all areas of the aneurysm neck before, during, and after clipping, and may also enable the surgeon to use a smaller craniotomy. This concept was developed initially by Perneczky and Boecher-Schwarz [41] and was elaborated on by Kalavakonda et al.[42], Kato et al. [43], and many other authors. Aneurysm clipping through a transnasal endoscopic approach has been reported, but the safety and general adaptability of this technique require additional study.

Considerations for side selection in pterional approach in A.Com aneurysm surgery:

Approaching anterior communicating artery aneurysms from the right has been recommended[3,36], because most neurosurgeons are right-handed, and the right hemisphere of the brain is believed to be not dominant.

The side of the dominant anterior cerebral artery, the direction of projection of fundus of the aneurysm(anterior superior, anterior dorsal or a posterior inferior), the open or a closed configuration of the A2s (i.e.ipsilateral A2 posterior or contralateral A2 posterior) mainly in a superiorly projecting aneurysm.

Basic steps of A.com artery aneurysm surgery by Yasargil:

1) Frontotemporosphenoidal craniotomy (Appropriate side).
2) Opening the Sylvian, carotid, and interpeduncular cisterns.
3) Opening the lamina terminalis cistern and control of the right A, segment.
4) Dissection of the lamina terminalis cistern over the contralateral AI segment to the left ICA.
5) Ipsilateral partial gyrus rectus resection.

6) Identification of the A2 segments and branches (there may be true or false A2).

7) Identification of the recurrent arteries of Heubner.

8) Dissection of the fronto-orbital and frontopolar arteries from the aneurysm.

9) Identification of the hypothalamic arteries.

10) Bipolar coagulation of the bulging parts of the aneurysm, or of the neck of the aneurysm.

11) Clip application to the properly prepared neck of the aneurysm.

12) Fundus resection.

13) Coagulation of the cut edges of the aneurysm distal to the clip, removal of the clip, coagulation of the entire base of the aneurysm, especially the inferiorly bulging parts of it.

14) Final clip application, after checking the position of hypothalamic arteries.

15) Check for adequacy of clip placement.

16) Papaverine and sympathectomy.

17) Hemostasis and closure.

REVIEW OF LITERATURE

The ACA- AcomA complex has become the area of interest for many neurosurgeons worldwide and a wide array of studies and reports on this part of the complex is available in literature. Variations in the Structure of AComA have been mentioned as follows:

Other than the "classical" single AComA ,structural variations are grouped as Anomalous AComA's.

Adapting the classification by Ozaki et al [6] in 1977 which has 13 types of structural variations in AComA many other studies have quoted their incidences as follows:

Reddy et al 1972[12] reported absence of AComA in 0.6% and various letter shaped AComA in 7% of 70 autopsies in India.

In 1977 Ozaki et al[6] had discovered single artery in 39.7%, 17.6% fused variety, letter shaped in 18.8% and 2.7% aneurysms in148 Japanese heads he examined.

Fujimoto and Tanaka et al [8] in their series of 50 autopsie sin Japan had 16% single, fused in 18%, 28% letter shaped, and 4% triplicated varieties of AComA.

Eftekar et al[9] of Iran and reported 1% absence and 11% hypoplastic AComA in their study of 60 heads.

Kapoor et al[10] from India in 2008 had a large sample size of 1000 autopsies from which he concluded his findings as: Absence in 1.8%, 2.1% hypoplastic, letter shaped in 10%,triplicate in 1.2%, plexiform in 0.4%,median ACA in 0.9%, and aneurysms in 1%.

In a study in Sri Lankan population, De Silva et al[11] 225 heads were dissected, to find hypoplasia in 25.07%, single artery in 65%, fused in 23%, letter shaped in 10%, triplicate in 0.4%, median ACA in2% and aneurysms in0.4%.

In another study from Japan by Serizawa et al. [13] in 2004 plexiform (33%), dimple (33%), fenestration (21%), duplication (18%), string (18%), fusion (12%), median artery of the corpus callosum (6%), and azygous anterior cerebral artery (3%) were discovered and reported.

In Turkey, a study by Ersa Gurdal et al[15], on 30 autopsies had found 1 head with duplicated AComA (0.3%), and one variation with an obliquely placed AComA.

Studies reported the frequency of anomalous AComA as ranging from 8 to 20% and a higher frequency of AComA anomalies in AComA aneurysms. [18,19,20,21]

Marinkovíc et al[22] reported that the "classical" AComA was observed in 41% of the cases, which indicates the anomaly observed in 59%.

Variations in length and breadth of AComA have been mentioned in various studies as follows:

Xu Tao et al[4] had studied a series of 45 Chinese heads and found the average length and breadth of AComA to be 3.34+- 1.74mm and 1.22+- 0.79mm respectively.

David Perlmutter and Albert L. Rhoton, Jr et al [5] in their series of 50 autopsies have reported the average length and breadth of AComA to be 2.7 and 1.6mm respectively and the incidence of anomalous AComA was 60%.

Serizawa et al[13] reported an average AComA length of 4mm and breadth of 1.7mm in their study in Japan.

Variations in number and supply of the perforators arising from AComA:

Initially studies have reported absence of any perforators from AComA[23,] or inconsistently one branch to the corpus callosum [24,25,26] before the advent of microscopic dissections.

After the advent of microscopic dissection, no fewer than 3 branches were seen issuing from the AComA.

The largest of the three branches entered the corpus callosum and cingulum. The lesser two branches perforated the superior aspect of the chiasm and both optic nerves, and sent branches to the septal and paraolfactory tissue in 19 cases studied by Dunker et al in 1976.[27]

In a study in 1999, Andrea Jakowski et al [28] had studied 22 brains and given her results as: Small branches varied between 1 and 5 in number and between 0.07 and 0.27 mm in diameter. Large branches were identified as the median artery of the corpus callosum (MACc) and the sub-callosal artery. The MACc was present in 9% and its diameter was between 0.55 and 1.3 mm. The subcallosal artery was present in 91%, and its diameter varied from 0.32 to 0.64 mm.

Another study by Serizawa et al et al.[13] in 1997 had given their observations as: The branches of the ACoA were classified as subcallosal, hypothalamic, and chiasmatic according to their vascular territory. The diameter of the subcallosal branch, usually single and large, ranged from 0.4 to 0.8 mm. The number of hypothalamic branches varied from one to six and the diameter ranged from 0.1 to 0.3 mm. The chiasmatic branch was present in 20%, and its diameter was 0.1 mm.

AIMS OF THE STUDY

1. To do a morphometric analysis of the ACA- AComA complex in the local population of the state for its implications on treatment of aneurysms in this part of the world.
2. To establish the anatomical details, both normal and variations occurring commonly in this area which may be a useful guide to surgical exploration of this subarachnoid space.
3. To study the length, width and morphology of the AComA in the above mentioned population.

MATERIALS & METHODS

Fresh cadavers were dissected during post mortem examination at the Forensic lab, Department of Forensic medicine at Government Rajaji Hospital, Madurai.

STUDY PATTERN

This is a prospective study done over a period of 2 years on forty fresh cadavers which were randomly selected.

EXCLUSION CRITERIA

1. Cadavers in which anatomy was distorted due to head injuries.
2. Cadavers where the postmortem could not be done.

   less than twelve hours.
3. Cadavers in which there were burns involving the head.
4. Cadavers with intracranial pathology.
5. Cadavers below the age of seventeen years.

REASONS FOR THIS EXCLUSION

In case of head injuries, especially fractures involving skull base distorts the normal anatomy. In any intracranial pathology an abnormal distorsion of the orientation of the suprasellar cisterns defies the observation. In old cadavers which is more than twelve hours old, advanced putrefaction process impairs the quality of tissues like fragility as well as elasticity. In cases of burns involving head and neck area, desiccation and dehydration affects the measurements. To avoid the variations due to age related changes, cadavers less than seventy years are excluded. All the cadavers were made sure that they are from South Indian origin.

INCLUSION CRITERIA

Cadavers which are excluded by the above said criteria were included.

METHODS

DISSECTION TECHNIQUE

40 cadavers were examined after ethical approval from medicolegal autopsies aged between 17 and 60 years who were selected according to the previously mentioned inclusion criteria. The cadaver was placed in supine position. Head of the cadaver was supported on a wooden block. Bicoronal incision was made by starting from root of zygoma in front of tragus towards opposite side same point. Scalp flap was everted in anterior and posterior directions in the sub galeal plane manually as well as by using same osteotome. Cranial vault was inspected to rule out anatomical

distortions such as fractures particularly in case of mode of death not known.

Pencil mark was made on the skull by encircling it horizontally, about one cm above supra orbital margin and external occipital protuberance, saw cut made along this line up to inner table. To break the inner table osteotome was used. Sagittal cut was made bilaterally along the superior sagittal sinus to the extent of the exposure, another cut was made circumferentially along the edges.

Falx cerebri detached from crista galli. Both frontal lobes were retracted laterally with help of brain retractors to expose the interhemispheric fissure. Further arachnoidal dissection was done with the aid of 4.5x loupe magnification and the relationship of the right to the left AcomA was identified.

As soon as adequate arachnoidal dissection was done through the chiasmatic,the lamina terminalis and the carotid cisterns, and the ACA- AcomA complex was definable on either side upto the level of ICA bifurcation on either side, a Vernier caliper and a measuring scale was used to measure the length and diameter of the AcomA. Fine dissection over the AcomA was done to clearly separate the AcomAs if they were more in number.

PHOTOGRAPHY:

Microphotographs of the procedures mentioned above were taken in all cases for documentation purpose. For this photography a SONY 12Mp T900 version camera was used in the macro shooting mode mounted on a tripod or used manually. However the anatomy, number and relationship of the perforators were not definable due to a lesser magnification range.

The Microanatomical observations of the ACA-AcomA complex:

Initially before start of dissection the age and sex of the cadaver was determined.

Orientation of the A2 of either side:

After dissection as mentioned in the previous section, the relationship of the A2 s on either side was first determined, and was categorized into either of the 3 of the following;

1. Right – If right A2 was anterior
2. Left – If left A2 was anterior
3. Horizontal – If both A2 were side by side
4. Unassessable – If only one A2 was present

The length and breadth of the A1 segments of either side were measured and their differences were calculated.

The length, breadth, number of AcomA were measured and charted down.

The number of perforators and their part of origin were not studied because of reasons mentioned in the previous section.

RESULTS

AGE DISTRIBUTION

Totally forty cadavers were examined for this study. Age varies from 17 to 60 years, with the mean age of 33. There were 6(15%) cases less than 20 yrs, 11(27.5%) cases from 21 to 30 yrs, 12(90%) majority of cases from 31 to 40 yrs, 7(17.5%) cases from 41 to 50 yrs, and 7(17.5%) cases from 51 to 60 yrs.

Table – 1

Age Distribution

Age in years	No.of cases	Percentage
17-20	6	15
21-30	11	27.5
31-40	12	30
41-50	7	17.5
51-60	4	10
Total	40	100

SEX DISTRIBUTION

Of the 40 cases 25(62.5%) were male cadavers and 15(37.5%) were female.

Table – 2

Sex Distribution

Sex	No.of cases	Percentage
Male	25	62.5
Female	15	37.5
Total	40	100

ORIENTATION OF THE ACA's IN THE AP PROJECTION

Of the 40 cases, left ACA was anterior to the right ACA on 23(57.5%) of cases, Right ACA was anterior to the left in 12(30%) cases and in 5(12.5%) cases the orientation was side to side.

Majority of the cadavers had the left ACA anterior to the right because of the calibre and the higher flow in the left compared to the right.

Table – 3

Antero posterior orientation of ACA's

AP Orientation of ACA	No.of cases	Percentage
Left	23	57.5
Right	12	30
Horizontal	5	12.5
Total	40	100

MORPHOLOGICAL VARIATIONS OBSERVED IN A.COM ARTERY

In 36(90%) of the cases a typical single A.Com artery was seen, in 1 case(2.5%) 2 separate A.Com artery was seen, in 1(2.5%) case a ‘H’ shaped variant was seen, in 1(2.5%) case a ‘Y’ shaped variation was observed and in 1(2.5%) case A com was absent.

As pointed out in the literature, of the 13 types of A.com morphological variations, in our study there were 3 of them found as mentioned above and in the table below.

Table – 4

Morphological variations observed in a.com artery

No.of AComs	No.of cases	Percentage
1	36	90
2 separate	1	2.5
H shaped	1	2.5
Y shaped	1	2.5
Nil	1	2.5
Total	40	100

A.COM ARTERY LENGTH VARIATION

Of the 40 cases examined, A.Com artery was absent in 1 case(2.5%), in 10(25%) cases it was 2mm in length, in 10(25%) cases it was 3mm, in12(30%) cases it was 4mm, in 7(17.5%) cases it was 5mm as tabulated. The average length of A.com artery in our study is 2.23mm.

In our study, most of the cases had a medium sized A.com artery of around 2- 4mm. There was however absence of anterior communicating artery- a rare variant – in 1 case as mentioned above.

Table – 5

ACom Length

A Com length	No.of cases	Percentage
Nil	1	2.5
2mm	10	25
3mm	10	25
4mm	12	30
5 mm	7	17.5
Total	40	100

OBSERVATION OF THE A.COM ARTERY BREADTH

Among the 40 observed cadavers, 1(2.5%) had no A.com artery, in 24(60%) of cases the a.com was 2mm, in 8(20%) it was 1mm, in 4(10%) cases it was 3mm, in 3(7.5%) cases it was 4mm.

The average A.com a. breadth in our study is 2mm.

Table – 6

ACom Breadth

A Com Breadth	No.of cases	Percentage
Nil	1	2.5
1 mm	8	20
2mm	24	60
3mm	4	10
4mm	3	7.5
Total	40	100

COMPARISON OF ACA BREADTH OF EITHER SIDE

Of the 40 cases on comparing the ACA diameters of either side left side was the dominant ACA in 24(60%), right dominance of ACA in 5(12.5%) cases and was equal in diameter in 11(27.5%) of the cases.

From our observation, the left ACA was dominant in majority of the cadavers, probably because of the dominance of left cerebrum in majority of the population.

Table – 7

Side of larger breadth of ACA

Wider ACA side	No.of cases	Percentage
Equal	11	27.5
Left	24	60
Right	5	12.5
Total	40	100

COMPARISON OF A1 SEGMENT BREADTH OF EITHER SIDE

As already tabulated in table 3, and as specifically pointed our in table 9, there is a definite broad ACA A1 segment on the left side compared to the right.

The right A1 was 2mm in 18 cases, 3mm in 17 cases, 4mm in 5 cases. On the Left side the A1 was 2mm in 5 cases, 3mm in 16 cases, 4mm in 18 cases and 5mm in 1 cases, Which shows the definite gradient towards the left side for the larger ACA.

Table – 8

A1 Breadth comparison on either sides

A 1 Breadth	No.of cases	
	Right	Left
2mm	18	5
3mm	17	16
4mm	5	18
5 mm	0	1
Total	40	40

COMPARISON BETWEEN ACOM BREADTH AND A1 BREADTH DIFFERENCE

A comparison between the difference in caliber between the 2 ACA i.e. larger supply preferentially from one side, and the caliber of the AComA was done.

Our study results as given in the table below, when the both side ACA were of equal diameter then 9(22.5%) of cases had a AComA diameter of 2mm, and when there was a significant difference in caliber if 2mm between either side, then also the caliber was 2mm in 8(20%) of cases. However when there is a significant difference in caliber of 2 or greater then there is a tendency of the AComA to be larger in caliber as seen that in 2 cases(5%) the AComA was 4mm, and in another 2 cases it was 3mm each.

Table - 9

Comparison between Acom breadth and A1 breadth difference

Difference between Right and Left A1 breadth in mm	Acom Breadth in mm				
	0	1	2	3	4
0	1(2.5%)	2(5%)	9(22.5%)	1(2.5%)	-
1	-	4(10%)	-	1(2.5%)	-
2	-	1(2.5%)	8(20%)	2(5%)	2(5%)
3	-	1(2.5%)	-	-	-
$P<0.001$ statistically significant by One way ANOVA test.					

OBSERVATION OF HEUBNER'S ARTERY ORIGIN

Of the 40 cases, the Heubner's artery could not be seen with our limited magnification in 22(55%) of the cases. Of the other 18(45%) cases where it could be visualized, 11(28.5%) arose from the initial part of A2, in 5(12.5%) cases it arose from the lateral wall of the ACA just at the level of A.Com artery origin, and in 2(5%) cases it arose from the distal A1 segment.

Table – 10

Heubner's artery-Level of origin

Heubner level	No.of cases	Percentage
1st part	2	5
2nd part	11	28.5
A Com	5	12.5
Not found	22	55
Total	40	100

DISCUSSION

The Anterior communicating artery and its pathoanatomy plays a very interesting yet challenging role in the life of every neurovascular microsurgeon. It is the duty of every neurosurgeon to master the knowledge of its normal anatomy by the way of reading literature and doing cadaveric cisternal microdissections before venturing any further into the treatment of its pathological affections, mainly aneurysms.

The anatomical knowledge gained should be put to use in the surgical treatment of aneurysms in this region and to prevent undue morbidity and mortality during surgery.

This study is mainly aimed at providing the reader a better understanding of the microanatomy of the anterior communicating artery and its variations and its incidence in the regional population. This may assist in better intraoperative decision making during aneurysm surgery.

The Anterior communicating artery (AComA) is the most preferable site for aneurysm formation (31.7%)[3] of all aneurysms, and nearly 91.2% of all Anterior cerebral artery aneurysms. Therefore, it is the most studied blood vessel among all the cerebral circulation.

The anterior communicating artery, the anterior connecting part in the Circle of Willis provides the communication between the internal carotid systems of either side, connecting the anterior cerebral arteries of both sides.

A wide array of variations in the anatomy of A.com artery has been seen and reported which makes dealing with each case different.

In this discussion the variations in anatomy of the A.com and ACA which were come across in this study are compared with previous studies among population of other parts of the world.

A. com. Structural variations:

Structural variations are grouped as Anomalous AComA's. The variations of the structure of AComA was initially classified in 1977 into 13 types according to Ozaki et al.[6] They are single, one point fusion, two point fusion, long fusion, N shaped, H shaped, Y shaped, V shaped, plexiform, triple, presence of the median ACA, fenestrations and aneurysms.

Adapting the classification by Ozaki et al [6] in 1977 which has 13 types of structural variations in AComA many other studies have quoted their incidences.

In our study 36(90%) of the cases a typical single A.Com artery was seen, in 1 case(2.5%) 2 separate A.Com artery was seen, in 1(2.5%) case a ‘H’ shaped variant was seen, in 1(2.5%) case a ‘Y’ shaped variation was observed and in 1(2.5%) case A com was absent.

Reddy et al 1972[12] reported absence of AComA in 0.6% and various letter shaped AComA in 7% of 70 autopsies in India. In 1977 Ozaki et al[6] had discovered single artery in 39.7%, 17.6% fused variety, letter shaped in 18.8% and 2.7% aneurysms in148 Japanese heads he examined. Fujimoto and Tanaka et al [8] in their series of 50 autopsies in Japan had 16% single, fused in 18%, 28% letter shaped, and 4% triplicated varieties of AComA. Eftekar et al[9] of Iran and reported 1% absence and 11% hypoplastic AComA in their study of 60 heads. Kapoor et al[10] from India in 2008 had a large sample size of 1000 autopsies from which he concluded his findings as: Absence in 1.8%, 2.1% hypoplastic, letter shaped in

10%,triplicate in 1.2%, plexiform in 0.4%,median ACA in0.9%, and aneurysms in 1%.

Incidence of absence of any communicating artery between two ACAs were seen in 2.5% in our study however studies from various populations and of various sample sizes suggest its absence from 0 – 2%.

The A.com artery can be deemed absent only on the basis of cadaveric studies and cannot be declared from any radiological studies. As our study was an anatomical cadaveric study and the region was thoroughly examined with magnification after microdissection, the non presence of any communication between the 2 ACA's is significant. However a larger sample size of the specific population is needed to clearly state the correct incidence of absence of A.com.

The incidence of letter shaped in our series of 40 cadavers was 5% overall. But variable incidence between 7- 28% had been described. Likewise fenestrated A.comA, the embryological variant could not be seen in our study.

One AComA was present in 60%, two in 30%, and three in 10% of the brains we examined as described by Perlmutter and

Rhoton. But in our study, 90% of the A.coms were single though of various lengths and breadths. Atypical a.com artery was present in 7.5% of cadavers with 2 A.coms. There were no case where 3 A.ComA were present.

Variations in the length of A.Com artery:

The length of the AComA is usually between 2 and 3 mm, but may vary from 0.3 to 7.0 mm as documented in various studies. The longer AComAs are commonly curved, kinked, or tortuous.

In our study, the average length of A.com artery was measured to be 2.23mm which is comparable to the other studies done worldwide. A.Com artery was absent in 1 case(2.5%), in 10(25%) cases it was 2mm in length, in 10(25%) cases it was 3mm, in12(30%) cases it was 4mm, in 7(17.5%) cases it was 5mm as tabulated in the results section.

Xu Tao et al[4] had studied a series of 45 Chinese heads and found the average length of AComA to be 3.34+- 1.74mm.

David Perlmutter and Albert L. Rhoton, Jr et al [5] in their series of 50 autopsies have reported the average length of AComA to be 2.7mm.

Serizawa et al[13] reported an average AComA length of 4mm in their study in Japan.

Variations in the breadth of A.com artery:

The breadth of AComA as seen from various studies have been found to vary between 1.2mm and 1.7mm.

In our study the average breadth of AComA is 2mm which is comparable to the other studies among other population as seen below.

Xu Tao et al[4] in his study in Chinese population, breadth of AComA to be1.22+- 0.79mm.

David Perlmutter and Albert L. Rhoton, Jr et al [5] in their series of 50 autopsies have reported the average breadth of AComA to be 1.6mm.

Serizawa et al[13] reported an average AComA breadth of 1.7mm in their study in Japan.

Other variations observed:

In our study, the orientation of ACA in the anteroposterior direction was seen to be as follows.

Left ACA was anterior to the right ACA on 23(57.5%) of cases, Right ACA was anterior to the left in 12(30%) cases and in 5(12.5%) cases the orientation was side to side.

Comparing this to the world literature shows a similar result that approximately 60% of the cases left ACA was anterior, in 35% of cases the right ACA was anterior and in another 15% the ACA ran side by side in the horizontal plane.

On comparison of the ACA of either side, the right A1 was 2mm in 18 cases, 3mm in 17 cases, 4mm in 5 cases. On the Left side the A1 was 2mm in 5 cases, 3mm in 16 cases, 4mm in 18 cases and 5mm in 1 cases, Which shows the definite gradient towards the left side for the larger ACA which is comparable to the other studies.[4,5,8]

The difference in calibre of either side of the ACA and the size of the AComA does have a statistically significant relationship in that as the difference increases the AComA breadth increases proving the point that there are cases where the majority of blood supply flows from the dominant ACA through the AComA into the contralateral side which is also in concordance with the previous studies.

This finding does help in surgeries, that during clipping of the AComA aneurysms, temporary clipping of an ipsilateral dominant A1 will reduce the chance of rupture and will tackle the premature rupture of the aneurysmal fundus during its dissection.

CONCLUSION

The conclusion from our study of the ACom-ACA complex in the regional population are as follows:

1. The variations in structural morphology of the AComA is not very common in our study population as compared to the other studies. There is a fairly standard anatomy on most of the patients and form the surgeon’s point of view its favorable to have a standard anatomy.

2. The length and breadth of the AComA have found to be comparable to the previous standard international studies.

3. There is a standard relationship of the breadth of the ACom and the difference in breadth of the 2ACA’s as already established in the previous similar studies.

4. The artery of Heubner was found to arise from the A2 segment of the ACA in majority of the cases which is in concordance with the literature reviewed.

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PROFORMA

Cadaver Details

Age :

Sex :

Side of the larger ACA :

Orientation of ACAs:

Dimensions of the ACom artery:

Length =

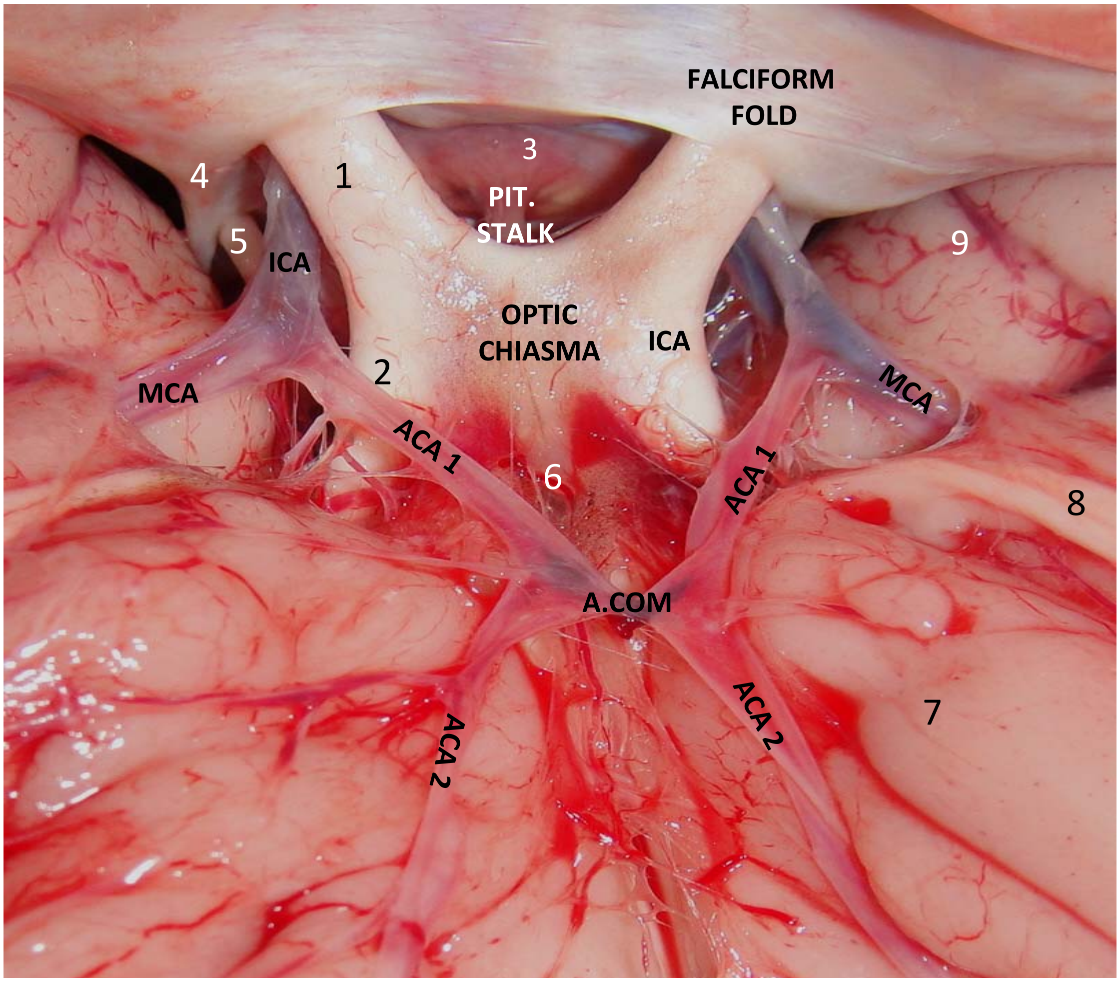
Breadth =

Number =

Structure =

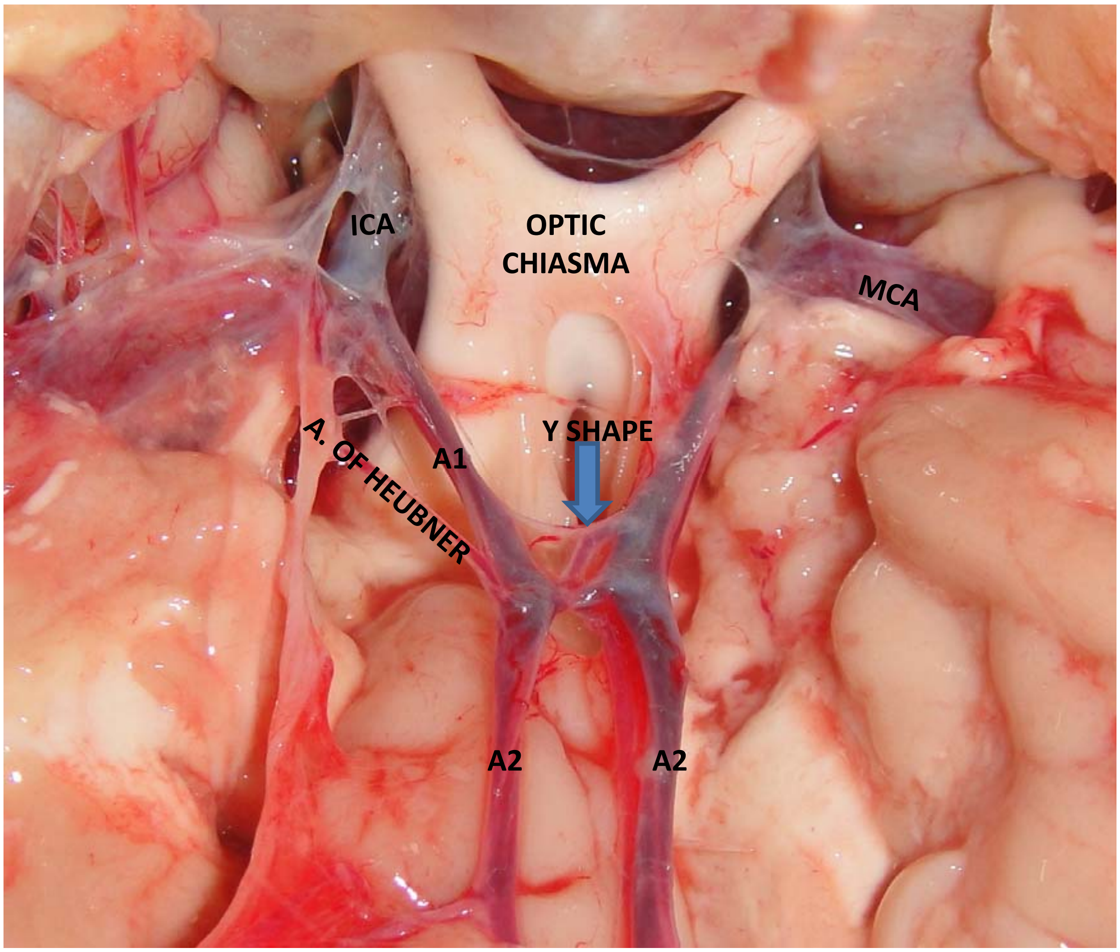
Single	H shaped
One point fusion	Y shaped
Two point fusion	V shaped
Long fusion	Plexiform
N shaped	Triple
Median ACA	Fenestrations
Aneurysms	

NORMAL ACA- A.COM A COMPLEX

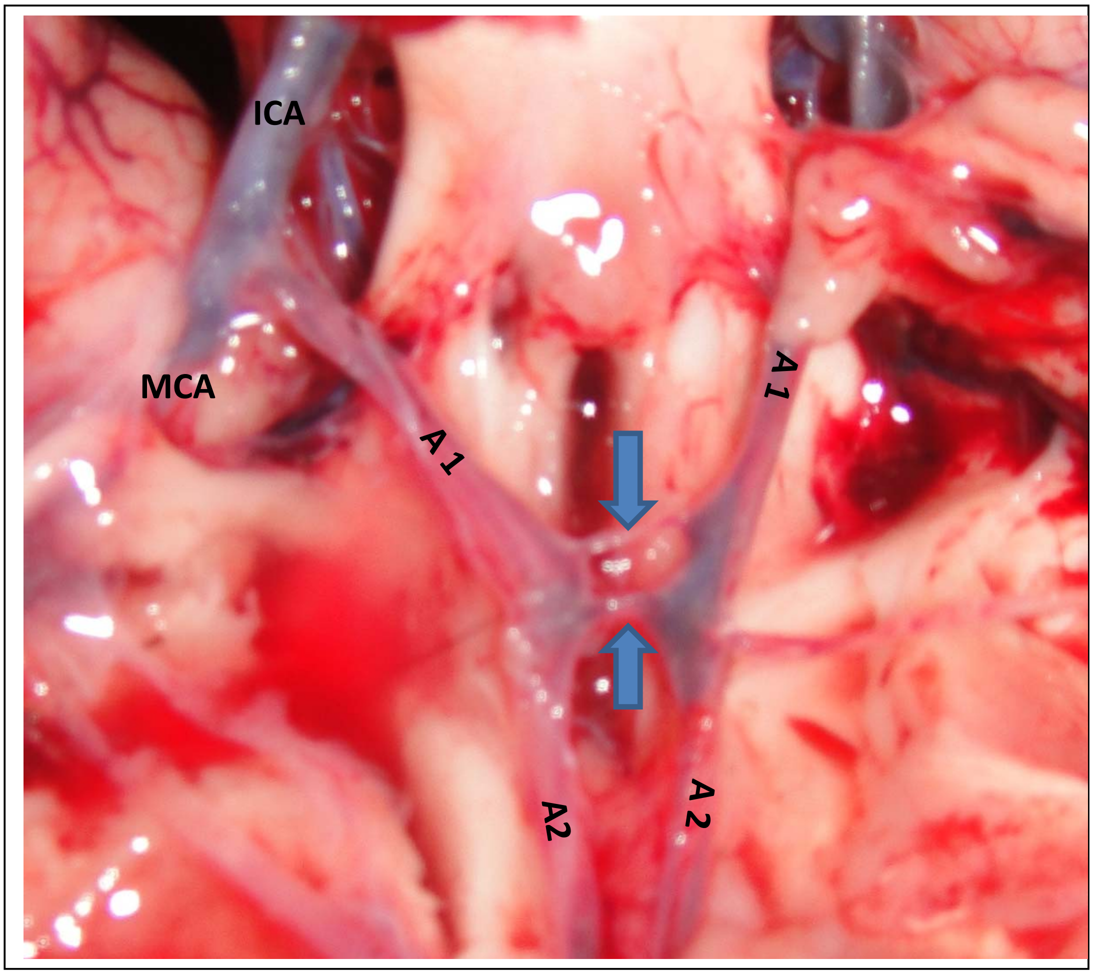


1. Optic nerve
2. Optic tract
3. Diaphragma sella (Roof of sella turcica)
4. Anterior clinoid process
5. Oculomotor nerve
6. Lamina terminalis
7. Gyrus rectus
8. Olfactory tract
9. Temporal pole

THE 'Y' SHAPED MORPHOLOGY OF A.COM.ARTERY

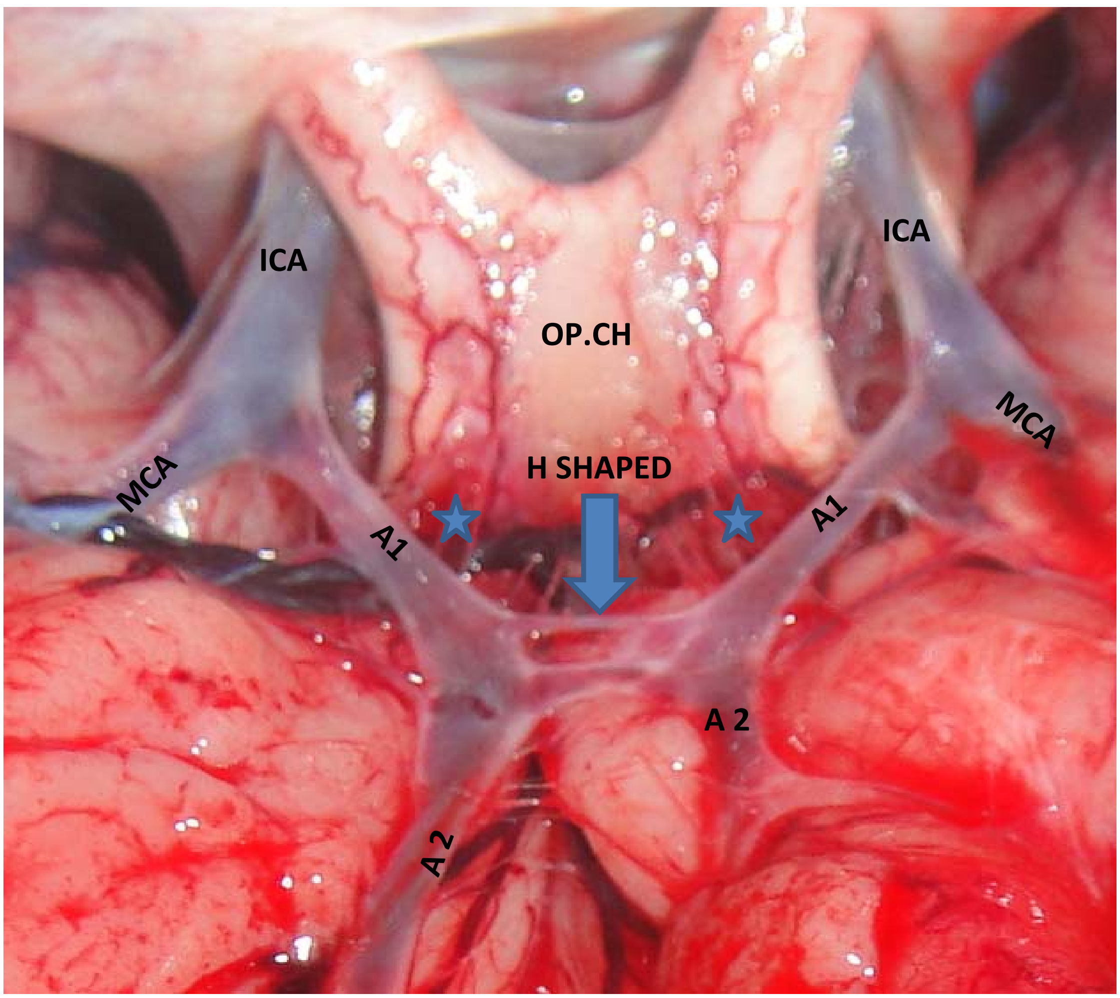


TWO SINGLE A.COM. ARTERIES PARALLEL TO EACH OTHER



The 'H' shaped morphology of A.Com. artery

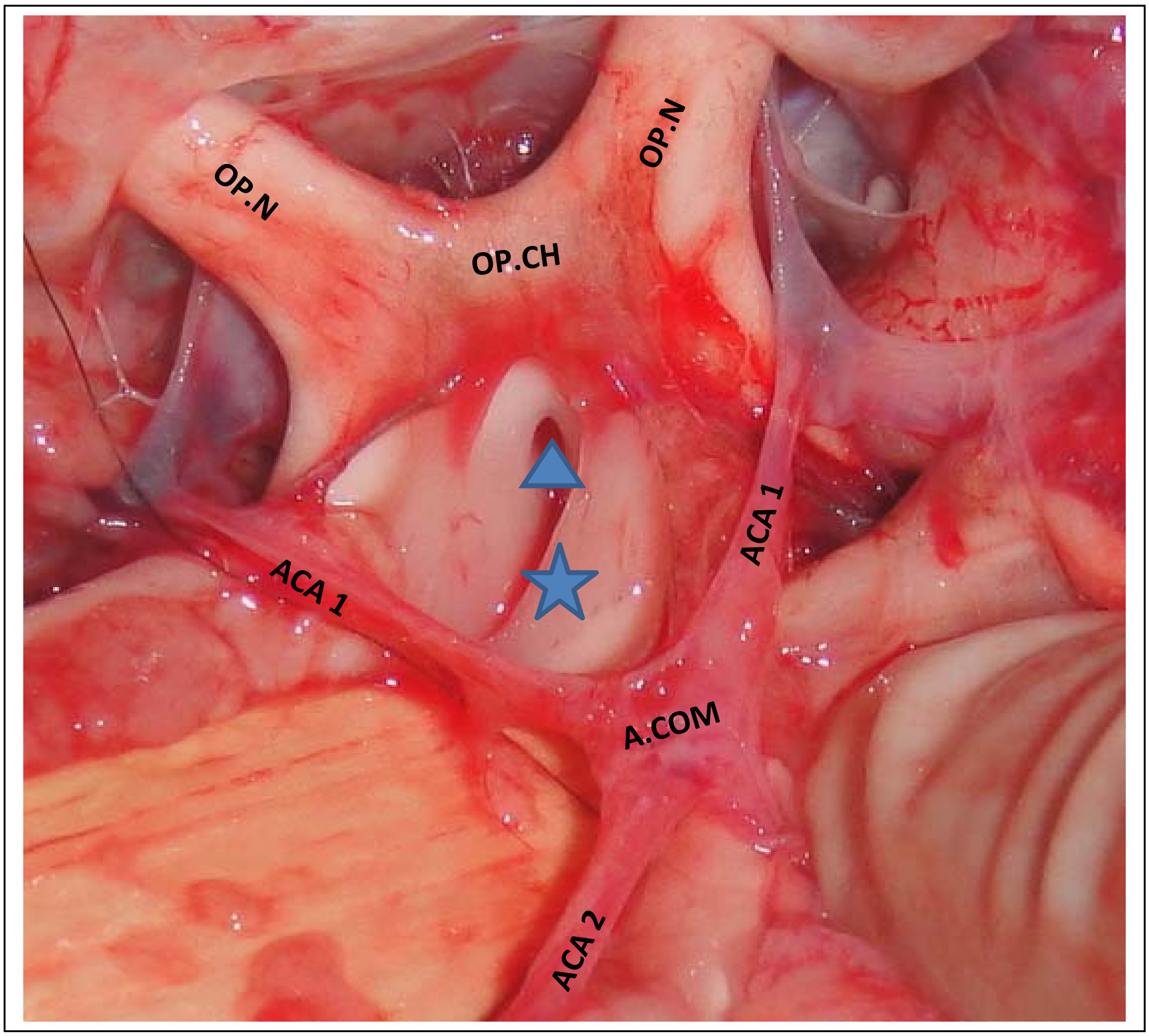
★ Numerous perforators to the chiasma



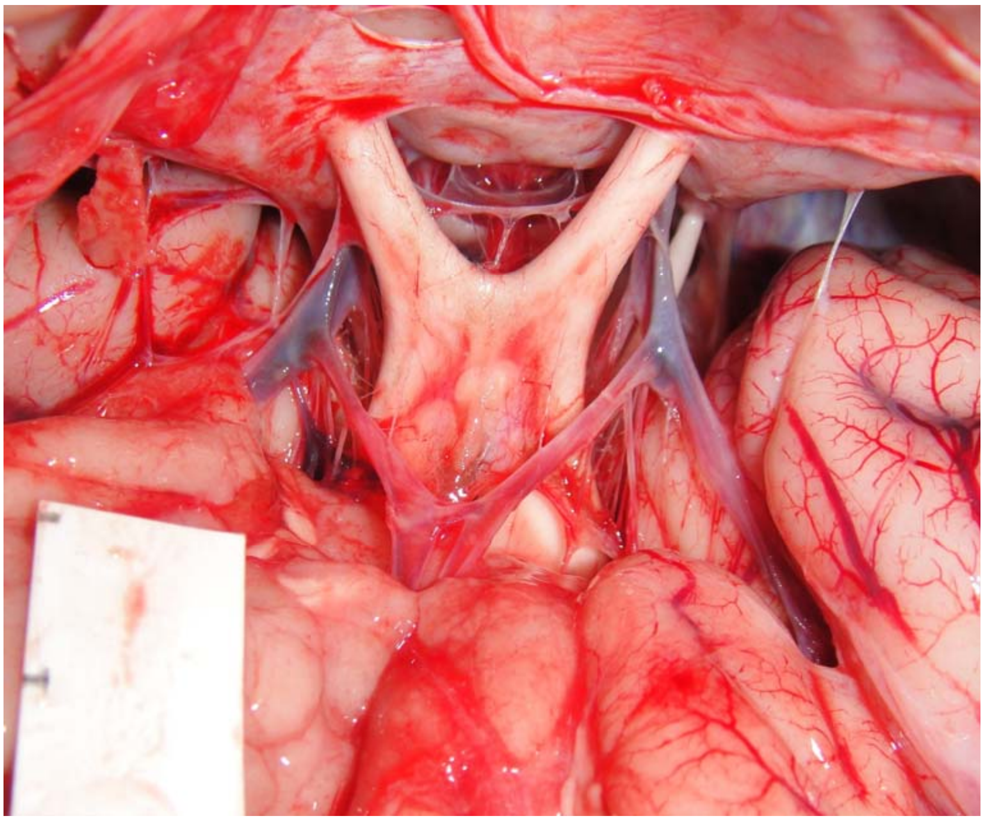
Short broad A.Com artery

★ Opened lamina terminalis- 3rd ventricle

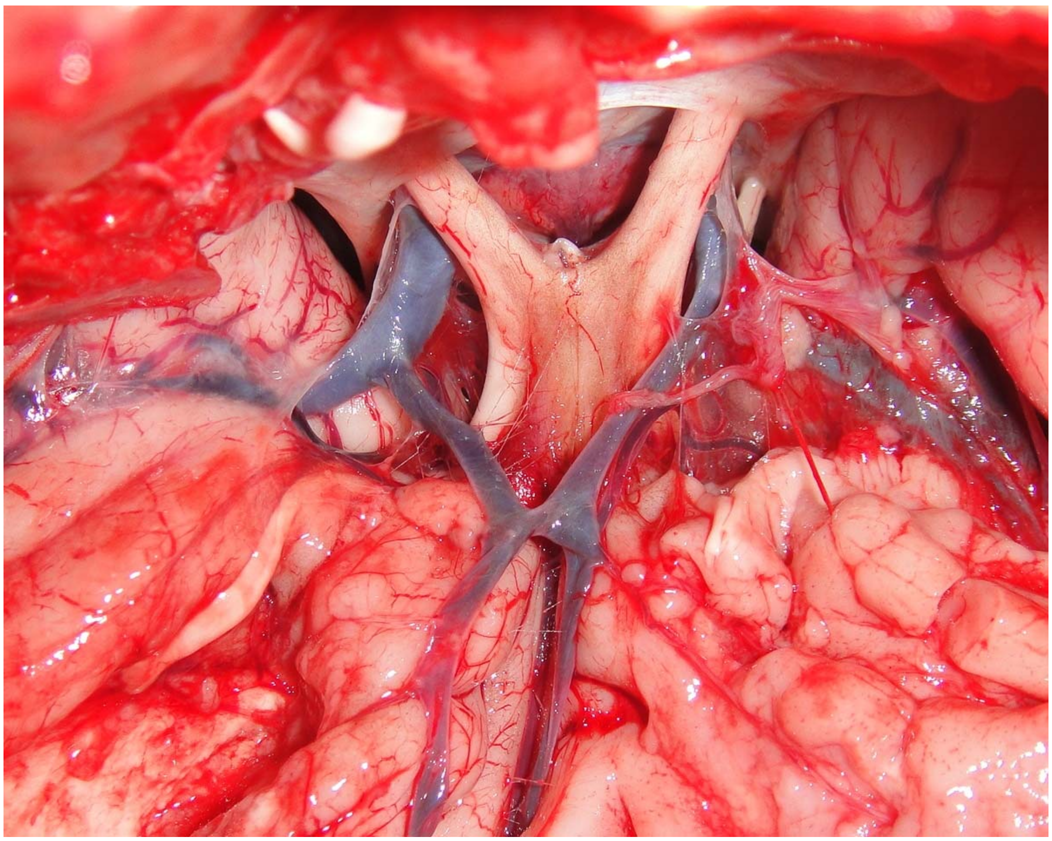
▲ Retrochiasmatic recess of 3rd ventricle



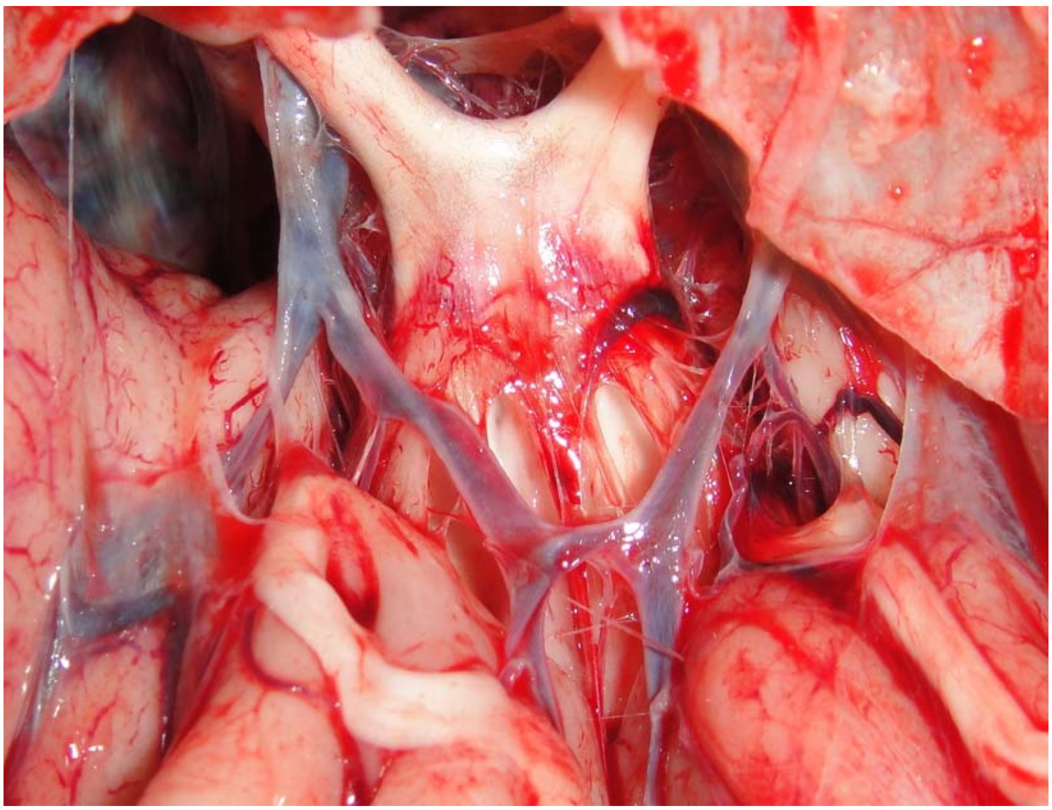
More views of A.Com Artery in cadaveric dissection

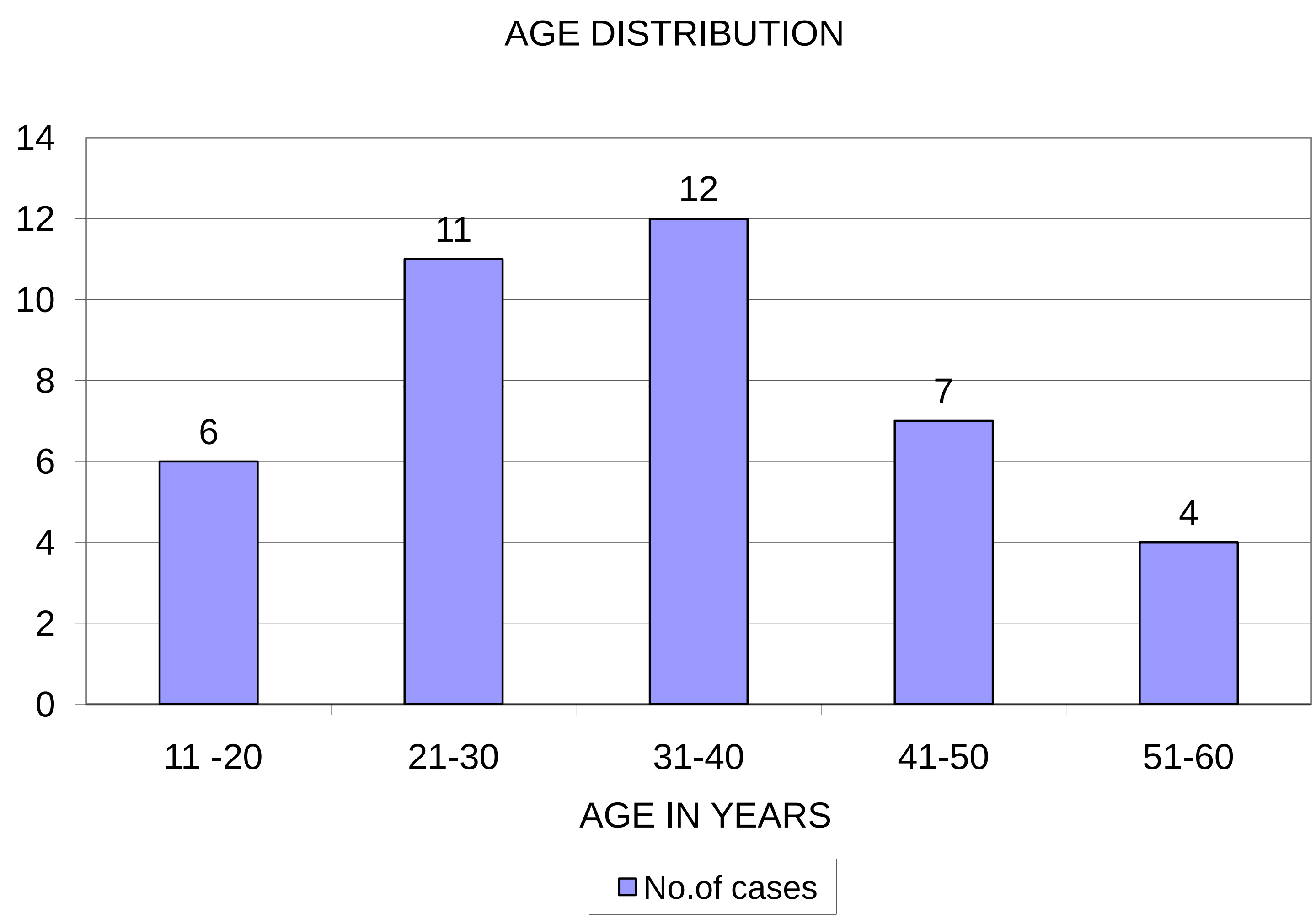


More views of A.Com Artery in cadaveric dissection



More views of A.Com Artery in cadaveric dissection

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12
10
8
6
4
2
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6
11
12
7
4
11 -20
21-30
31-40
41-50
51-60
AGE IN YEARS
No.of cases