

Surgical and angiographic anatomy of the posterior communicating and anterior choroidal arteries

Mustafa K. Baskaya^[1] +
Ernesto Coscarella^[1]
Ferdinand Gomez^[2]
Jacques J. Morcos^[1]

[1] Department of Neurological Surgery, University of Miami, Florida, Miami, USA
[2] Department of Anatomy, Florida International University, Florida, Miami, USA



+ Mustafa K. Baskaya, M.D.
Department of Neurological
Surgery, University of Miami,
Lois Pope LIFE Center, 1095
NW 14th Terrace (D4-6),
Miami, FL 33136, USA
☎ 305-243 4572
✉ 305-243 3180
✉ mbaskaya@med.miami.edu

Abstract

The posterior communicating (PComA) and anterior choroidal arteries (AChA) are the two major branches of the supraclinoid internal carotid artery. Thorough knowledge of the anatomy and awareness of the variations and anomalies of these arteries are of clinical and scientific importance in dealing with lesions involving these arteries and their branches. This article briefly reviews surgical and angiographic anatomy of the PComA and AChA.

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Introduction

Thorough knowledge of the anatomy of the intracranial vessels is important to clinicians as well as basic scientists who deal with problems related to intracranial vasculature in daily basis. This review article will focus on the anatomy of the posterior communicating artery (PComA) and anterior choroidal artery (AChA) from surgical and angiographic perspective.

Surgical Anatomy

Posterior Communicating Artery

The PComA arises from the postero-lateral wall of the ICA within the carotid cistern (Figure 1). Throughout its course within this cistern the PComA is actually encased by its own arachnoid trabeculae and then it pierces the Lilliequist's membrane to enter the interpeduncular cistern. While discussing the anatomy of the PComA, it is also important to describe the Lilliequist's membrane, which is the thick arachnoid membrane between the interpeduncular cistern inferiorly and the chiasmatic and carotid cisterns superiorly. As the PComA passes near the dura of the posterior clinoid process it might be attached to the posterior clinoid process with arachnoid

bands or rarely it might lie within a sulcus in the posterior clinoid process. During manipulations and dissection of the artery this variations should be kept in mind. An important anatomical landmark in surgical anatomy of the PComA is the oculomotor nerve, which enters the dura lateral to the posterior clinoid process and medial to the dural band passing from the tentorium toward the anterior clinoid process. Generally, the PComA runs medial to the oculomotor nerve (Figures 1 and 2). The PComA then courses in a posteromedial direction toward the interpeduncular fossa and joins the posterior cerebral artery, marking the beginning of the P2 segment (Figure 2). A supero-lateral course of the artery towards the oculomotor nerve has also been reported by Gibo et al when the fetal configuration is present [1]. Avci and Baskaya [2], however, reported that the PComA was lying medial to the third nerve in all configurations. Larger PComA has been found more often in children (39–75%) than in adults (8–29%) [3]. This observation supports that the caliber of this vessel diminishes with age. Yasargil reported the findings in 400 cadaver hemispheres, indicating that the size of the PComA is smaller than the corresponding posterior cerebral artery in 67.5% of the cases and its size is equal to or larger than

the posterior cerebral artery in 32.5% of the cases [4]. Similar findings (20% and 30%) have also been found by others [5,6]. In this situation, the PComA fails to regress, the P1 segment often remains hypoplastic and the ICA supplies posterior cerebral territory via this “*fetal type PComA*” (Figure 3). In a very recent study, incidence of the fetal type PComA was found to be 28% [2].

The PComA usually gives off 2–10 branches which begin approximately 2 to 3 mm from the origin. These branches, so-called anterior thalamoperforating arteries, run postero-medially into the interpeduncular cistern (Figure 1) and supply the inferior optic chiasm, optic tract, tuber cinereum, mammillary bodies, subthalamus, posterior hypothalamus, and the anterior thalamus [7]. An important point is that they almost always arise from the superior medial aspect of the PcomA (Figure 4), so that, when the interpeduncular cistern is filled with blood in case of a ruptured intracranial aneurysm, it is safer to open the membrane of Lilliequist below the PComA to avoid injury to these perforators that may be covered with blood. Of these perforators, the largest and most constant one is referred as the premamillary artery or thalamotuberal artery [4,7] (Figures 1,2,4). This artery always courses toward the paramedian perforating substance. Despite the caliber of the PComA, the number of its perforating branches is relatively constant and even in some cases, the diameter of the anterior thalamoperforating branches has been found to exceed that of the parent PComA. Therefore, the size of the PComA does not always reflect its functional significance. This was also confirmed by Avci and Baskaya in a study in which 24 cerebral hemispheres were studied [2].

The segment of the ICA between the PComA and the AChA gives off 1 to 3 branches in 8% to 40% of the specimens studied [1,8]. These branches supplies blood to the optic tract, optic chiasm, infundibulum, anterior and posterior perforated substances.

Infundibular widening or dilatation may be present in about 6% of the cases and it is always found on the carotid side of the PComA, which can be explained by occurrence of embryological regression in a posterior-anterior direction [9]. Furthermore, media defects have been demonstrated in infundibular dilatations in 21 cases histologically examined, suggesting that these infundibuli have a pre-aneurysmal potential [10]. However, the findings of Epstein’s study did not support this speculation [11]. Subsequently some clinical cases have been reported, suggesting that an aneurysm may develop from infundibular dilatation [12, 13]. Whether or not this occurs remains controversial.

Anterior Choroidal Artery

The AChA arises 2–5 mm distal to the PComA from the postero-lateral (postero-lateral) wall of the ICA (Figures 1,4,5). Its origin is usually further lateral on the posterior wall of the ICA compared to origin of the PComA. As a variation, AChA may occasionally arise from the PComA or ICA bifurcation. It usually arises as a single trunk [14] (Figure 5), however, duplicate or

even multiple AChA [2–4] has been reported in 30% of the cases [4]. The origin of the AChA is almost always lateral to the optic tract. The artery then crosses the optic tract from lateral to medial direction and courses along the optic tract to reach the lateral margin of the cerebral peduncle. The length of the artery beyond the optic tract is approximately 12 m. At a point just anterior to the lateral geniculate body, the AChA again crosses the optic tract from medial to lateral direction to enter the crural cistern (Figure 5). It then reaches through the choroidal fissure to the choroid plexus of the temporal horn of the lateral ventricle. According to Rhoton et al [14], the AChA terminates in the choroid plexus of the lateral ventricle. Contrary to this report, Erdem et al [15] found that, in 16% of the specimens studied, the plexal segment of the AChA passes through the choroid fissure as a single trunk and then divides into the lateral plexal and medial perforating branches within the choroid plexus. This finding is of clinical importance because occlusion of the artery by surgical or endovascular means after ventricular penetration may carry a significant risk.

The AChA has 2 segments throughout its course as originally proposed by Goldberg and Rhoton et al [16]: the first, cisternal segment begins from origin and ends at the point where the artery reaches to the choroidal fissure (*choroidal or plexal point*). The second segment, plexal segment, consists of one or more branches, which pass through the choroidal fissure and enter the choroid plexus [14,17]. It may give a few small recurrent perforating branches that exit the temporal lobe through the choroidal fissure to supply the optic tract, the cerebral peduncle and the thalamus.

The first branch that takes off from the AChA in the cisternal segment is the unco-hippocampal branch, which supplies the head of the hippocampus (Figure 5). The other branches are “*the superior branches*” that pass to anterior and posterior perforated substances and the optic tract, “*the lateral and inferior branches*” that pass to the temporal lobe and the uncus, and “*the medial branches*” that penetrate the cerebral peduncle and lateral geniculate body [14].

The AChA supplies the optic tract, lateral geniculate body, posterior limb of the internal capsule, globus pallidus, the origin of the optic radiation, middle one-third of the cerebral peduncle, pyriform cortex, uncus, part of the amygdaloid nucleus, substantia nigra, and ventro-lateral nucleus of the thalamus. Occlusion of the AChA in the cisternal segment may result in contralateral hemiparesis, hemihypesthesia, homonymus hemianopsia, and depressed level of consciousness, whereas its occlusion at the level of choroid fissure may be better tolerated because of rich anastomoses between the AChA and the posterior lateral choroidal artery.

Interchangeability of the brain regions supplied by the AChA may occur. This is particularly important when considering the internal capsule because if the PComA is small, the AChA may take over its area and supply the genu and anterior one-third of the internal capsule. If the AChA is small, the PComA may supply

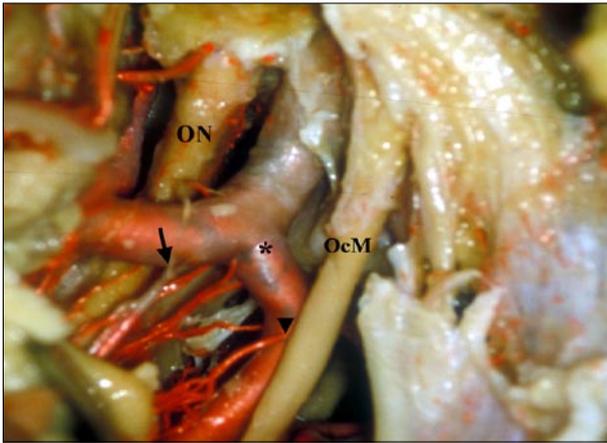


Figure 1. Exposure of the right supraclinoid ICA with its branches via transylvian approach after removal of the anterior clinoid process and opening of the cavernous sinus in the cadaver. The origin of the fetal type of the PComA (asterisk) is from the postero-lateral wall of the ICA. The oculomotor nerve (OcM) courses lateral to the PComA. A large anterior thalamoperforating artery originates from the PComA (premamillary artery) (arrow head). The origin of the AChA (arrow) as a single trunk is 3 mm away from the origin of the PComA. Note the short and lateral course of the ICA which may be a significant problem in microsurgical exposure in case of aneurysm. Note the anterior thalamoperforating branches running towards to the optic chiasm, hypothalamic region and premamillary area. Also note the course of the AChA is lateral to the optic tract after its origin. ON, optic nerve.

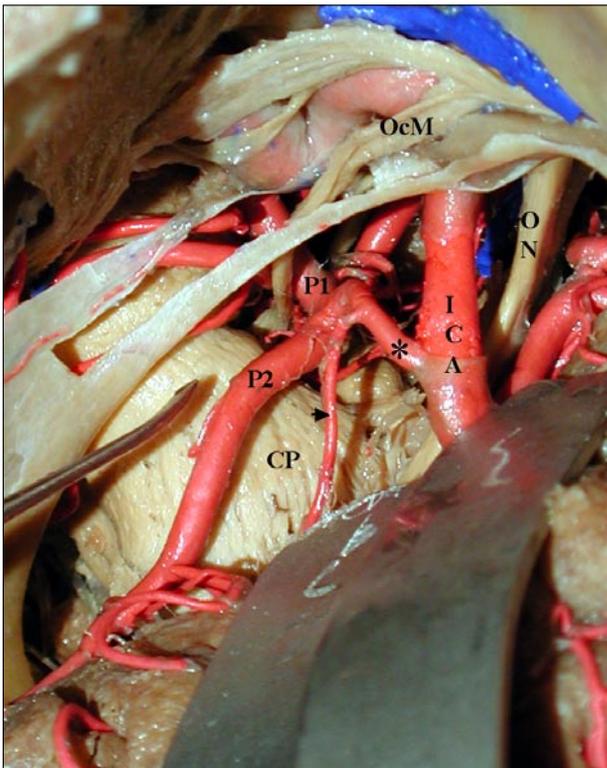


Figure 2. Exposure of the cavernous sinus, its contents, the internal carotid artery and its branches. In this specimen, the posterior communicating artery (asterisk) is in its normal configuration joining to the posterior cerebral artery (PCA). P1 is the segment before the PComA and P2 is the segment after the PComA. Note the premamillary artery (arrow head). (CP: cerebral peduncle, OcM: oculomotor nerve, ON: optic nerve, ICA: internal carotid artery)

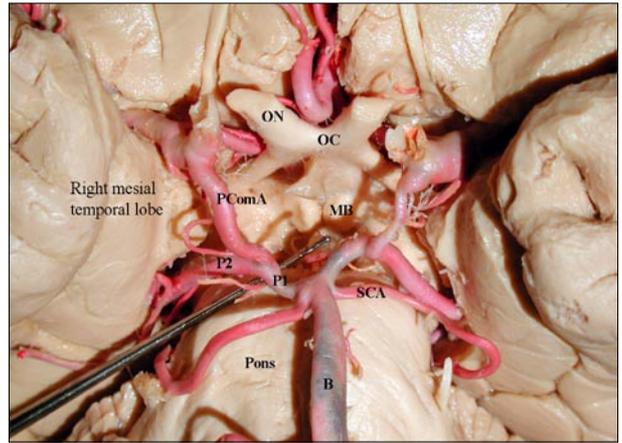


Figure 3. Demonstration of the fetal type PComA. Surgical instrument is elevating the junction of P1 segment of the PCA and PComA (right side). Note the size of the right PComA is slightly larger than the size of the P2, making this a fetal type. In contrast, the left PComA is smaller than its corresponding PCA. (MB: mamillary body, OC: optic chiasm, ON: optic nerve, B: basilar artery; SCA: superior cerebellar artery)

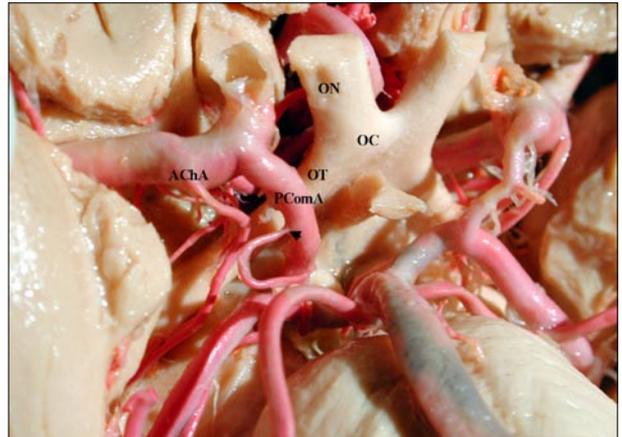


Figure 4. Fetal type PComA gives rise to its most constant perforator, premamillary artery (arrow head). Also, note the origin of the AChA from the supraclinoid ICA after the PComA.



Figure 5. The right AChA arises as a single trunk from the ICA and then crosses the optic tract (OT) from lateral to medial direction. It courses along the OT to reach the crural cistern and it then enters choroidal fissure. Note the branch arising from the AChA (unco-hippocampal artery) (arrow).

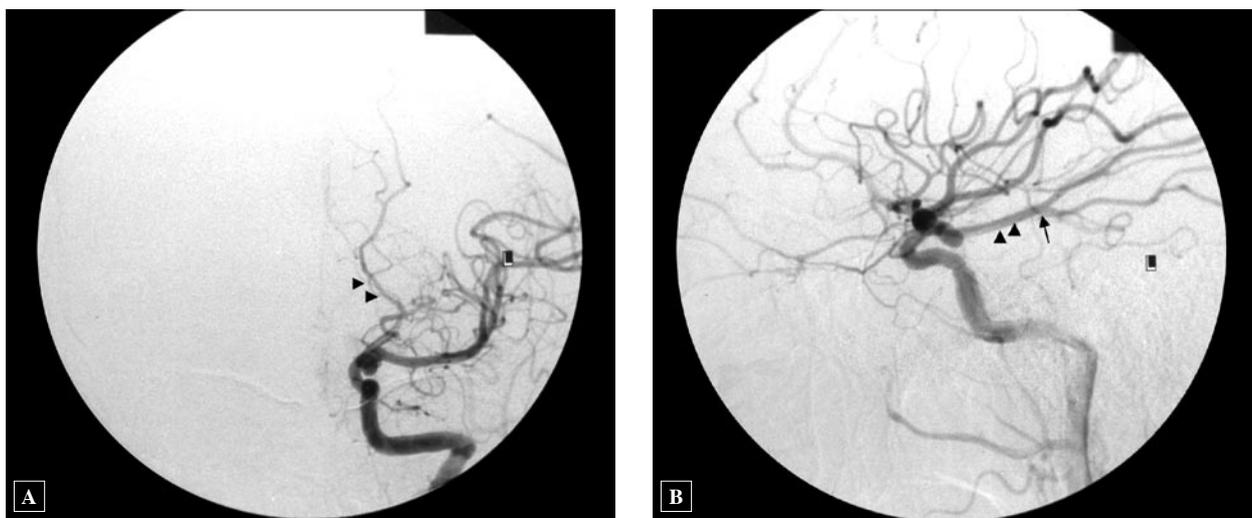


Figure 6. Antero-posterior (A) and lateral (B) views of the carotid angiogram showing a postero-laterally projecting PComA aneurysm. Note presence of a fetal origin of the PComA which fills the PCA through the left carotid injection (arrow heads). Arrow points the bifurcation of the PCA into the parietooccipital and calcarine arteries.



Figure 7. Antero-posterior view of the carotid angiogram showing an AChA aneurysm. The AChA makes a medial curve and then turn laterally and upward. Arrow head indicates plexal point.

the posterior limb of the internal capsule. This type of interchangeability may also occur between the AChA and the branches of the posterior cerebral artery that supply the cerebral peduncle, substantia nigra, optic tract and lateral geniculate body. This variability accounts for the unpredictability of the consequences of intended or accidental AChA occlusion: from little clinical consequence to hemiplegia and hemianopsia.

Angiographic Anatomy

Posterior Communicating Artery

On antero-posterior (AP) carotid and vertebral angiograms, visualization of the PComA is only possible in 30–40% of cases. Yasargil was able to demonstrate

the PComA in 36% of cases in 1000 normal angiograms [17]. Infundibular dilatation was less visible in younger patients (4%) than in older ones (13%). When both the PComA and the posterior cerebral artery are of equal diameter, the posterior cerebral artery appears to arise directly from the ICA (Figures 6a and b).

The course of the supraclinoid ICA on A-P angiogram is of clinical importance because an extreme lateral course in association with fetal origin may obscure exposure of the proximal neck of the aneurysm involving the PComA during surgery, necessitating removal of part of the anterior clinoid process. A method for angiographic prediction of the necessity to remove the anterior clinoid process was proposed in a recent study in which the angle formed by the midline of the skull and the axis of the supraclinoid ICA (angle A) and the angle between the axes of the supraclinoid and cavernous ICA segments were measured (angle B) [18]. The authors concluded that if angle A is more than 60° and angle B is more than 90° close proximity between a PComA aneurysm and the anterior clinoid process is probable and removal of the process might be necessary at surgery.

Anterior Choroidal Artery

It is also difficult to visualize the AChA on angiograms because its caliber is small (approximately 1 mm) and branches of the MCA may obscure it. The frequency of angiographic visualization of the AChA has been reported as 61% on lateral view and 41% on AP view [17], although with modern digital subtraction angiography visualization of the AChA is possible in the great majority of cases. On AP views, the AChA makes a medial curve and then turns laterally and upward. It makes a significant angle to enter to the choroidal fissure at the *plexal point* and this appears as a kink on the AP angiogram (Figure 7).

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