Absent anterior communicating artery and varied distribution of anterior cerebral artery

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ABSTRACT

خلال تشريح جثة رجل يبلغ من العمر67 عاماً، تبين وجود اتحاد فريد من نوعه لاختلافات دورة ويليز وتوزيع الشريان الدماغي الأمامي (ACA). كانت هنالك قطعة من الشرايين الدماغية الأمامية مصهورة بدون أي شريان موصل (ACoA)، وتشكل شكل حرف إكس (X) وتعطي ارتفاعاً بجانب الشريان الثفني (CPA)، وعدم اكتمال الشريان الدماغي الأمامي (ACA) البعيد (IACA). تعرض (IACA) لدورة غير عادية والتي تعد مهمة من وجهة نظر جراحية. يستمر الشريان بجانب الثفني كالقطعة (A2) و (A3) ويتشعب إلى شرايين بجانب الثفني. قيمت النماذج المتفرعة من الشرايين المختلفة إلى المنطقة داخل نصف المخ وتمت مناقشة النتائج. بالإضافة إلى أن كلى الشرايين الخلفية والموصلة ناقصة التنسج. على حد علمنا، لم يتم وصف إتحاد هذه التغيرات في نفس الحالة من قبل في الأدبيات المتوفرة.

During the cerebral dissection of a 67-year-old male cadaver, a unique combination of variations at the circle of Willis and anterior cerebral artery (ACA) distribution were encountered. The A1 segment of both ACA were fused without an anterior communicating artery (ACoA), forming an X shape and giving rise to a common pericallosal artery (CPA), an incomplete distal ACA, and an incomplete distal anterior cerebral artery (IACA). The IACA had an unusual course, which may be important from the surgical point of view. The CPA continued as the A2 and A3 segments, and bifurcated into 2 pericallosal arteries. Branching patterns of the varied arteries to the interhemispheric region were evaluated, and results were discussed. Additionally, both posterior communicating arteries were hypoplastic. There was no aneurysm formation at the circle of Willis and its branches.

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The anterior cerebral artery (ACA) is one of the important terminal branches of the internal carotid artery that supplies frontobasal, and medial hemispheric portions of the brain. Many classifications have been proposed for the sections of ACA. The part between the bifurcation of the internal carotid artery and anterior communicating artery (ACoA) has been called the A1 segment or proximal ACA, whereas the section after the ACoA has been called the distal ACA. The latter has been divided into 4 parts: the A2 segment, which extends from the ACoA to the rostrum of the corpus callosum (CC), the A3 segment, from A2 to where the artery turns sharply to the posterior on the genu of the CC, the A4 segment, from A3 to the line where the CC intersects laterally with the coronal suture; and the A5 segment, from A4 to the splenium of the CC.[1-5] The portion of the ACA that is located from the distal to the ACoA is also called the pericallosal artery (PCA).[5] The distal ACA usually has 9 branches, however, 2 or more adjacent branches come more frequently from a common stem, associated with isolated branches in the same specimen; but practically any combination is possible. Not only the way of branching, but the number of branches may vary.[6] An ACoA is a bridging vessel, connecting ACA on 2 sides, and one of the most frequent sites of arterial anomalies in the circle of Willis.[7] Knowing the variations and normal anatomy of the arterial distribution of the region is of utmost importance during surgical procedures.

Case Report. The A1 segments of both sides were fused on the midline, and formed an X-shaped view with the initial segments of the distal portions of the ACAs. Although there was a communication of both A1 segments, there was no so called ACoA existing between the ACAs. The branches, which we called the "common pericallosal artery" (CPA) and the "incomplete distal anterior cerebral artery" (IACA) and recurrent artery of Heubner (HRA) were the branches of the fusion site (**Figures 1a - 1c**). The CPA coursed over the rostrum and genu of the CC as the A2 and A3 segments and supplied only the right hemisphere during this course. It ended by dividing into 2 PCA, which continued on the epicallosal

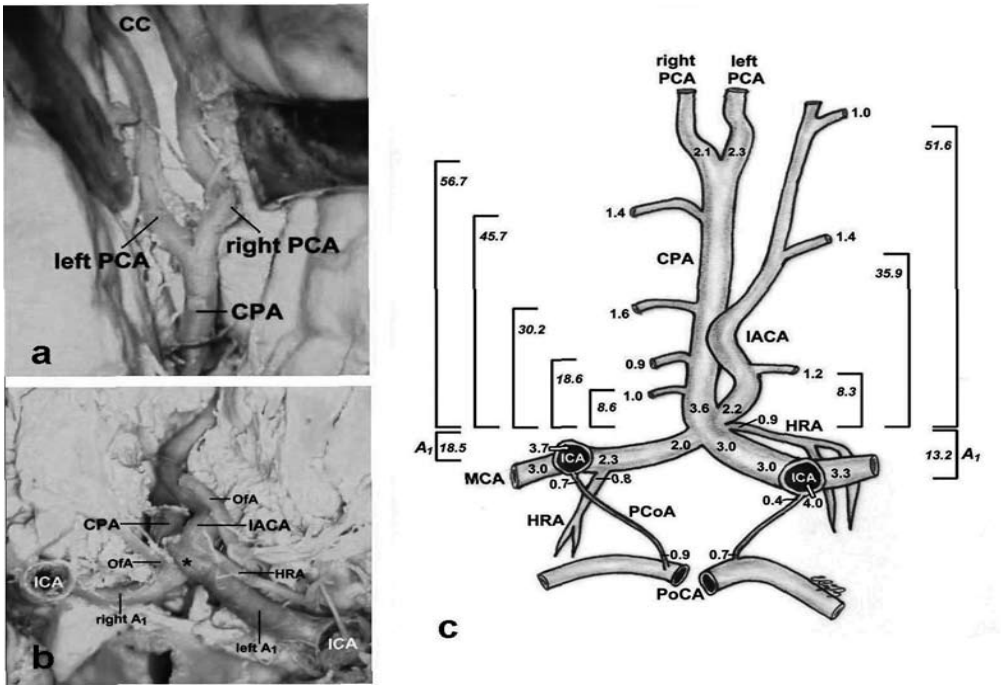

Figure 1 - Photograph of the **a**) common pericallosal artery (CPA) and pericallosal arteries coursing on the epicallosal sulcus. **b**) Anterior part of the circle of Willis showing the fusion site (asterisk) and its peripheral branches CPA, incomplete distal anterior cerebral artery (IACA), and recurrent artery of Heubner (HRA). **c**) Schematic representation of the circle of Willis and ACA distribution of this case given with the diameters as indicated on the corresponding section of the artery and lengths as indicated within the corresponding lines in mm. CC - corpus callosum, ICA - internal carotid artery, MCA - middle cerebral artery, OfA - orbitofrontal artery, PCA - pericallosal artery, PCoA - posterior communicating artery, PoCA - posterior cerebral artery, ACA - anterior cerebral artery, A1, length of proximal ACA.

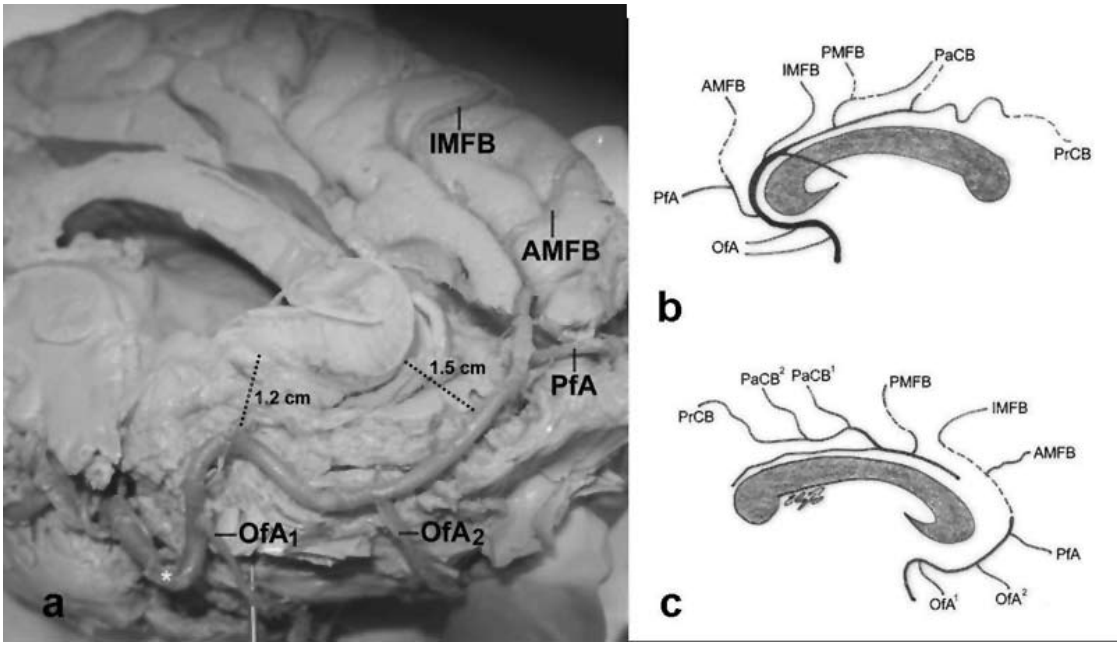

Figure 2 - Photograph of the **a**) left hemisphere with the incomplete distal anterior cerebral artery (IACA) away from the CC, presenting an unusual course and its cortical branches. **b**) Schematic representation of the cortical branches of the CPA and right PCA of the right hemisphere. **c**) Schematic representation of the cortical branches of the IACA and left PCA which is a branch of the CPA of the left hemisphere. AMFB - anteromedial frontal branch, IMFB - intermediomedial frontal branch, PaCB - paracentral branches, PfA - frontopolar artery, PMFB - posteromedial frontal branch, PrCB - precuneal branches, OfA - orbitofrontal artery, CPA - common pericallosal artery, IACA - incomplete distal anterior cerebral artery, CC - corpus callosum, PCA - pericallosal artery.

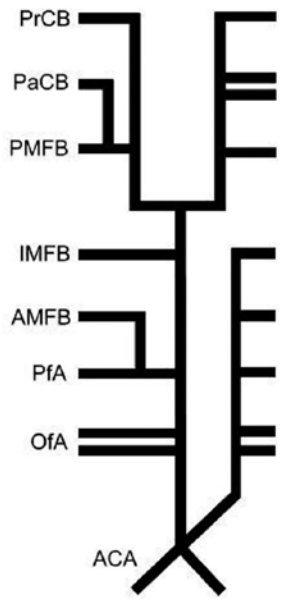

Figure 3 - Diagrammatic representation of a crossed-branch type (type V) in which one of the 2 distal arteries is a bihemispheric ACA showing the ACoA complex and distribution of distal ACAs based on Baptista.[6] ACA - anterior cerebral artery, ACoA - anterior communicating artery, OfA - orbitofrontal artery. PfA - frontopolar artery, AMFB - anteromedial frontal branch, IMFB - intermediomedial frontal branch, PaCB - paracentral branches, PrCB - precuneal branches, PMFB - posteromedial frontal branch

sulcus, and supplied their corresponding hemispheres (**Figures 1a, 1b, 1c, & 2a & 2b**). The IACA, during the course of its initial segment was inferior to the CPA instead of the usual side by side position. The artery then ascended on the right of the midline anterosuperiorly 1.2 cm under the rostrum of the CC and after bending backwards 1.5 cm in front of the genu of the CC, it ascended posterosuperiorly as the distal ACA on the medial surface of the left hemisphere instead of coursing on the usual epicallosal sulcus. It supplied the inferior and medial aspects of the left frontal lobe and left parietal lobe (**Figures 1a - 1c, 2a, & 2c**). The left HRA arose from the left side of the fusion site (**Figures 1b & 1c**). The right HRA originated from the A1 segment of the right ACA from a distance of 3.25 mm from the internal carotid artery. Both posterior communicating arteries (PCoA) were hypoplastic with diameters ranging from 0.4-0.9 mm (**Figure 1c**).

Cortical branches of the right hemisphere. There were 2 medial orbitofrontal arteries (OfA) originating from the A2 segment of the CPA on the right side. The right frontopolar artery (PfA) also arose from the A2 segment of the CPA and anteromedial frontal branch (AMFB), which usually is the first branch of callosomarginal artery arose from the PfA. The intermediomedial frontal branch (IMFB) arose from the A3 segment of the CPA. The posteromedial frontal branch (PMFB) and paracentral branches (PaCB) arose as a common trunk from the A4 segment of the right PCA. The right PCA, after giving the second PaCB, continued as a thick precuneal branch (PrCB) (**Figures 1c, 2a, 2b**).

Cortical branches of the left hemisphere. There were no branches to the left hemisphere from the CPA. There were 2 OfAs originating from the IACA, which corresponded to the A2 segment. The PfA arose from the A3 segment of the IACA, and the AMFB, and IMFB were the last branches of the IACA. The PMFB originated from the A4 segment of the left PCA. The left PCA ended by bifurcating at the termination of A4 segment. The thinner branch (0.9 mm) continued as the A5 segment of the left PCA and the thick branch (1.5 mm) gave 2 PaCBs. The continuation of the thinner artery ended as the PrCB (**Figures 1c, 2a, 2b, 2c**). All branches of the circle of Willis and their distal distributions were evaluated under the surgical microscope (Zeiss, OPMI-pico), however, no aneurysm formation was encountered.

Discussion. It has been proposed that hemodynamic alterations caused by vascular anomalies or variations of the circle of Willis lead to aneurysm formation.[8-11] Classically, ACoA is supposed to be a short bridging vessel between 2 ACAs of equal diameter. It is grouped as simple and complex type on the basis of its number and morphology. The simple type contained only one ACoA, bridging ACAs of both sides and accounted for 45-80% of the total. The complex type contained double branches, X-shaped, Y-shaped, H-shaped, O-shaped, or reticular ACoAs. The ACoAs were absent in a small proportion of people, in such cases, ACAs from 2 sides fused to avoid the necessity of an ACoA. Marinkovic et al,[12] reported that A1 of 2 sides fused to replace the ACoA in 4.5%, and Tao et al[7] reported that A1 of 2 sides fused to replace the ACoA in 4.4%. In this case, ACAs from 2 sides fused and formed an X-shaped view in the region avoiding the ACoA. The X-shaped view of the region should not be mixed with X-shaped ACoA, which is a complex type of ACoA. It has been proposed that hemodynamic alterations caused by vascular anomalies or variations of the circle of Willis lead to aneurysm formation.[9-12] The ACoA is one of the most frequent sites of the intracranial aneurysms. The frequency of the ACoA aneurysms is reported to range from 19-84% of all the cerebral aneurysms according to some studies.[12] The peripheral branches of the fusion site were an IACA and HRA of the left hemisphere and a CPA for both hemispheres. The IACA had an unusual course, keeping such a course in mind may

be of great importance in planning a surgical approach to the region for any reason. The HRA of the left side originated from the intersection point of X, whereas the right one originated from the right A1 segment. In different studies, the percentages of HRA originating from the A1 segment ranged from 7.03-14.3% and from the junction of ACoA to distal ACA ranged from 8-62.3%.[7,11,13-15] The X-shaped view of the region gave the impression of that CPA was the continuation of left A1, and the IACA was the continuation of right A1. Thus, a thrombus originating from any side might easily cross and obstruct any artery of the opposite hemisphere. Such an anomaly should also be kept in mind, that when there is an ischemic finding on one side, the source of the thrombus might be on the other side. If one of the 2 A2 segments is underdeveloped, its territory may be vascularized either by the median artery of the CC or by the contralateral PCA. The latter variation corresponds to the bihemispheric PCA (4-13.3%), in which an anterior right or left cerebral artery supplies most of the branches of the PCA of both hemispheres and is accompanied by a hypoplastic contralateral artery.[3] In this case, the left distal ACA was not underdeveloped but incomplete. The IACA for the left side continued only as the A2, and A3 segments. The CPA continued as the A2, and A3 segments as a common trunk and bifurcated into 2 pericallosal arteries. The right distal ACA (CPA in this case), complemented the IACA of the left hemisphere by bifurcating into 2 pericallosal arteries. As the CPA supplied both hemispheres in this case, this type of arterial distribution is type V, the crossed-branch type according to Baptista[6] in which one of the 2 arteries is a bihemispheric ACA (**Figure 3**). Baptista[6] reported all bihemispheric ACA types as 12%, but there is no frequency reported for the crossed-branch type. It may be regarded as a hemodynamic solution in which abnormal regression of one part of the complex is balanced by the development of blood-supplying channels for the corresponding territory. The resulting variations may be explained by the combination of 2 types of exchange between territories: those between the right and left hemisphere, and those between the territories of the cortical branches in each hemisphere.[3] Although the circle of Willis has been shown to exhibit many kinds of anatomical variations, such a combination of variations in the same specimen has not been published elsewhere before and makes this case interesting. In order to be able to plan, and design confident surgical, and endovascular interventions and yield successful results, probability of combined anatomical variations in the region should be kept in mind by the professionals.

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