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Microsurgical Anatomy of the Labyrinthine Artery and Clinical Relevance

Labirentin Arterin Mikrocerrahi Anatomisi ve Klinik Önemi

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ABSTRACT

AIM: To describe the origin, the course, and relationships of the labyrinthine artery (LA).

MATERIAL and METHODS: Thanks to a colored silicone mix preparation, ten cranial bases were examined using x3 to x40 magnification under surgical microscope.

RESULTS: The LA often arose from the meatal loop of the anterior inferior cerebellar artery (AICA) (90%), or basilar artery (10%). The loop was extra-meatal of the internal auditory meatus (IAM) in 30%, at the opening of the internal auditory meatus in 20%, or intra-meatal in 35%. The AICA coursed in closed relationship to the VII and VIII cranial nerves. It coursed between VII and VIII cranial nerve roots in 85%, or passed over the ventral side of both VII and VIII cranial nerve. The average diameter of the LA was 0.2 +/- 0.05 mm. LA was single trunk in 60%, and bi-arterial in 40%.

CONCLUSION: The implication of these anatomic findings for cerebello-pontine angle tumors surgery and neurovascular pathology such as infarction, aneurysm of the LA or the AICA are reviewed and discussed.

KEYWORDS: Labyrinthine artery, Internal auditory meatus, Anterior inferior cerebellar artery, Microsurgical anatomy

ÖZ

AMAÇ: Labirentin arterin (LA) kökenini, seyrini ve ilişkilerini tanımlamak.

YÖNTEM ve GEREÇLER: Renkli bir silikon karışımı preparatı sayesinde on kafa kaidesi, cerrahi mikroskop altında x3 ile x40 büyütme kullanılarak incelendi.

BULGULAR: LA anterior inferior serebellar arterin (AISA) meatal halkasından (%90), veya baziler arterden (%10) köken alıyordu. Halka, hastaların %30'unda internal audituar meatusa (İAM) göre ekstrameatal durumdaydı, %20'sinde internal audituar meatusun açıklığındaydı ve %35'inde intrameataldi. AISA, VII ve VIII. kraniyal sinirlerle yakın ilişki halindeydi. Hastaların %85'inde VII ve VIII. kraniyal sinir kökleri arasında seyrediyordu veya hem VII hem VIII. kraniyal sinirin ventral tarafı üzerinden geçiyordu. LA'nın ortalama çapı 0,2 +/- 0,05 mm bulundu. LA, hastaların %60'ında tek gövdeye ve %40'ında iki gövdeye sahipti.

SONUÇ: Bu anatomik bulguların serebellopontin açı tümörlerinin cerrahisi ve LA veya AISA enfarktüsü veya anevrizması gibi nörovasküler patolojilerdeki önemi gözden geçirilmekte ve tartışılmaktadır.

ANAHTAR SÖZCÜKLER: Labirentin arter, İnternal audituar meatus, Anterior inferior serebellar arter, Mikrocerrahi anatomisi

INTRODUCTION

The labyrinthine artery (LA) also called internal auditory artery in others nomenclatures, arises from the meatal loop of the anterior inferior cerebellar artery (AICA) (12,17). The LA is mostly single and mainly supplies both facial (VII) and vestibulocochlear (VIII) nerves. Its terminal branches divide into anterior vestibular artery, vestibulo-cochlear artery and cochlear artery and are intended for the vascularization of the inner ear. The purpose of this study was to improve our knowledge of the vascularization of the facio-vestibulocochlear nerve complex that is required for an enhanced understanding of the vascular ischemic syndroms (sudden deafness, vertigo or facial paralysis), and to perform regional surgical techniques (microvascular decompression, aneurysm surgery, resection of the CPA tumors and vestibular neurotomy) (7, 8, 21, 24).

MATERIAL and METHODS

10 cadaver cranial bases of both sexes were examined using x3 to x40 magnifications under surgical microscope (Carl Zeiss Inc., Göttigen, Germany). Saline irrigation was used to wash residual luminal clots. In one half of the specimens, the internal carotid arteries and internal jugular veins were dissected, cannulated and perfused with colored silicon in fresh cadavers (Latex, Fouche Chimie Service, Marseille). The other half of specimens was perfused only with arterial injection of formalin-fixed normal adult human brains.

RESULTS

Origin

The LA arose as a single branch in 90% of cases from the meatal loop of the AICA, at the opening or medial to the internal auditory meatus (IAM) (Figures 1, 2). The average caliber of the LA was 0.19 mm (range 0,15-0,24 mm).

Course

From its origin, the LA presented a short cisternal or precanalicular segment and entered the IAM by crossing the antero-inferior rim of the porus. It sent collateral branches to the bone and dura lining the IAM, and supplied the nerves within the canal (Figures 3, 4). In the IAM, the LA coursed closely to facio-vestibulocochlear nerve pedicle. It was most

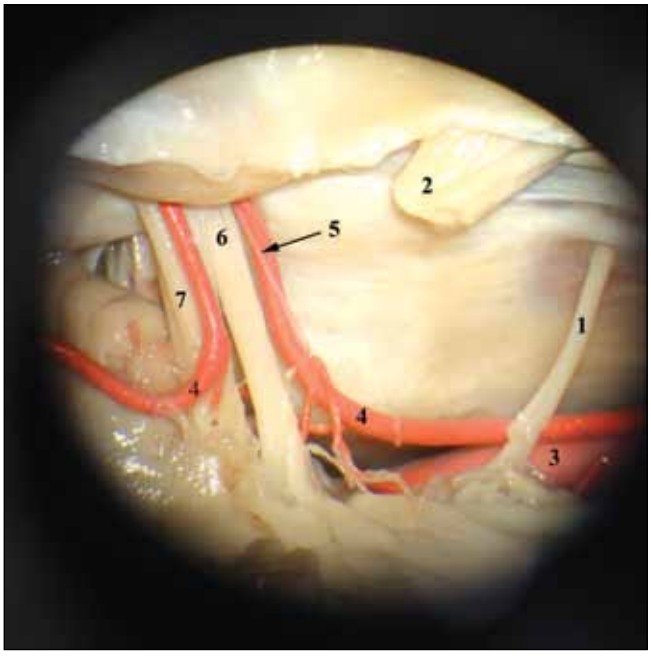

Figure 1: Superior view of the left Cerebellopontine angle. **1.** abducens nerve, **2.** trigeminal nerve, **3.** vertebral artery, **4.** Anterior-inferior cerebellar artery meatal loop, **5.** Labyrinthine artery, **6.** facial nerve, **7.** vestibulo-cochlear nerve.

Figure 2: Coronal anatomic slice of the right Cerebellopontine angle passing by the internal auditory meatus. **1.** right vertebral artery (V4 segment), **2.** Anterior-inferior cerebellar artery, **3.** Labyrinthine artery, **4.** trigeminal nerve, **5.** internal auditory meatus, **6.** middle ear (cavum tympanicum), **7.** Malleus, **8.** inner ear, **9.** cerebellopontine cistern.

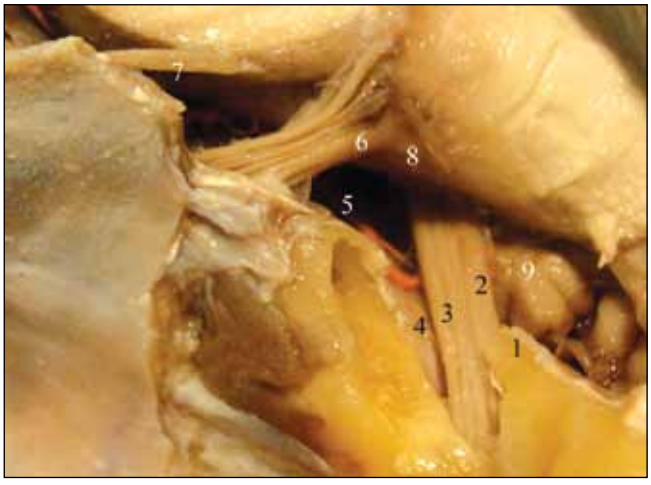

Figure 3: Superior view of the internal auditory meatus after opening the roof. **1.** internal auditory meatus, **2.** vestibular nerve, **3.** facial nerve, **4.** labyrinthine artery, **5.** Anterior-inferior cerebellar artery, **6.** trigeminal nerve, **7.** oculomotor nerve, **8.** lateral face of the pons, **9.** floculus of the cerebellum.

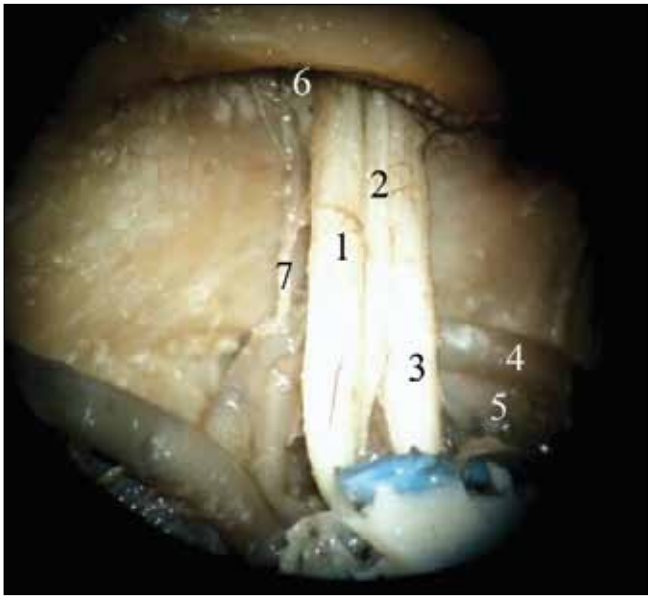

Figure 4: Microscopic view of the opening of the internal auditory meatus. **1.** facial nerve, **2.** intermediate nerve of wrisberg, **3.** vestibulo- cochlear nerve, **4.** Anterior-inferior cerebellar artery meatal loop, **5.** second Anterior-inferior cerebellar artery meatal loop, **6.** internal auditory meatus, **7.** labyrinthine artery.

commonly located above the cochlear nerve and passed under the facial nerve.

Ending

The LA ended at the fundus of the IAM, in the hiatus between the cochlear and the vestibular nerve, and then it divided into two main branches: the anterior vestibular artery (AVA) and the common cochlear artery (CA). The AVA ran on the anterior surface of the superior vestibular nerve (SVN). Both structures reached the fundus of the IAM. It supplied the utricle, the superior part of the saccule and the anterior and horizontal semicircular canals. The CA divided into the main cochlear artery and the vestibulo-cochlear artery (VCA) which reached the fundus of the IAM between the cochlear nerve (CN) and the inferior vestibular nerve (IVN). The VCA gave off the posterior vestibular artery and the cochlear ramus. The main cochlear artery (CA) crossed with the cochlear nerve (CN) and supplied the apex part of the cochlea, whereas cochlear rami irrigated the basal one. The destination of the posterior vestibular artery was to the inferior part of the saccule and the posterior semicircular canal.

Anatomical Relationships

In the CPA angle the LA and the AICA were in close relationship with the facial and cochlea vestibular nerves. The AICA originated from the basilar artery and its proximal segment coursed toward the CPA crossing the dorsal or the ventral aspect of the abducens nerve. After passing next to the abducens nerve, it descended toward the CPA, where it divided into a rostral and caudal trunk before crossing the facial and vestibulo-cochlear nerve. After passing the nerves the rostral trunk coursed laterally above the flocculus to reach the middle cerebellar peduncle and the superior part of the petrosal cerebellar surface which faced the back of the petrosal bone. The caudal trunk coursed inferomedially above the flocculus and usually supplied the inferior part of the petrosal cerebellar surface. The rostral trunk was usually nerve-related.It was divided in three segments based on their relation with the opening of the internal auditory meatus, and the seven and eight cranial nerves complex as premeatal, meatal and postmeatal segments. The meatal segment realized a constant loop and was usually located between the VII and VIII nerves.

The AICA trunk during its course gave off the following three branches: the LA entered and coursed the IAM with the VII and VIII nerve to reach the inner ear; the recurrent perforating arteries which coursed medially from their origin to supply the brainstem; the subarcuate artery penetrated the subarcuate fossa which is a small depression on the posterior surface of the petrosal bone along or near the posterior part of the ring of the IAM.

Variations

In 10% of the specimens the LA arose from the BA, 1 cm above the origin of the AICA (Figure 5); it coursed laterally toward the CPA, passed dorsally to the abducent nerves. It divided in two disproportionate branches before crossing the VII and VIII nerves, and reached the IAM. The higher branch ran antero-inferior to VII nerve while the other was posteroinferior. In 5% of cases, the AICA gave a single trunk from which arose both subarcuate artery and labyrinthine artery.

DISCUSSION

Morphology

The anatomical findings of the IAM-related arteries and their relationship with facio-vestibulocochlear nerves complex have been the focus of considerable reports (1, 2, 6, 11, 14, 15, 17, 20, 22, 25, 26). The LA is defined as the vessel or vessels that penetrates the IAM and supplies the meatal content, the temporal bone and lining dura, with terminal branches to the inner ear. Opinions vary on the origin of the LA. It mostly arises from the AICA or one of its branches (6, 11, 21). However it has been reported to arise in a few cases directly from the basilar artery (13), or rarely from the posterior inferior cerebellar artery (PICA) (11). Mazzoni and Hansen (12), have reported that of 94 LA were present in 50 CPAs, 72 (77%) originated from the premeatal segment of the AICA, 20 (21%) from the meatal segment and 2 (2%) from the postmeatal segment. 52 to 54% originated from a single AICA, and 23 to 40% from a duplicated or triplicated artery (14%). They also noted that the LA may arise from the RPA (recurrent perforating artery), subarcuate or cerebello subarcuate arteries. Martin (11) has divided the LA into two groups based on their relationship to the IAM. One group originated medial to the porus, and the other arose at the porus or within the IAM. Those arising medial to the porus most commonly originated and coursed anteriorly, antero-inferiorly or inferiorly to the nerves. Those

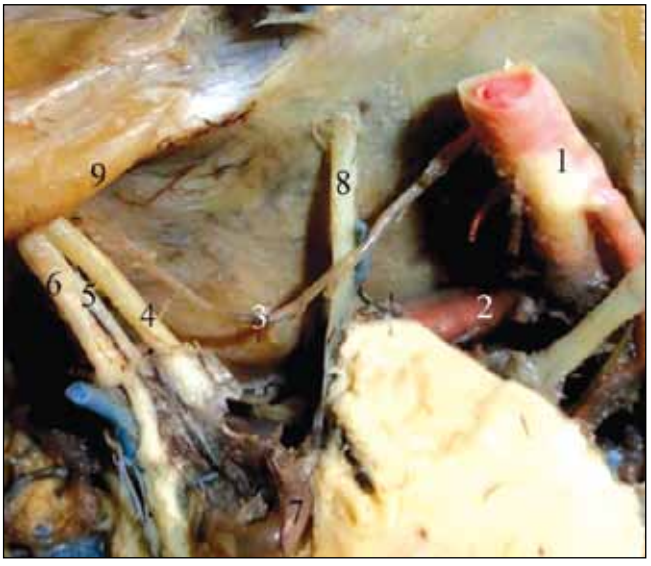

Figure 5: Superior view of the left Cerebellopontine angle. **1.** basilar artery, **2.** initial segment of the Anterior-inferior cerebellar artery, **3.** LA, **4.** facial nerve, **5.** intermediate nerve of Wrisberg, **6.** vestibulo-cochlear nerve, **7.** distal segment of the Anterior-inferior cerebellar artery, **8.** abducens nerve, **9.** internal auditory meatus.

arising at the porus or within the IAM, originated anterior or antero-inferior to the nerves. In its internal IAM course, the LA was commonly located on the supero-anterior surface of the cochlear nerve in the proximal one third or one half of the canal. It continued to run on the superior aspect of the same nerve at the distal one third of the canal and gave off its labyrinthine branches. In 50% of cases, a second branch of the LA may be located at the postero-inferior surface of the same nerve. This latter branch kept its course until the end of the canal (11, 12).

Clinical Considerations

Labyrinthine infarction

Thrombosis or occlusion of the LA is a possible vascular mechanism to explain labyrinthine infarction (7,10,16,18). Commonly the cochlea is more vulnerable to ischemia than the vestibular labyrinth (19). The symptoms, which include sudden vertigo and deafness, are common with AICA occlusion or infarction because of either thrombotic narrowing or occlusion of the basilar artery or the AICA itself (13, 26). When the AICA is completely occluded, the brainstem and cerebellar signs are always associated. The inner ear is one of the most commonly affected areas in case of AICA strokes (13).

Aneurysms

Aneurysms of the LA are extremely rare (3, 4, 8). The unique case has been described by Kocak et al. (9), who have reported a case of aneurysm located on a LA arising directly from the basilar artery, next to the AICA. Most of those reported have been aneurysms of the distal AICA or AICA-LA junction. The symptoms are dominated by headaches (58%) due to the subarachnoid hemorrhage (SHA) in the ambient and CPA cisterns, following by eight cranial and seven cranial nerves disorders (50%). In 40% of cases the SHA is absent. In this location the treatment of the aneurysm by surgery clipping or endovascular procedure may ligature or occlude the LA causing complete deafness (3, 5, 26).

Surgery of the CPA (tumor or hemifacial spasm)

During CPA surgery, for removal of tumors such as acoustic neurinoma, the LA is exposed and may be injured by the surgical maneuvers of nerves dissection (17, 23). It has been also described that a vasospasm of the LA can occur during the surgery, causing decrease or interruption of the cochlea blood flow with severe functional damage (18). At the root exit zone, blood vessels such as the AICA, the LA, the basilar artery, the vertebral artery, the PICA or veins may come into contact with the facial and vestibulocochlear nerve complex. A real pre operative topography global view of these relationships is now possible thanks to a 3D volume visualization MRI. There was vascular contact between the distal nerve segment of the facial and the LA in 12% of the patients suffering from hemifacial spasm (20, 26).

CONCLUSION

The LA is a very important artery which mainly supplies the facio-cochleovestibular nerve complex and the inner ear contents. Its origin, coursed and relationships in the CPA and IAM are very variable and justify a detailed knowledge for the understanding of the labyrinthine vascular ischemic syndromes. The LA commonly arises from the meatal loop of the AICA at the opening or in the IAM and course between the VII and the VIII nerves. However its damage can be avoided during acoustic neurinoma surgery, when its branch is located in the anterior half of the IAM (13).

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