Surg Radiol Anat (2010) 32:171–174
DOI 10.1007/s00276-009-0527-6

ANATOMIC VARIATIONS

Subarcuate canal and artery: a case report

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Received: 25 January 2009 / Accepted: 3 June 2009 / Published online: 25 June 2009

Abstract Variations in the course of the subarcuate artery (SAA) and of its related funnel are infrequent and asymptomatic. We present a case of a 15-year-old girl with a preverbal severe bilateral hearing loss and a subarcuate canal with an unusual course and atypical correlation with the adjacent anatomical structures, particularly with the lateral semicircular canal and the facial nerve. The variation proposed in this case, not previously reported in the literature consulted, can have important implications during middle ear surgical procedures, particularly for the retro-facial tympanoplasty approach: in fact otologic surgeons should consider any kind of variation of the SAA in surgical planning to avoid unexpected hemorrhages. The CT-scan, particularly HRCT, is a very useful tool for the study of intrapetrous vessels and their funnels, and should be considered mandatory in the case of a posterior approach to the tympanic cavity.

Keywords Subarcuate artery · Anatomic variation · HRCT-scan · Retrofacial approach

Introduction

In the otological literature, the subarcuate canal (SAC) is classically defined as a bony pathway between the mastoid antrum and the intracranial cavity [9]. Inside the SAC is the subarcuate artery (SAA) that provides blood supply to the bony labyrinth, the facial canal and the mastoid antrum. The SAC originates from the subarcuate fossa, a space localized on the posterior surface of the petrosa. The SAA enters the SAC and runs in a posterior, lateral and superior direction. In its proximal segment, the artery reaches the posterior wall of the internal auditory canal and then branches to the dura and the bone, and connects with the internal auditory artery. Then the SAA proceeds under the arch of the superior semicircular canal giving blood supply to the otic capsule (Fig. 1a). In its distal segment, the vessel reaches the antrum and divides into a posterior and an anterior branch for the vascularization of mastoid cells and the middle fossa's dura. Some authors have suggested that, through this structure, middle ear infections can be transmitted into the intracranial cavity [3, 7, 9].

We present a case of a subarcuate canal with an unusual course, and atypical correlation with the adjacent anatomical structures, particularly with the lateral semicircular canal and the facial nerve (Fig. 1b) The variation proposed in this case, not previously reported in the literature consulted, can have important implications during middle ear surgical procedures, particularly for the retro-facial tympanoplasty approach.

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Case report

A 15-year-old girl presented at our department with a preverbal severe bilateral hearing loss. A bilateral tinnitus and a subjective vertigo with spontaneous resolution had occurred, respectively, 6 and 3 months before the evaluation at our department. In her medical history, the only relevant element was cardiosurgery for Botallo's duct persistence 5 years earlier. All blood exams (hemocytometric, coagulation, autoimmunity, viral immunoglobulin, thyroid function)

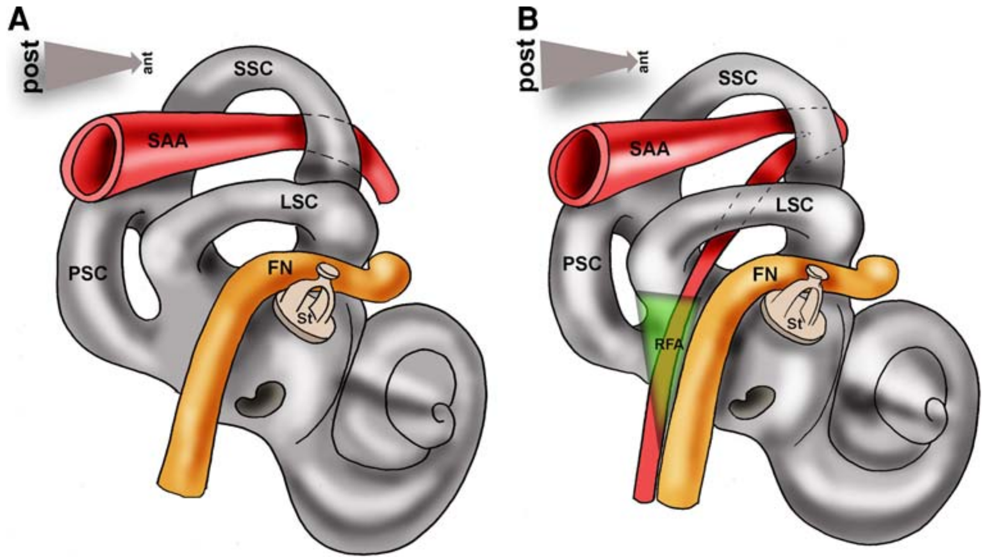

Fig. 1 **a** Normal course of SAA, **b** variation of the course of SAA (our finding)

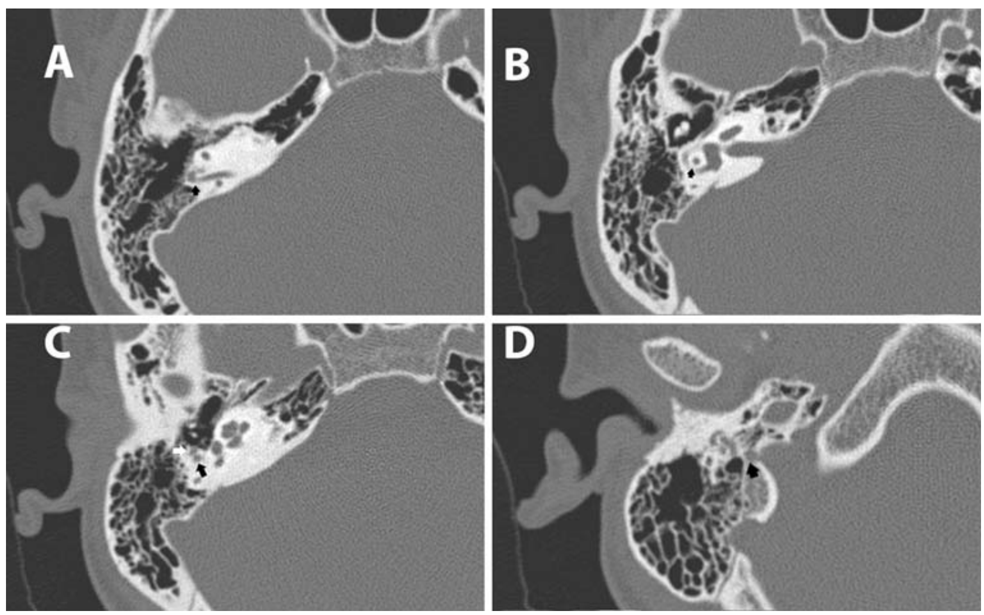

Fig. 2 (Axial HRCT-scan). **a** Proximal tract of the intrapetrous portion of the SAA (*arrow* indicates a kinking of the canal), **b** Course of the artery in the middle of the arches of the LSC, **c** Close relationship of the SAA (*black arrow*) to the mastoid tract of the Fallopian canal (*white arrow*), **d** Distal tract of the SAA opening toward the jugular foramen

were normal. The patient was treated with corticosteroids, heparin and vitamin B, but further audiometric examinations showed no improvement after therapy, and audiometric evaluations were stable 1 month after treatment.

Because of inefficacy of medical treatment and the gravity of hearing loss, the patient was proposed for a cochlear implant. She underwent a routine pre-operative high resolution CT-scan (HRCT) and MRI. The CT-scan study showed a variation of the SAA bone funnel in the right temporal bone. This funnel originated from the subarcuate fossa (SF) and the proximal tract ran postero-laterally between the two arches of the superior semicircular canal (SSC) near the non-ampullary arch (Figs. 2a, 3b). Then the funnel turned caudally with a "kinking" and ran through the arches of the lateral semicircular canal (LSC) (Figs. 1b, 3a); at this point, the canal proceeded caudally and laterally, reaching the second genu of the facial nerve in a posteromedial position, being adjacent to the nerve along its intramastoid tract (Fig. 2c). Proceeding caudally, the funnel lay in close relationship to the posterior semicircular canal (PSC), running afterwards extracranially and ending in the lateral aspect of the jugular foramen (Fig. 2d). The width of this bone canal was between 1.2 and 1.8 mm. The left temporal bone did not show any variation.

At MRI, the cochlea, vestibule and acoustic and facial nerves were all normal. A fusiform aneurism of the distal tract of the right internal carotid artery involving the proximal tract of the median cerebral artery was seen in angio-MRI images. The anterior communicating artery was not able to be seen. No other vascular variations were found.

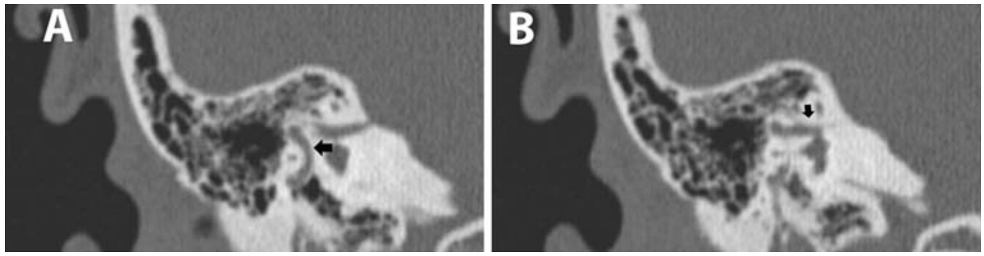

Fig. 3 (Coronal HRCT-scan). **a** Vertical tract of the SAA running through the LSC arches (*arrow*), **b** Horizontal tract of the SAA running through the SSC arches (*arrow*)

Discussion

In the otologic literature, several authors have studied the SAC and its artery [1, 2, 4–7, 9]. Mazzoni found that the artery originates from the anterior inferior cerebellar artery in 80% of cases, from an accessory anterior inferior cerebellar artery in 17% and from the posterior inferior cerebellar artery in 3%, while the SAA originates from the internal auditory artery (IAA) in only a few cases [4, 5]. The artery arises from an arterial loop inside or at the porus of the internal auditory canal (IAC) or close to it in the cerebellopontine space; the loop has been observed to be constantly at the level of the SF [4, 5].

The intrapetrous course has been divided into three segments: a proximal, an intermediate and a distal segment [4]. In the proximal segment, the SAA enters into the temporal bone through the SF localized in the posterior aspect of the petrous bone giving branches for the bone, the dura and the IAC. At this level, some communication branches of the IAA have been found. Then the funnel runs in the temporal bone in a postero-lateral direction in a space delimited by the posterior wall of the internal auditory canal and the petrous bone. In the intermediate tract, the SAC runs deeply in the petrous bone and reaches the SSC passing through its arches on the non-ampullary side giving many small convoluted branches. These are for the vascularization of the otic capsule, the semicircular canals and the vestibule, and the middle fossa's dura and there are vascular connections with the superficial petrosal artery for the mucosa of the supralabyrinthine cell. The last tract of the canal (the distal segment) heads to the antrum where it stops because the SAA divides into its terminal branches (anterior and posterior) for the vascularization of the antrum and the aditus. In this tract, many anastomoses have been observed with the stylomastoid artery [4].

While the origin of the SAC is always the same, its course is not always constant and in the literature, several variations are described, discovered in anatomical dissection studies. In the case reported, the SAC variations occur in the intermediate and distal segments (Figs. 1, 2, 3). In fact, the canal passes through the two branches of the LSC after an anomalous kinking. In the vertical tract, the funnel reaches the facial nerve canal, at the level of its second genu, lying posteriorly and medially to the nerve strictly close to the Fallopian canal; at some points, the bone lamella that divides the Fallopian canal from the SAC is not well defined and it seems that the two structures merge into one. This condition may have important consequences in some otologic approaches, especially in the retro-facial approach during tympanoplasty. In fact, in the case of retro-facial approaches, the surgeon has to drill from the posterior side at this level to achieve adequate exposure of the posterior region of the tympanic cavity.

Our variation could arise from a complex anastomosis of three arteries [8]: (a) SAA, since in the first tract of the funnel (the horizontal one) it is identical to the normal course of SAA; (b) Stylomastoid artery, particularly the tract in close relationship with the intramastoid portion of the facial nerve; (c) Inferior tympanic artery, particularly in the most caudal tract of the funnel, since our variation ends in the jugular fossa just as the inferior tympanic canal does.

The portion crossing the LSC could arise from a deep anastomosis between SAA and stylomastoid artery, while the portion starting from a region very close to the facial nerve and running anteriorly toward the inferior tympanic canal could arise from a deep anastomosis (inferior and posterior to the tympanic cavity) between stylomastoid artery and inferior tympanic artery.

The causes of these variations arise from the embryologic development of these vessels and the Thoma's principle could be a good explanation [11]. In fact it says that the blood vessels of a region first appear as a capillary network, rather than in the final trunk like form, even in those places where the position of a vessel might seem to be predetermined by inherence. Fortuitous circumstances, such as the relations to the adjacent larger vessels and the local requirements of the tissues for blood, determine which channels of the primitive capillary network differentiate into stem arteries and veins and which become branches and tributaries, also which channels atrophy and dissapear entirely. In our case, for unknown reasons, anastomoses between the arteries mentioned above could have assumed, at a certain point of the temporal bone development, a dominant role in the vascularization of the district, originating the variation that we found in our patient.

Although the SAA is not an essential vascular supply and the coagulation of this vessels does not produce any sequela, if not previously recognized in the pre-operative CT study the presence of this anomaly may lead to damage to the SAC and severe bleeding from the SAA, with possible reduced visualization of the surgical field and possible consequent injury to the facial nerve.

Another point to underline is related to the width of the canal which is normally approximately 1 mm [10], while in the present case, it is clearly enlarged (about 1.6 to 1.8 mm) and this could be related to the pneumatizaton of the temporal bone [12].

The patient underwent a cochlear implant for a deep neurosensorial hearing loss; during the surgical procedures, the artery or its funnel was not visualized, as a classic posterior tympanotomy was adopted, drilling between the chorda tympani and the mastoid tract of the Fallopian canal. Another anatomic variation was noted at the level of the ossicular chain: the neck of malleus was completely merged with the cochleariform process and a clear medialization of the whole ossicular chain was observed. No other variations in the tympanic cavity were seen.

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