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OTOLOGY

The significance of vascular loops in the internal auditory meatus: a true incidental imaging finding?

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Abstract

Purpose To determine the clinical significance of vascular loops (VL) in the internal auditory meatus (IAM) and cerebellopontine angle (CPA).

Methods We carried out a retrospective case series in a tertiary referral centre. Out of 6978 patients undergoing magnetic resonance imaging (MRI) of the IAM for unilateral cochleovestibular symptoms we identified the ones with VLs and reviewed their medical notes. We performed a statistical correlation between the laterality of the VL in the IAM/ CPA as graded according to the Chavda classification (type 1 in the CPA, type 2 extending in the IAM, type 3 extending to the distal IAM end), the laterality of symptoms and the patient's age.

Results A total of 77 VL were identified in 64 patients (0.9%); 39 patients had the VL on the same side of the main symptom, while 25 patients had the VL on the contralateral side. There were 37 Type 1 loops, 29 Type 2 loops and 11 Type 3 loops. The comparison between the grading of the VL and the laterality of symptoms did not reach the level of significance ($p = 0.321$). There was also no association between the presence of the loop and the patients' age ($p = 0.5$). All patients were reassured and discharged without any representation in three years follow-up.

Conclusions We did not identify any significant correlation between the laterality of VLs and the laterality of symptoms, irrespective of the grading of the loop or the patients' age. Such VLs should be considered an incidental rather than causal findings.

Keywords Hearing loss · Magnetic resonance imaging · Tinnitus

Introduction

The term "vascular compression syndrome" was first suggested by Janetta in 1975 and describes a group of conditions caused by direct contact between a blood vessel and a cranial nerve [1]. Although the concept of vascular compression is widely accepted for hemifacial spasm and trigeminal neuralgia, their relationship with audiovestibular symptoms remains unclear.

There is significant variability in the vascular anatomy around the eighth cranial nerve (CN VIII; vestibulocochlear nerve) with vascular loops (VLs) commonly found at the anterior inferior cerebellar artery (AICA) at the cerebellopontine angle (CPA) and internal auditory meatus (IAM) [2]. The clinical significance of these anatomical variants is controversial with some studies suggesting that direct compression of the vestibulocochlear nerve by vascular loops at the AICA may result in otological symptoms such as vertigo, tinnitus and/or sensorineural hearing loss [3-5] Conversely, other studies have concluded that vascular loops in the IAM and CPA are an incidental finding rather than a true abnormality [6-11].

Given the existing discrepancy in the literature, we aimed to determine whether there is a statistically significant association between vascular loops identified on high-resolution MRI and cochleovestibular symptoms, examining a large database of patients and whether such imaging findings should be considered incidental.

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Materials and methods

Basic settings and patient selection

We performed a retrospective, case series in a tertiary referral, academic hospital. The project was approved by the local committee as an audit; no further approval was required.

We retrospectively reviewed a database of 6978 consecutive adult patients, who had undergone Magnetic Resonance Imaging (MRI) of the IAM between August 2012 to November 2015 to exclude a CPA or IAM pathology. All patients had been referred and undergone MRI due to asymmetrical or unilateral sensorineural hearing loss and/or unilateral tinnitus.

Patients identified with a vascular loop on MRI IAM had their clinical records independently analysed. We recorded demographic factors (age and gender), the main presenting symptom(s), indication for imaging, laterality of symptoms and laterality of the vascular loop.

The patients were organised in two groups, group A with the vascular loop on the same side as the presenting symptom and group B, with the vascular loop in the contralateral CPA/IAM.

Radiological evaluation

The MRI IAM images were reported by Head and Neck radiologists and also scored by a single senior otorhinolaryngologist blinded to the clinical history.

The MRI studies were performed using a 1.5 T system without intravenous gadolinium administration with reconstruction on axial, coronal and sagittal plane including T1-weighted and a balanced steady-state gradient echo sequence (mostly Fast Imaging Employing Steady-state Acquisition (FIESTA) or three-dimensional constructive interface steady state (CISS) sequences due to the available scans within the Trust). Although the studies were performed in different scanners within the Trust, the above-named sequences were used as a screening protocol to exclude retrocochlear pathology. Additional T1-weighted with gadolinium was acquired in cases of abnormal findings requiring further characterization. For the purposes of this study focusing on vascular loops, the FIESTA/ CISS sequences were reviewed by the radiologists but also an experienced otorhinolaryngologist.

Vascular loops were graded according to the Chavda classification based on the anatomical location of the AICA loop outlined in Table 1 (Fig. 1, 2) [3].

In patients with bilateral vascular loop, such findings were considered incidental if the patients' symptoms were unilateral; if the vascular loop was thought to be the cause of symptoms, the patients would be expected to be symptomatic bilaterally.

Table 1 Chavda classification system of vascular loops

	Description
Type I	Lying within the CPA but not entering the IAC (Fig. 1a)
Type II	Entering but not extending > 50% of the length of the IAC (Fig. 1b)
Type III	Extending > 50% of the IAC (Fig. 1c)

Data analysis

The data were organised in an Excel spreadsheet. The one-way ANOVA test was used to evaluate the presence of an association between the presence of a vascular loop and unilateral auditory symptoms taking into consideration the grade of the vascular loop. The Mann–Whitney U test was also used to assess the impact of the patients' age on the non-incidental presence of the vascular lops. Statistical significance was accepted at a level of 0.05.

Results

A total of 6978 MRI IAM scans were performed over the 39-month study period, corresponding to 13,956 ears for analysis. There were 64 patients with a vascular loop in the CPA or IAM; 34 men (53.1%) and 30 women (46.9%) in the study group. The mean age at scan was 50 years (SD 16.7) with a range of 13 to 83 years.

A total of 77 vascular loops were identified in 64 patients (0.9%). There were 37 Type 1 loops, 29 Type 2 loops and 11 Type 3 loops (Table 2). 13 patients had evidence of vascular loops bilaterally (Fig. 2). Four of the 13 patients had different types of loop in each ear (Table 3).

Out of the 64 patients, 39 (60.9%) had the VL on the same side as the main presenting symptoms (group A) and 25 (39.1%) on the contralateral side (group B). The mean age for group A was 49 years (SD 15.4) and group B 50 years (SD 19.0). There was no association between the age of the patients and the presence of an AICA loop, as the comparison of the age between the group with vascular loops on the ipsilateral side of symptoms and the group of vascular groups on the contralateral side did not reach the level of significance ($p = 0.5$).

Type I loops were present in 51.9% of same-side symptomatic ears compared to 48.1% of the contralateral-side symptomatic ears. Type II loops were seen on 71.4% of the same-side symptomatic ears and 28.6% of the contralateral-side

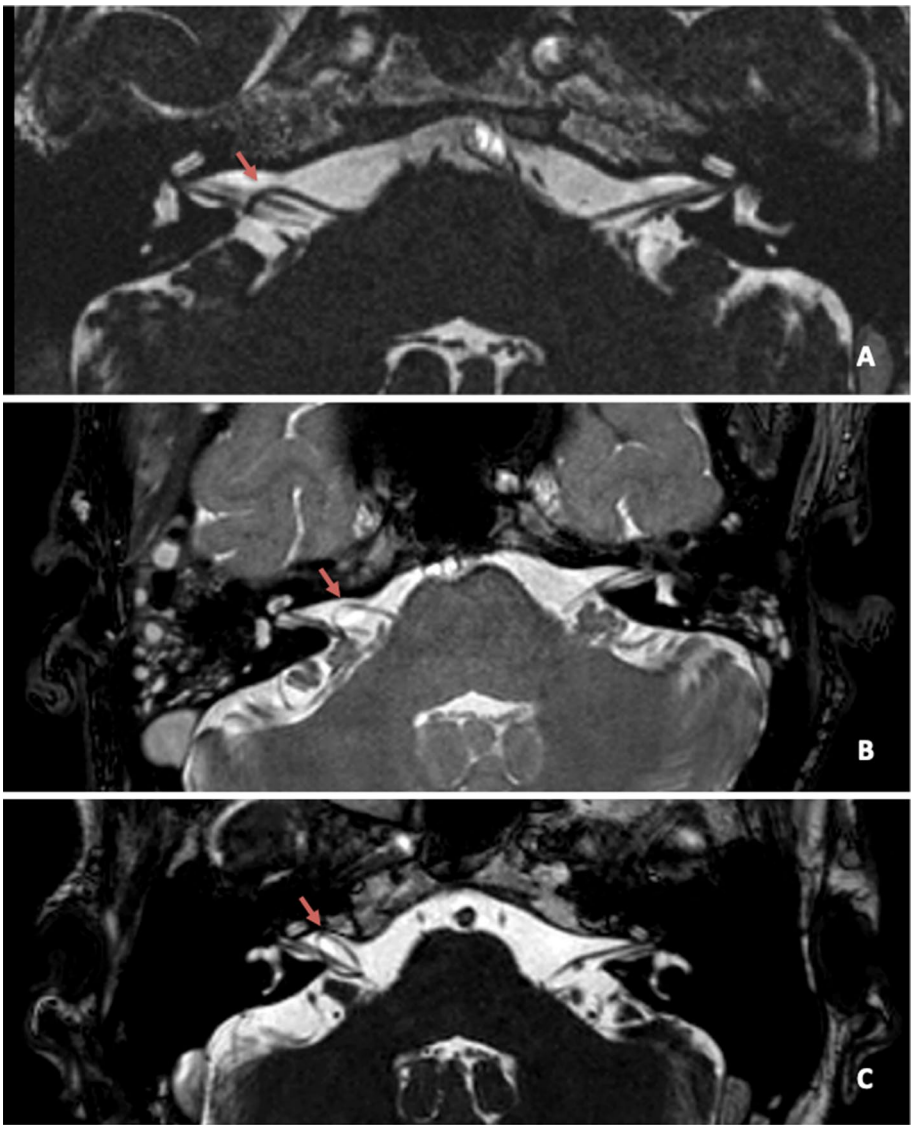

Fig. 1 Vascular loops (arrows) in the IAM and CPA as shown on axial sections FIESTA MRI; grade 1 (**a**), grade 2 extending in the IAM but not more distally than 50% of its length (**b**) and grade 3 extending far distally (over 50% of its length) (**c**)

Table 2 Distribution of AICA loops in the study population

Side	Type I	Type II	Type III
Right	16	18	5
Left	21	11	6
Total	37	29	11

symptomatic ears. Type III loops were only identified in 55.6% of the symptomatic same-side ears and 44.4% of the symptomatic contralateral-side ears (Table 3). The comparison between the grading of the vascular loops and the laterality of symptoms (ipsilateral/ contralateral) did not reach the level of significance ($p = 0.321$).

All patients were reassured and discharged. No patients represented with worsening symptoms or required intervention over a follow-up period of three years.

Discussion

Main findings

Our study did not find any statistically significant correlation between the laterality of vascular loops and the laterality of the symptoms, irrespective of the grading of the loop (how deep it goes into the IAM) or the patients' age. Based on our findings, vascular loops in the CPA and IAM should be considered an incidental finding rather than a pathological event. Despite the discrepancy in the literature, the relatively large number of patients in our study compared to similar existing studies, twofold assessment by both a radiologist and otorhinolaryngologist, and statistical analysis accounting for the age of the patients in both groups, ensured the accuracy of our interpretation and results.

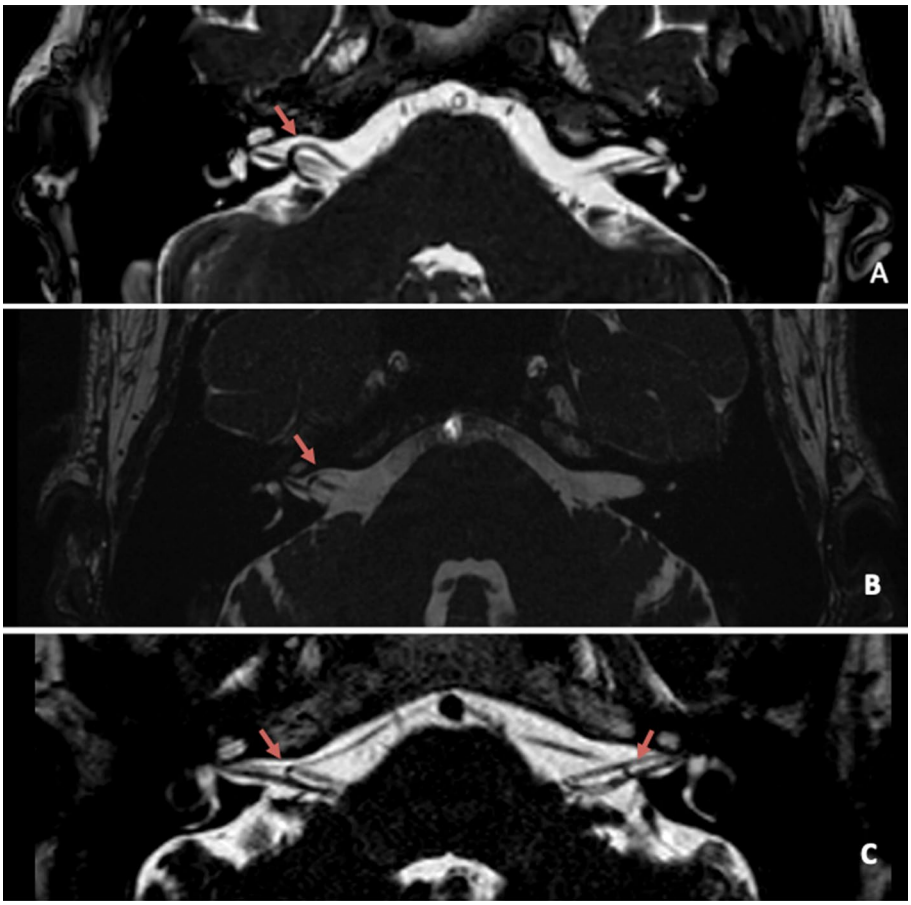

Fig. 2 Axial sections on FIESTA MRI showing vascular loops (arrows) in the IAMs: grade 2 on the right side (**a**), grade 3 on the right side (**b**) and bilateral grade 1 (**c**)

Table 3 Bilateral loops and AICA loop type

Patient	Age	Gender	Symptom laterality	Vascular loop type	
				Left	Right
1	78	F	Left	1	2
2	57	M	Left	1	2
3	78	F	Left	1	1
4	54	F	Left	1	3
5	41	M	Left	1	1
6	62	F	Left	1	1
7	51	M	Right	1	1
8	17	F	Left	3	2
9	53	M	Left	1	1
10	69	M	Right	1	1
11	51	F	Left	1	1
12	36	M	Left	2	2
13	34	M	Left	1	1

F female, *M* male

CPA vascular anatomy and its significance

The AICA arises from the lower portion of basilar artery into the cerebellopontine angle where it is closely related to important structures including the trigeminal nerve, facial nerve and vestibulocochlear nerve [12]. There is significant variability in the vascular anatomy surrounding the eight cranial nerve, including the presence of vascular loops in the CPA that can extend into the internal auditory canal [13]. Although the concept of vascular compression has become accepted for hemifacial spasm and trigeminal neuralgia, the significance of these vascular loops and their association with ipsilateral cochleovestibular symptoms remains controversial in the literature due to the continued observations of AICA vascular loops in asymptomatic patients [7].

Several theories have been suggested, namely progressive pulsatile vascular compression of the nerve resulting in focal demyelination at the junction between the central glial and peripheral non glial junction [14], hardening of the arterial wall from atherosclerosis [15] and arachnoid adhesions that cause fixation of the vessel to the nerve [16]. Impaired blood flow by direct result of neurovascular compression may also reduce vascular perfusion of the cochlear and vestibule, leading to dysfunction and development of symptoms

[17]. Despite the above theories, it might be that it is the wide variability in the anatomy of the IAM [13] and potentially the more available space for the existing structures that makes the VL in this area incidental than causal findings.

In our study, we did not find any significant correlation between the presence of vascular loops in the CPA, even extending distally into the IAM, and patients symptoms, indicating that the vascular loops in this anatomical area should be considered an anatomic variation rather than a causal radiological finding. Indeed, the presence of a vascular loop in this region was not significantly associated with ipsilateral symptoms, at any grade of AICA loop, with a high prevalence of vascular loops present in the asymptomatic ear. Our results are in concordance with those by van der Steenstraten, De Carpentier and Makins, where no statistically significant association was found between auditory symptoms and the presence of an AICA loop causing compressing of the eight cranial nerve [6, 7, 11].

Interestingly, other studies have reported that unilateral hearing loss is significantly related to the presence of AICA loops [3, 18]. This discrepancy may be explained by the methodology; whilst McDermott recruited consecutive patients with unilateral auditory symptoms or asymmetrical hearing loss, we used consecutive MRI IAM scans (aiming to exclude CPA tumours) and retrospectively correlated to clinical findings in a very large number of MRI scans. Examining the presence of a vascular loop in a symptomatic ear can lead to biased outcomes unless such results are compared with a control group; a group of patients with the radiological presence of vascular loop on the contralateral side. The direct comparison of the two groups of patients with vascular loops, the one with the loop on the ipsilateral and the one with the loop on the contralateral side in our work, strengthens our outcomes.

As a result of possible causal relation, invasive neurosurgical microvascular decompression of the vestibulocochlear nerve has been described for patients with vascular loops in contact with CN VIII in an attempt to relieve unilateral symptoms with variable results [1, 18-20]. Such techniques include the decompression of the internal auditory canal [20] or placement of a silicon or Teflon cushion between the "compressing artery" and CN VIII [18]. It has been suggested that neurophysiological basis for vascular compression is unconvincing; with some authors suggesting the reported successes in alleviating these symptoms by surgical decompression may in fact be secondary to trauma to the CNVIII during operative dissection [21]. Microvascular decompression is infrequently performed for audiovestibular symptoms because of its invasive nature and the unclear impact of the vascular loop on the patients' symptoms.

Are such surgical measures really necessary? A review article on vascular loops causing otological symptoms by Chadha et al., found a high prevalence of vascular loops in contact with CN VIII in asymptomatic ears (21–34%) suggesting that VLs should be considered a normal anatomical variant and although, in theory, a vascular loop contact CN VIII may contribute to unilateral auditory symptoms, it should not be considered as the primary causative diagnosis [22]. Our results demonstrating that vascular loops in the CPA and IAM are a true incidental finding, are in agreement with most of the otherwise limited published works, suggesting that surgical interventions, like the ones briefly described above, are not indicated.

Of note that in our study we also added the patients' age in our statistical analysis, as one could suggest that the older the patients are the harder the vessels become, predisposing to the potential impact of a VL on the cochleovestibular nerve. Given the lack of any statistical significance, such theory is not supported. Finally, the lack of any representations of any of the enrolled patients in our study within a three-year follow-up strengthens our conclusion even more.

Incidence of vascular loops in the CPA and IAM

Our study demonstrated that vascular loops were found in the CPA in 0.9% of cases. This is in partial concordance with previous literature examining the prevalence of incidental findings on magnetic resonance imaging in patients presenting with audiovestibular symptoms with studies by Papanikolaou et al., Htun et al. and Gupta et al. demonstrating rates of 1%, 6.4% and 8.66%, respectively [23-25]. Higher rates of vascular loops reported in the literature may be related to the enrolled patients and the assessment method (MRI, CT, histopathology); nevertheless, higher rates of vascular loops amongst the population support their lack of clinical significance with rates of up to 50% on MRI [26] reported, while unilateral auditory symptoms are, although difficult to estimate, lower than the reported incidence of vascular loops.

Strengths and weaknesses

The retrospective nature of this study and the associated inherent bias represents the main weakness of the present study. However, the enrolment of a large number of patients with IAM/ CPA vascular loops, detailed analysis taking into consideration the grade of vascular loop and age of the patient in addition to the direct comparison between Group A with the presence of the loop on the ipsilateral side and Group B with the loop on the contralateral side of symptoms, was used to overcome such limitations and ensure the accuracy of the findings.

Conclusion

We did not identify any statistically significant relationship between vascular loops in the IAM or CPA and neuro-otological symptoms, regardless of the vascular loop grading or the patients' age. Such radiological findings should be considered an anatomical variant and a true incidental finding rather than a pathological event.

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Compliance with ethical standard

Conflict of interest None to declare.

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