Original Article

SYSTEMATIZATION OF VESTIBULAR AQUEDUCT ANATOMICAL STUDY BY HIGH-RESOLUTION COMPUTED TOMOGRAPHY IN PATIENTS WITH UNILATERAL MENIERE'S DISEASE*

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Abstract **OBJECTIVE: To systematize the assessment of vestibular aqueduct by high-resolution computed tomography (HRCT) in patients with unilateral Ménière's disease as compared with a control group. MATERIALS AND METHODS: We have selected 20 patients with unilateral Ménière's disease, according to the guidelines proposed by the American Academy of Otolaryngology – Head and Neck Surgery. The control group consisted of ten individuals with normal audiometric tests. Overall, we have studied 60 ears, equally divided into three groups: group I – Ménière's disease, affected ear; group II – Ménière's disease, non-affected ear; group III – control. All the individuals have undergone temporal bones HRCT. Images were blindly reviewed, trying to evaluate the visibility of the descendent portion of the ventricular aqueduct. Afterwards data were correlated with their respective groups. RESULTS: We have identified the vestibular aqueduct in 95% of ears in group I, 90% in group II, and 100% in group III. CONCLUSION: It is possible to perform a systematic evaluation of the vestibular aqueduct by axial HRCT, using the same radiological technique, anatomical knowledge and sequential images of inner ear structures. With this systematic approach we have obtained a high rate of vestibular aqueduct visualization, with no statistically significant difference between the groups.**
Keywords: Vestibular aqueduct; Temporal bone; Tomography – methods; Helicoidal computed tomography; Ménière's disease.

Resumo *Sistematização do estudo anatômico do aqueduto vestibular por tomografia computadorizada de alta resolução em pacientes com doença de Ménière unilateral.*
OBJETIVO: Sistematizar a avaliação do aqueduto vestibular por tomografia computadorizada de alta resolução (TCAR) em pacientes com doença de Ménière unilateral e comparar com um grupo-controle. MATERIAIS E MÉTODOS: Selecionamos 20 pacientes com doença de Ménière unilateral, segundo critérios da Academia Americana de Otorrinolaringologia – Cirurgia de Cabeça e Pescoço, e um grupo-controle composto por dez indivíduos com avaliação auditiva normal, totalizando 60 orelhas, distribuídas igualmente em três grupos: grupo I – doença de Ménière, orelha comprometida; grupo II – doença de Ménière, orelha não-comprometida; grupo III – controle. Submetemos os pacientes à TCAR de ossos temporais. O estudo das imagens foi feito de modo cego, procurando avaliar a visibilidade da porção descendente do aqueduto vestibular. Os dados obtidos foram correlacionados com os respectivos grupos. RESULTADOS: A visualização do aqueduto vestibular foi de 95% no grupo I, 90% no grupo II e 100% no grupo III. CONCLUSÃO: É possível sistematizar a avaliação por TCAR do aqueduto vestibular, com aquisição axial, usando a mesma técnica radiológica, conhecimento anatômico e seguimento seqüencial das estruturas da orelha interna. Com esta sistematização houve alta taxa de visualização do aqueduto vestibular, sem diferença estatisticamente significante entre os grupos.
Unitermos: Aqueduto vestibular; Osso temporal; Tomografia – métodos; Tomografia computadorizada helicoidal; Doença de Ménière.

INTRODUCTION

From an anatomophysiological perspective, the vestibular aqueduct (VA) is one of the most studied labyrinthine structures in the context of Ménière's disease. The VA is a small bony canal of labyrinthine capsule linking the medial wall of the vestibule of the inner ear to the posterior part of the petrous temporal bone. It surrounds the endolymphatic duct and includes part of the endolymphatic sac where the endolymph reabsoption occurs [(1)].

The VA anatomy was described in the sixties[(2–4)], as a bony tunnel containing the endolymphatic duct and the endolymphatic sac. It originates from the medial wall of the vestibule, proceeding through the optic capsule medial and anterior to the crus commune, which is an useful radiographic marker. Initially running in the same direction, it then bends inferiorly and continues up to its aperture on the medial and posterior surface of the petrous bone between the internal acoustic pore and the sigmoid sulcus (Figure 1).

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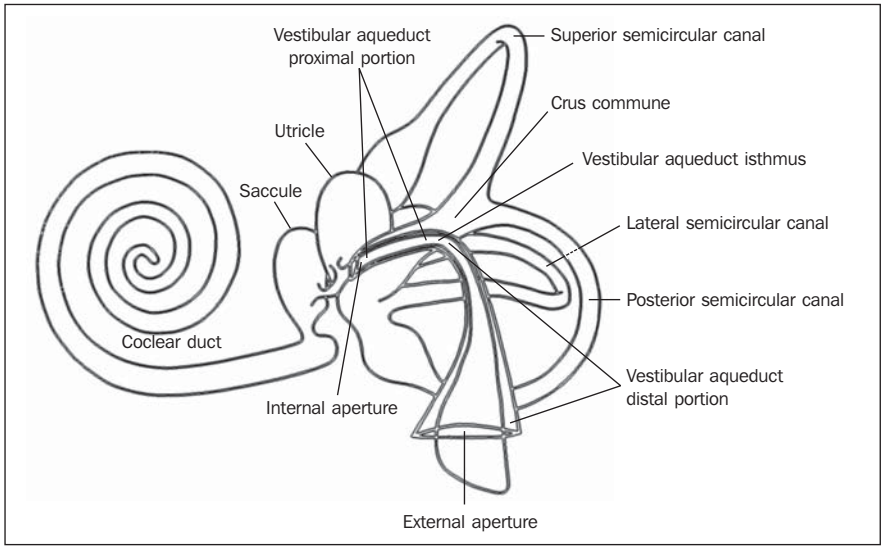

Figure 1. Schematic representation of the membranous labyrinth and of the right vestibular aqueduct. The VA originates from the medial wall of the vestibule as a bony canal towards the endolymphatic duct and sac. The VA external aperture is localized on the pyramid posterior surface.

In the literature concerning Ménière's disease, there are several studies reporting high rates of non-visualization of the VA[1,5–21], and poorly pneumatized mastoid in affected ears[11,15–18,21,22]. However, other authors[23–25] have considered such remarks as non-specific diagnostic signs found in an array of otologic conditions and even in normal ears.

Despite the high number of publications correlating VA and Ménière's disease, there still remains a great controversy on the best method of evaluating it. Additionally, there is a great difficulty in comparing the results of these studies because of the non-standardization of radiological interpretation techniques.

Therefore, this study has been performed with the purpose of contributing to the systematization of the VA anatomical evaluation by means of high-resolution computed tomography (HRCT) and, based on this standardization, to study VA of patients with unilateral Ménière's disease compared with normal individuals.

MATERIALS AND METHODS

Casuistic

We have selected 20 patients presenting with Ménière's disease at the Otology and Otoneurology Clinic of Hospital São Paulo/Universidade Federal de São Paulo-Escola Paulista de Medicina, according to criteria proposed by the American Academy of Otolaryngology – Head and Neck Surgery[26]. These patients have been submitted to otorhinolaryngological and otoneurological examinations, including a complete audiometric evaluation (tonal, vocal audiometry, intelligibility threshold test, vocal discrimination, imitanciometry) and bilateral electrocochleography (transtympanic).

A control group was formed by ten normal individuals who did not present any complaint about hearing loss and with normal audiometric evaluation. None of the individuals included in the present study had antecedents of chronic otitis media, noise exposure or use of ototoxic drugs.

Therefore, we have studied 60 ears distributed into three groups: group I (GI) – 20 ears affected by unilateral Ménière's disease; group II (GII) – 20 contralateral ears (non-affected by Ménière's disease); group III (GIII), control group – 20 normal ears.

We have included ten normal individuals who not complained of hearing loss, with no antecedent of chronic otitis media, noise exposure or use of ototoxic drugs. All of them presented normal audiometric evaluation (tonal audiometry, vocal audiometry, intelligibility threshold and vocal discrimination).

The research protocol was previously approved by the Committee of Ethics and Research of Unifesp-EPM, project No. 0081/04. All the individuals have signed a Term of Informed Consent.

The present study constitutes a case-control type study.

Procedures

The 20 previously selected patients with unilateral Ménière's disease and 10 control patients were submitted to temporal bones HRCT for evaluation of their inner ear, in the period between March and June 2004. The images were acquired in a Siemens® Somaton Balance helicoidal tomograph, with the patient in supine position, 1.0/1.5 mm thickness/increment, axial scanning along the orbitomeatal line, 512 × 512 matrix, 135 mAs, 130 kVp, 180 mm FOV, 1.5 pitch, bone filter, the reading being performed with a 4.000/600 Hounsfield unit window/level. The images were blindly reviewed, without the reviewers' knowledge of the Ménière's disease group and the control group systematized posterior labyrinth evaluation, trying to identify the VA, focused only on the study of the post-isthmian segment.

Initially, the superior semicircular canal was identified (an image equivalent to both contiguous portions, the superior portion being the possible identification of the arcuate eminence); contiguous craniocaudal images were acquired, with later visualization of vestibule, posterior semicircular canal, crus commune between superior and posterior semicircular canals, lateral semicircular canal and vestibular aqueduct (descending portion up to the external aperture on the petrous pyramid posterior surface), according to Figures 2A–H.

Images data were stored, digitized in magnetic-optic disks and transferred to a PC, using a Dicom protocol. The DicomWorks® software for recording and analysis of HRCT images was utilized, allowing images magnification.

After the tomographic evaluation, findings regarding VA visibility were correlated with groups I, II e III.

Figures 2A–H show axial/craniocaudal contiguous views of the left temporal bone (1 mm thickness), from the superior semi-

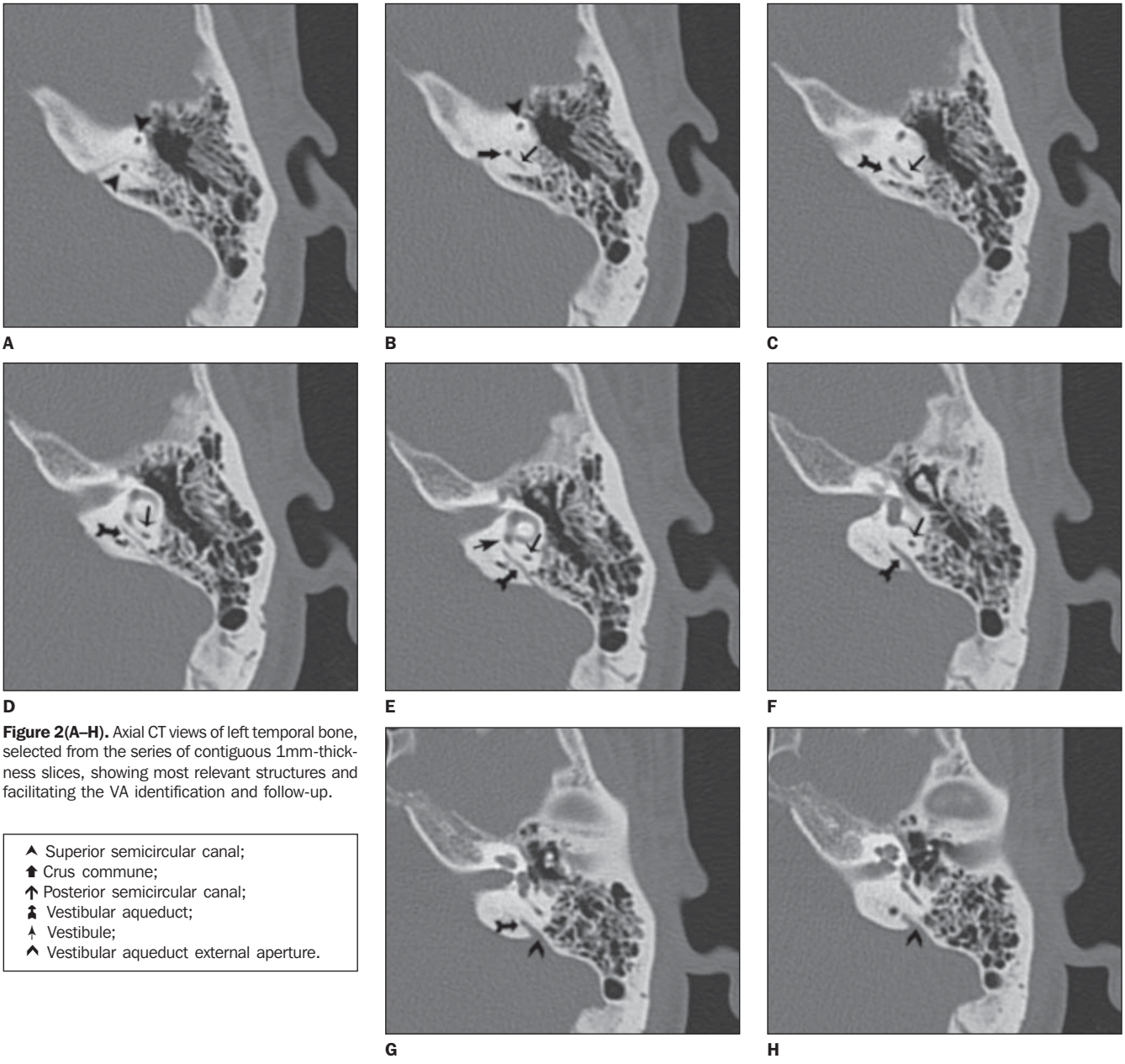

Figure 2(A–H). Axial CT views of left temporal bone, selected from the series of contiguous 1mm-thickness slices, showing most relevant structures and facilitating the VA identification and follow-up.

- Superior semicircular canal;
- Crus commune;
- Posterior semicircular canal;
- Vestibular aqueduct;
- Vestibule;
- Vestibular aqueduct external aperture.

circular canal up to the last view where the VA external aperture is seen.

RESULTS

A comparative analysis was made between study-groups (I, II) and control group (III).

The VA visualization analysis in the three groups is shown on Table 1. The VA visualization rate was higher than 90% in all the groups, and the low number of cases with non-visualization impeded the application of statistical analysis.

DISCUSSION

In the present study, we have opted to select patients with unilateral Ménière's disease, just to allow us to comparatively study the contralateral ear, not as a control-group, but rather to evaluate the diagnostic imaging method — HRCT — as regards the study of the vestibular aqueduct anatomical structure. Considering that a percentage of patients with unilateral Ménière's disease could be bilaterally affected along the disease progression, it seemed interesting to study the ears in a blind way, without the knowledge of the affected ear, comparing them with those in the control-group[17,21,24].

We have opted to utilize temporal bone HRCT for being the most appropriate method for studying bone structures like VA, a reliable method (correlation with measurements performed during the temporal bone microdissection[27,28]), and for allowing the study of structures with up to 0.5 mm in diameter. We have studied only the VA distal segment because usually it is well defined [13], contrarily to the proximal segment (isthmus) that frequently is not

Table 1 Analysis of vestibular aqueduct visualization in groups I, II e III.

	Group I		Group II		Group IIII		Total	
Vestibular aqueduct	N	%	N	%	N	%	N	%
Visualized	19	95.0	18	90.0	20	100.0	57	95.0
Non-visualized	1	5.0	2	10.0	0	0.0	3	5.0
Total	20	100.0	20	100.0	20	100.0	60	100.0

visualized due its lumen narrowing, besides being obscured by the contiguous crus commune.

The non-visualization of VA does not mean necessarily that it is absent[29]; besides, other technical factors or anatomical characteristics[12,22,30,31], as well as the influence of the partial volume effect [32] may be involved.

Along the development of the present study, we have concluded that the series of axial slices is sufficient for the VA study, since it can be visualized between the crus commune and the VA external aperture in a same slice plane in the contiguous slices series of the image acquisition. This technical refinement associated with a reasonable anatomical knowledge facilitates the identification of the VA as well as the study of the segment between the crus commune and the external aperture.

Although the role of the VA size and shape in the Ménière´s disease pathogenesis and diagnosis remains inconclusive, these parameters have been studied in this context. There are many controversies in the literature as regards the VA visualization, or not, in the Ménière's disease by means of CT or even HRCT. Additionally, because of the absence of study protocols systematization, the existent studies do not allow us to make a reasonable number of comparisons. Also, it is important to note that since 1973, with the CT introduction, this technology has had a significant development, allowing a better visualization of smaller structures, like in the HRCT, where it is possible to study 0.5 mm details. For this reason, we have proposed to systematize the VA study by means of HRCT and, consequently, to study the descendent course of the vestibular aqueduct and the temporal bone a retrolabyrinthic region in the three groups (I, II, III).

It is important to note that several studies have shown a low rate of visualization of the vestibular aqueduct in patients with Ménière's disease, in contrast with our study which has shown high rate of visualization (90%) with our systematization. Our results have shown no statistically significant difference in visualization rates between groups, i.e, the patients with Ménière's disease have not presented lower visualization rates when compared with the control group.

We agree with the assertion of Wilbrand[22], that there is no specific radiological sign for Ménière's disease, but, based on the results of our study where the VA has been visualized in 95% of patients in GI and 90% in GII, we disagree with their assertion considering as irrevocable the concept that the VA tomographic reproducibility is more difficult in patients with Ménière's disease.

As regards the VA visualization rates, all the groups in our study compare to other studies utilizing 1.0 mm slices thickness[30,31,33] and, as regards the Ménière's disease group, they are higher than those reported by Xenellis *et al*.[21], maybe because they have utilized a 1.5 mm slice thickness.

In contrast with our findings, we have the pioneering study of Clemis and Valvassori[5], correlating the non-visualization of VA with the Ménière's disease, a concept that is corroborated by other studies[7,8,20–22]. On the other hand, our findings regarding the VA visibility compare to the control groups, excepting those reported by De Groot *et al*.[20], who have visualized the VA in only 74% of their control-group. Maybe this is due to the 1.5 mm slice thickness utilized, not to the use of polytomography in the other studies, with the exception of the latest one which has utilized HRCT.

Even with magnetic resonance imaging, some studies have shown that there is a controversy about the lower visibility of the endolymphatic duct in the Ménière's disease in relation to the control-group. Lorenzi *et al*.[34] have observed that the endolymphatic duct/endolymphatic sac seems to be statistically less visible in patients with Ménière's disease, with no difference between affected and non-affected ears in cases of unilateral disease. On the other hand, Salvinelli *et al*.[35] have found a lower visibility of the endolymphatic duct/sac in the affected ear, and visibility, although partial, in the ear not affected by the Ménière's disease.

In the present study, the incidence of non-visualization of VA was low in all of the groups. This allows us to systematize the VA study by means of HRCT with axial acquisition utilizing the same radiological technique, anatomical knowledge and sequential follow-up of the internal ear structures.

Chart 1 expresses the difference of non-visualization of VA in the control group and non-visualization of VA in the Ménière´s disease between several studies. This is the reason of the importance of systematizing the VA study, since we think that the low rate of VA visualization in some studies may occur because of the polytomography technical difficulties compared to HRCT and other previously discussed factors, not the Ménière's disease.

Our opinion is that, the systematization of the VA study as well as standardization of terms may allow a comparison between studies, contributing to the Ménière´s disease evaluation and determining what is a normal VA and, in the future, what is an enlarged VA.

CONCLUSION

It is possible to systematize the vestibular aqueduct evaluation by means of HRCT with axial acquisition, utilizing the same radiological technique, anatomical knowledge and sequential follow-up of the internal ear structures. With such systematization there is no statistically significant difference in the VA visualization in cases of Ménière´s disease in relation to the control-group.

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Chart 1 Non-visualization of vestibular aqueduct in the control-group and non-visibility of vestibular aqueduct in the Ménière's disease group among different studies.

Author(s)	Control group Non-visualization of vestibular aqueduct (%)	Ménière's disease Non-visualized/oblitarated/ non-identified vestibular aqueduct (%)
Rumbaugh *et al*., 1974[8]	3	37.5
Stahle e Wilbrand, 1974[7]	0	41
Oigaard *et al*., 1975[23]	3	47
Arenberg *et al*., 1977[11]	0	41
Valvassori & Clemis, 1978[13]	8	31
Kraus & Dubois, 1979[24]	30	28
Austin, 1981[14]	5	65
Hall *et al*., 1983[30,31]	12.3	12.8
De Groot *et al.*, 1987[20]	26	75
Yazawa & Kitahara, 1991[18]	25	55
Takeda *et al*., 1997[33]	0	0
Xenellis *et al.*, 2000[21]	3.4	27.8

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