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Clinical Record

Large vestibular aqueduct syndrome and endolymphatic hydrops: two presentations of a common primary inner-ear dysfunction?

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Abstract

Objective: To present the theory that large vestibular aqueduct syndrome (i.e. the recognised existence of an enlarged vestibular aqueduct with progressive sensorineural hearing loss) and endolymphatic hydrops are due to a common primary dysfunction of inner-ear fluid homeostasis.

Method: Case report and review of the world literature concerning large vestibular aqueduct syndrome and endolymphatic hydrops.

Results: We report a family in which one sibling suffered from large vestibular aqueduct syndrome while the other had classic Ménière's disease. This suggests that large vestibular aqueduct syndrome and endolymphatic hydrops, in some cases, may be due to a common primary dysfunction of inner-ear fluid homeostasis.

Conclusion: To our knowledge, this is the first report in the world literature to postulate that variation in the relative compliance of inner-ear membranes could be the factor that determines the manifestation of the disorder as either endolymphatic hydrops or large vestibular aqueduct syndrome.

Key words: Meniere's Disease; Inner Ear; Vertigo; Vestibular Aqueduct

Introduction

The vestibular aqueduct is a bony canal within the otic capsule, which courses from the operculum on the surface of the petrous pyramid of the temporal bone to end along the medial wall of the vestibule. Contained within the vestibular aqueduct is a membranous canal, the endolymphatic duct, which allows the flow of endolymph between the vestibule and the endolymphatic sac. By the age of four years, due to growth of the posterior cranial fossa during childhood development, the endolymphatic duct is pulled from a rather short, broad column into an elongated, inverted 'J' shape.[1] This results in an adult vestibular aqueduct diameter of 0.4–1.0 mm, with a mean of 0.62 mm.[2]

Valvassori and Clemis first defined the radiographic appearance of an enlarged vestibular aqueduct, stating that a vestibular aqueduct was enlarged if it had an anterior to posterior diameter of greater than 1.5 mm, measured halfway between the common crus and the operculum.[3] These authors coined the phrase 'large vestibular aqueduct syndrome' to describe patients with an enlarged aqueduct diameter and progressive sensorineural hearing loss (SNHL). Large vestibular aqueduct syndrome is usually bilateral and begins in early childhood, and stepwise losses of acuity are reported, frequently following seemingly trivial head trauma.[4,5] Histologically, these patients are described as having large or even 'huge' endolymphatic sacs that are thin-walled and without the rugal folds and perisaccular loose vascular tissue that would be found in the more normally developed sac.[6–8] Jackler and De La Cruz postulate that a 'teratogenic insult' during development may result in persistence of the immature widened duct. Recently, mutations in the pendrin gene have been shown to be responsible for Pendred syndrome as well as isolated large vestibular aqueduct syndrome.

Another cause of SNHL resulting from abnormalities within the endolymphatic compartment is endolymphatic hydrops, including Ménière's disease, for which myriads of possible aetiological causes have been described. In contrast to the findings in large vestibular aqueduct syndrome, the endolymphatic hydrops of Ménière's disease is frequently associated with a small aperture of the vestibular aqueduct and a small, malfunctioning endolymphatic sac, thus prompting some authors to describe Ménière's disease as a 'congenital disorder of the endolymphatic sac'.[9,10]

Large vestibular aqueduct syndrome and endolymphatic hydrops are considered distinct clinical disorders without clinical or pathological similarities. In this paper, we report a family in which one sibling had bilaterally enlarged vestibular aqueducts and the other had classic Ménière's disease, suggesting that there may be a common underlying pathogenesis for large vestibular aqueduct syndrome and Ménière's disease.

Case history

A 42-year-old man was referred with complaints of slowly progressive hearing loss, greater on the left side than the right, over the past eight years, becoming most noticeable

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over the previous four years. He had been given a hearing aid seven years prior, had no significant trauma or noise exposure, and reported occasional bilateral tonal tinnitus without vertigo.

The patient's family history was significant. A 39-year-old brother had been diagnosed 10 years ago with Ménière's disease, manifesting as: near-constant tinnitus; episodic, sudden SNHL involving the left side more than the right; and periodic vertigo, nausea and vomiting.

Physical examination revealed bilaterally intact tympanic membranes, with a midline Weber test and bone conduction greater than air conduction bilaterally.

Audiometric evaluation revealed bilateral down-sloping SNHL with relatively flat conductive hearing loss (CHL) bilaterally, slightly greater on the left than the right. Laboratory evaluation for autoimmune dysfunction, endocrine abnormality and infectious disease was negative. Computed tomography (CT) of the patient's temporal bones revealed bilateral enlarged vestibular aqueducts, more so on the right than the left, with no radiographic evidence for otosclerosis and no soft tissue masses or abnormalities of the internal auditory canal, cochlea or cochlear duct.

This patient had originally been diagnosed with otosclerosis and referred to us for surgical management, before the diagnosis of large vestibular aqueduct syndrome was made. In light of the large vestibular aqueduct syndrome, surgery was not recommended. A CT scan of the brother's temporal bones revealed normal vestibular aqueducts.

Discussion

Endolymphatic hydrops and large vestibular aqueduct syndrome have in general been considered to be separate, unrelated entities, and some authors have suggested that it is 'doubtful that endolymphatic hydrops plays a role in the SNHL of large vestibular aqueduct syndrome'.[6] Enlarged vestibular aqueduct is probably a heterogeneous disorder with distinct bony or membranous pathology.[11] Specifically, it may be due to either a primary abnormality of development of the petrous section of the temporal bone, or to a primary abnormality of the endolymphatic space with subsequent canal enlargement due to hydrostatic pressure. Jackler and De La Cruz speculated that an enlarged vestibular aqueduct probably results from cessation of the development of the endolymphatic duct due to decreased stretch of the temporal bone and duct during growth of the posterior cranial fossa. Furthermore, they suggest that, in patients with large vestibular aqueduct syndrome, increased endolymphatic pressure manifests as distension of the sac and duct rather than intracochlear distension or endolymphatic hydrops.[6] The bone enlargement of the vestibular aqueduct may be secondary to hydrostatic pressure from an enlarged vestibular aqueduct. In support, Gussen has reported histopathological findings suggestive of bony erosion secondary to increased pressure within the endolymphatic duct.[8] These patients may be subject to increased risk of perilymphatic fistula and round window abnormality because of increased pressure transmission via the vestibular aqueduct and cerebrospinal fluid (CSF).[12]

Endolymphatic hydrops has been differentiated from large vestibular aqueduct syndrome in that the former is not associated with an enlarged vestibular aqueduct. Clinically, large vestibular aqueduct syndrome is associated with a sudden, stepwise development of SNHL rather than the progressive hearing loss more commonly seen in endolymphatic hydrops. Theories for the sudden hearing loss associated with large vestibular aqueduct syndrome have included reflux of hyperosmolar endolymphatic sac contents into the cochlea, and build-up of toxic metabolites due to a hypofunctioning, enlarged endolymphatic sac.[6,13] It has also been postulated that an enlarged vestibular aqueduct could act as a conduit for pressure variations within the posterior cranial fossa, leading to sudden high pressures within the endolymphatic space with resultant direct damage of inner-ear structures, or, if the pressure is maintained, impairment of inner-ear blood supply.[13] This is particularly intriguing when considering that children with enlarged vestibular aqueduct often exhibit hearing loss following seemingly innocuous head trauma; it may be that sudden increases in CSF pressure overwhelm the pressure equilibration capacity of the cochlear duct and eustachian tube.[14–16] It is also interesting to note that perilymphatic fistula and round window membrane abnormalities have been observed in patients with enlarged vestibular aqueduct, perhaps because of pressure gradients from the endolymphatic space.[17–19]

A patient with enlarged vestibular aqueduct and stapes fixation has been reported; this patient was considered a poor surgical candidate given the likelihood of progressive, stepwise SNHL and also the high risk of a stapes 'gusher'.[20] Several authors have noted the coexistence of perilymphatic fistula with congenital ear malformation. The sex-linked genetic condition known as XDFG (i.e. X-linked deafness, fixed stapes footplate and perilymphatic gusher) further demonstrates how stapes footplate fixation and high fluid pressures may be linked within families.[21] The high risk of a stapes gusher and hearing loss following surgical intervention led us to avoid stapes surgery in our patient.

- **The term 'large vestibular aqueduct syndrome' describes patients with a enlarged aqueduct diameter and progressive sensorineural hearing loss**
- **This paper reports a family in which one sibling suffered from large vestibular aqueduct syndrome while the other had classic Ménière's disease**
- **This suggests that large vestibular aqueduct syndrome and endolymphatic hydrops may in some cases be due to a common primary dysfunction of inner-ear fluid homeostasis**

Most interesting is the possibility that large vestibular aqueduct syndrome and endolymphatic hydrops are actually both manifestations of a primary, and potentially congenital, abnormality in inner-ear fluid volume and pressure haemostasis, with variation in the location of presentation of the hydrops due to differences in membrane compliance in different parts of the ear amongst patients. Higher compliance at Reissner's membrane would favour the development of endolymphatic hydrops, while higher compliance in the vestibular aqueduct (perhaps with coexisting stapes footplate fixation) would favour development of large vestibular aqueduct syndrome and a subsequent increased susceptibility to stepwise hearing loss following CSF pressure fluctuation. Our patient probably had maximum compliance in the vestibular aqueduct, leading to large vestibular aqueduct syndrome, while his brother had higher compliance at Reissner's membrane, resulting in manifestation of his inability to normally regulate inner-ear fluid equilibrium as endolymphatic hydrops. Temporal bone studies aiming to assess membrane compliance in patients with the two disorders may provide support for the notion of a common primary abnormality. Furthermore, our theory of a fundamental primary abnormality is supported by recent evidence for a potential familial large vestibular aqueduct syndrome; the authors involved state 'it is more

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accurate to consider enlarged vestibular aqueduct as a radiologic marker for the underlying molecular or cellular pathogenetic defects causing the clinical manifestation of large vestibular aqueduct syndrome'.[22]

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