PATHOGENESIS OF MENIERE’S DISEASE

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Introduction

Meniere’s disease, a disorder of inner ear function that is commonly encountered in otolaryngologic practice, can cause devastating hearing and vestibular symptoms. Successful treatment of this disorder depends upon understanding its mode of origin and natural development, its pathogenesis. Because current understanding of the pathogenesis of Meniere’s disease is imprecise, treatment is significantly influenced by empiric principles. This review will show, however, that anatomic variations in temporal bone, malabsorption in the endolymphatic sac, and genetic factors each play major roles in the pathogenesis of Meniere’s disease. Knowledge of these factors can be helpful in the design of methods of treatment.

Classification of Meniere’s Disease

Rather than distinguishing Meniere’s disease (of “idiopathic,” ie, as yet unknown, etiologic origin) from Meniere’s syndrome (of known etiologic origin), we prefer to use the term Meniere’s disease for all cases demonstrating the symptom-complex characteristic of Meniere’s. Cases can then be divided into those of known and of unknown etiologic origins, as listed in Table 1. Among our patients, approximately 25% can be associated with one of the known causes listed in Table 1.

Natural History

In a review of over 500 patients with Meniere’s disease (1), we found an equal distribution between the sexes. The disease was by far the most common among adults, although there are many instances of children as young as 6 years of age with classical Meniere’s disease (2). Roughly 15% of patients with Meniere’s disease can identify blood-relatives with the same disease. This suggests the significance of genetic factors in its etiology. The reported incidence of bilaterality of involvement ranges between 33% and 50% (1,3). Certainly the probability of bilaterality increases as the patient ages.

Pathogenesis: Functional Factors Resulting in Hydrops

A phenomenon fundamental to the development of Meniere’s disease is endolymphatic hydrops. The development of hydrops is generally a function of dysfunctional malabsorption of endolymph. Absorption of endolymph is believed to occur rather exclusively in the endolymphatic duct and sac (4). Malabsorption may itself be a result of 1) disturbed function of components comprising the endolymphatic duct and sac, 2) mechanical obstruction of the endolymphatic duct and sac, or 3) altered anatomy in the temporal bone. The first two issues are discussed below, while anatomic factors are discussed in the next section.

Received 16 January 1990; Accepted 19 January 1990.
Table 1. Meniere's Disease: Etiologic Classification

<table>
<thead>
<tr>
<th>Meniere's disease (cause known)</th>
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<tr>
<td>infection (inflammation—bacterial, viral, etc.)</td>
<td></td>
</tr>
<tr>
<td>trauma (physical or acoustic)</td>
<td></td>
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<tr>
<td>otosclerosis</td>
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<tr>
<td>syphilis</td>
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<tr>
<td>genetic</td>
<td></td>
</tr>
<tr>
<td>other (including allergies, tumors, leukemia, and autoimmune diseases)</td>
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</tr>
<tr>
<td>Meniere's disease (idiopathic)</td>
<td></td>
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<tr>
<td>typical (with the triad including vestibular symptoms, cochlear symptoms, and aural pressure)</td>
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<tr>
<td>atypical</td>
<td></td>
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<tr>
<td>1. vestibular Meniere's disease (including vestibular symptoms and aural pressure)</td>
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</tr>
<tr>
<td>2. cochlear Meniere's disease (including cochlear symptoms and aural pressure)</td>
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Endolymph is produced primarily by the stria vascularis. A small amount comes from the planum semilunatum and dark vestibular cells. Endolymphatic flow is both longitudinal (along the axis of the endolymphatic duct toward the endolymphatic sac) and radial (across the membrane of the endolymphatic space into the perilymphatic system) (5). Meniere's disease is generally a consequence of altered longitudinal flow. Typically, a causative pathologic condition leading towards symptomatic Meniere's disease and hydrops evolves over a long course of time (years).

Studies in temporal bones provide insights into some of the many different pathologic mechanisms that may result in hydrops. For example, perisaccular fibrosis (6), atrophy of the sac (7), and narrowing of the lumen in the endolymphatic duct (8) have been observed in human temporal bones that also demonstrated hydrops. Kimura (9) and Paparella (2) have reported on the common coincidence of otitis media and hydrops. Otosclerotic foci enveloping the vestibular aqueduct and resulting in malfunction of the endolymphatic duct and sac have been reported (10,11,12).

Ikeda and Sando (8) studied vascularity near the endolymphatic sac in temporal bones that exhibited hydrops, and in normal bones. They found poor vascularity surrounding the endolymphatic sac in ears with Meniere's disease and hypothesized that the normally rich vascular system of the endolymphatic sac has an important function in absorption of endolymph and that the lack of vascularity associated with hydropic ears may be a factor in the pathogenesis of endolymphatic hydrops. Other lesions in the temporal bone that have been associated with development of hydrops include syphilitic osteitis of the otic capsule (13,15) and leukemic infiltrate (14,15). Type II collagen autoimmunity toward the endolymphatic sac has been suggested as a mechanism (16) but has not been proven in a human temporal bone. It has been known for some time that experimental obstruction of the endolymphatic duct will routinely result in endolymphatic hydrops in many animal models (9).

Pathogenesis: Anatomic Factors

Many anatomic studies have found significant differences between hydropic and normal temporal bones. Rumbaugh et al (17) observed, using radiography, a smaller vestibular aqueduct in ears affected by Meniere's disease. Stahle and Wilbrand (18) reported results from radiographic evaluations of 86 ears with Meniere's disease. They found 1) decreased or absent pneumatization of the petrous portion of the temporal bone, 2) lack of periaqueductal pneumatization, 3) short vestibular aqueducts, and 4) reduction in the size of the mastoid air-cell system. Sando and Ikeda (19) compared the area near the vestibular aqueduct in 27 temporal bones and found the area in hydropic bones to be significantly less (9.2 mm² versus 14.6 mm²).

We reported on the relationship of the position of the lateral sinus as well as the size of

Table 2. Dimensions of the Temporal Bone in Patients with Meniere's Disease Compared with Dimensions in Normal Temporal Bones

<table>
<thead>
<tr>
<th>Measurement</th>
<th>In 23 patients with Meniere's disease</th>
<th>In 15 controls</th>
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<tbody>
<tr>
<td>Measurement A</td>
<td>11.4 mm</td>
<td>12.7 mm</td>
</tr>
<tr>
<td>Measurement B</td>
<td>14.0 mm</td>
<td>16.6 mm</td>
</tr>
<tr>
<td>Measurement C</td>
<td>2.43 mm</td>
<td>5.73 mm</td>
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Pathogenesis of Meniere's Disease

Trautmann's triangle to the occurrence of Meniere's disease (20). In 23 patients undergoing endolymphatic sac enhancement surgery for Meniere's disease, measurements of the position of the lateral sinus and the area of Trautmann's triangle were obtained intraoperatively. Figures 1 and 2 illustrate the dimensions ("A, B, and C") that were measured. These measurements were compared with those obtained through dissection of 15 normal (pneumatized) temporal bones (Table 2 summarizes these comparisons). Comparison between ears with Meniere's disease and normal ears showed statistically significant differences in each of the measured dimensions. This study showed that the lateral sinus is displaced a) anteriorly and b) medially. This displacement results in a Trautmann's triangle diminished in size.

Arenberg's (21) studies also described anatomical variations of the endolymphatic sac and the vestibular aqueduct. He showed that ears affected by Meniere's disease were associated with smaller endolymphatic sacs and anteriorly displaced lateral sinuses. He hypothesized that an anteriorly located lateral sinus could lead to incomplete posterior migration of the developing sac and duct.

Taken together, these studies suggest that ears affected by Meniere's disease are likely to demonstrate hypodevelopment of the endolymphatic duct and sac, the periaqueductal cells, and the mastoid air cells. It is perhaps not surprising that these particular anatomic alterations are associated with endolymphatic hydrops. One can postulate a cause-and-effect relationship between constricted anatomy in the temporal bone and malabsorption of endolymph.

Mechanisms (Pathophysiology)
Underlying Clinical Symptoms

Any explanation of the clinical symptoms of Meniere's disease should account for all of
the symptoms, including rapid or prolonged attacks of vertigo, disequilibrium, positional vertigo during and between attacks, fluctuating progressive sensorineural hearing loss, tinnitus, aural pressure, inability to tolerate loudness, and diplacusis. The attacks of Meniere's disease (vertigo, hearing loss, aural pressure) have been explained on the basis of both physical and chemical mechanisms. Schuknecht (4) has proposed membranous ruptures as the cause of all attacks of Meniere's disease. A recent review, however, of temporal bones that both demonstrated endolymphatic hydrops and were associated with well-documented Meniere's disease (5) has demonstrated cases with no evidence of membranous rupture. The theory of rupture would predict that in a typical attack of Meniere's disease, there would be simultaneous ruptures in the cochlear duct and the saccule in order for both cochlear deafness and vertigo to occur together. Studies in temporal bone, however, have demonstrated that when membranous ruptures are present they are not necessarily seen in the scala media and in the saccule or utricle simultaneously. It seems more likely, in fact, that membranous ruptures are temporally associated with resolution of the symptoms of aural pressure and vertigo or sudden "drop" attacks of Meniere's disease.

Other mechanisms beside membranous rupture are needed to account for all the symptoms associated with attacks of Meniere's. Physical and chemical mechanisms are most likely both operational. Physical factors can tamponade the cochlear duct, contributing to fluctuating progressive sensorineural hearing loss and other cochlear symptoms, while dis
tension of the oto
tilithic organs can physically affect the crista ampullaris, resulting in vestibular symptoms. Chemical factors can also affect the pars inferior and/or the pars superior through the occasional membranous rupture or through leaks in the membrane (1).

In typical Meniere's disease, cochlear and vestibular structures are similarly involved due to a dysfunctional endolymphatic duct and sac. In atypical Meniere's disease, secondary obstructive sites can occur in addi-

Summary and Conclusions

While endolymphatic hydrops is a characteristic pathologic feature of Meniere's disease, there are exceptions to this rule. There is evidence that hydrops develops as a result of malabsorption of endolymph. This implies dysfunction of the endolymphatic sac and duct, which normally absorb endolymph. In approximately 20% of cases of Meniere's disease, a specific pathologic condition in the temporal bone can be associated as a cause of endolymphatic hydrops. Syphilis, fractures of the temporal bone, otosclerosis, and preceding chronic otitis media are some of the more commonly encountered pathologic conditions so associated. Hypoplasia of the mastoid air cell system and of periaqueductal air cells, and especially displacement medially but also anteriorly of the sigmoid (lateral) sinus are commonly observed in patients with Meniere's disease. Evidence is available to substantiate the etiologic bases of Meniere's disease as including multifactorial inheritance (1).

The clinical symptoms and findings result from both chemical and physical mechanisms. Pathogenesis appears to be due to malabsorption of endolymph in the environment of the endolymphatic sac, primarily affecting longitudinal flow. The possible role of such processes as autoimmune reactions and viral inflammation, especially in the endolymphatic sac, should be further investigated in the future.

Acknowledgment—This research was supported, in part, by NIH Grant #P50 NS4538 09A1, and by the International Hearing Foundation.
REFERENCES