The Contribution of Otoneurological Evaluation to Tinnitus Diagnosis

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Abstract: Tinnitus has been reported for nearly 80% of patients referred to the otolaryngology services. Usually, its evaluation is based on tonal and vocal audiometry, tympanometry, brainstem-evoked potentials, electrocochleography, and otoacoustic emissions. However, as the cochleovestibular system works as a unit, the use of vestibular tests has been proposed to evaluate tinnitus. Many patients with tinnitus have altered vestibular test results even in the absence of vestibular symptoms. This finding accounts for the indication of complete vestibular and audiological evaluation of tinnitus. The aim of this study is to analyze the contribution of otoneurological evaluation in the diagnosis of tinnitus. Patients were selected and divided into two groups. Group 1 was composed of patients complaining about tinnitus only, whereas group 2 was composed of patients with tinnitus associated with dizziness, hearing loss, and fullness. All submitted to otoneurological evaluation based on directed clinical history, physical examination, tonal and vocal audiometry, tympanometry, and vestibular examination. A total of 195 patients were analyzed. The otoneurological evaluation was conclusive in the diagnosis in 48 cases (75%) in group 1 and in 94 cases (72%) in group 2. The present study showed that otoneurological evaluation contributes to the etiological diagnosis of tinnitus.

Key Words: cochleovestibular system; otoneurological evaluation; tinnitus

BACKGROUND

Few clinical conditions are as unknown as tinnitus in practical otology. Pulec et al. [1] stated that tinnitus has been reported in up to 80% of patients in otolaryngology offices. This symptom is especially marked in patients with some kind of audiological problem and sometimes may be very severe and incapacitating.

Tinnitus may be defined as an auditory illusion, a sound sensation related to an external source of stimulation. It may be the main or even the only symptom in many kinds of disease, compromising many individuals and their relatives. Thus, precise diagnosis and effective treatment are required [2,3].

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National research conducted by the Public Health Agency of America in 1984–1985 showed that severe tinnitus is perceived as the third worst symptom in humans, owing to the pain and untreatable dizziness with which it is associated. The same research estimated that 36 million adult Americans have some kind of tinnitus and that 7.2 million have severe tinnitus. The incidence varies in different countries [2].

Complete audiological and clinical evaluations are an important initial step in the diagnosis and treatment of tinnitus, because tinnitus is a symptom related to several diseases. The analysis of clinical history, physical examination, and audiological tests helps to identify the main site of lesion. This site may be the cochlea, the cochlear nerve, the cochlear nuclei, the brainstem, or the auditory cortex. Clinical history is the most important part of the diagnostic workup. The characteristics of tinnitus are investigated: type, intensity, duration, frequency, improvement factor, and associated symptoms. The examinations usually involved in the diagnosis of tinnitus are tonal and vocal audiometry, tympanometry, electrocochleography, and the brainstem evoked potential response. However, as the cochleovestibular system

works as a unit, the use of vestibular tests has been proposed for the evaluation of patients with tinnitus even in the absence of vestibular symptoms. In many patients complaining of tinnitus, vestibular tests are altered even in the absence of vestibular symptoms (e.g., vertigo). This fact must signal the indication for a complete evaluation of audiological and vestibular systems in patients with tinnitus [4,5].

Some authors consider that vestibular evaluation in tinnitus cases is useful to indicate the image test that will be adequate to make the diagnosis, and it could be enough to establish the diagnosis without the use of any other tests [6,7]. Other authors relate that vestibular tests are part of screening for suspected vestibular schwannoma [8,9] or other tumors in the cerebellopontine angle, such as meningioma [10], which could be altered in up to 95% of cases [11] or normal in one-half of small tumors [12]. Some practitioners conclude that no reliable vestibular tests can confirm the suspicion of a tumor and that magnetic resonance imaging is indicated for all cases [13,14]. Some studies demonstrated the use of vestibular tests for evaluating (1) vestibular function during the use of ototoxic drugs [15,16], (2) vestibular function in Ménière's disease after intratympanic gentamicin use [17], or (3) the effect of diphenidol [18], or for following up vestibular compensation after vestibular neurectomy [19]. Also in regard to Ménière's disease, vestibular tests are used to evaluate the stage of disease [20]. Others studies propose their use in investigating tinnitus related to metabolic disorders [21,22], headache [23,24], or alcohol abuse [25]. Vestibular tests have also been put to use in evaluating tinnitus caused by noise exposure; the altered test results proved that noise also affects vestibular function [26]. A study by Goldstein and Shulman [27] summarized the use of vestibular tests as part of the evaluation of a patient with tinnitus and emphasized the importance of audiologists and otologists working as a team to establish the correct diagnosis and treatment of affected patients.

The aim of our study was to analyze the results of a proposed method called *otoneurological evaluation* in patients with tinnitus as a main complaint and to assess this evaluative method's contribution to establishing the etiology of tinnitus.

PATIENTS AND METHODS

Patients complaining of tinnitus, regardless of its association with other symptoms, were selected and divided into two groups. Group 1 was composed of patients complaining about tinnitus only, and group 2 was composed of patients with tinnitus linked to other symptoms (e.g., dizziness, hearing loss, and fullness). All patients submitted to otoneurological evaluation that consisted of a clinical history directed at tinnitus, otolaryngologic physical examination, cranial nerve evaluation, tonal and vocal audiometry, tympanometry, and vestibular tests as described in 1991 by Rubin and Brookler [28,29] and in 1999 by Maudonnet [30]. The vestibular tests included evaluation of ocular mobility (saccadic and smooth-pursuit eye movements, optokinetic nystagmus); evaluation of spontaneous, positional, and cervical nystagmus; vertebrobasilar privation nystagmus; and rotary and caloric tests.

The inclusion criteria were age beyond 12 years; visual acuity and collaboration in performing the tests; no use of admitted sedatives, psychoactive drugs, or vestibular depressors in the last 48 hours before the examination; and absence of ocular dysfunction.

We analyzed the patients' clinical history (the most important factor), the otolaryngologic physical examination results, the cranial nerve evaluation results, and results of tonal and vocal audiometry, tympanometry, and vestibular tests to establish the probable etiological diagnosis of tinnitus.

RESULTS

We analyzed a total of 195 patients comprising two groups. Group 1 was composed of 64 patients with tinnitus in one or both ears (without specified location of the complaint). Their ages ranged from 12 to 78 years (average, 51.05 years). They were evenly divided by gender. A total of 42% could define their tinnitus as unilateral or bilateral. Table 1 shows their main related conditions (e.g., hypertension, noise exposure, pain at the nape of the neck). The patients in this group had also experienced other diseases not described in the table (e.g., breast, prostate, and thyroid cancers; ocular herpes;

Table 1. Conditions Affecting Patients in Group 1 (n = 64)

Condition	No. of Patients	Percentage
Noise exposure	12	19
Migraine	6	9
Hypertension	14	22
Diabetes	2	3
Hyperlipidemia	6	9
Pain at nape of the neck	7	11
Cardiopathy	2	3
TMJ dysfunction	4	6
Facial paralysis	1	1.5
Thyroid diseases	3	5
Allergic rhinitis	6	9
Head injury	1	1.5
Familiar hearing loss	2	3
Other	8	12

TMJ = temporomandibular joint.

Table 2. Results of Otoneurological Evaluation in Group 1 Patients (n = 64)

Etiology	No. of Patients	Percentage
Metabolic	7	11
Presbycusis	5	8
Vascular	17	26.5
Eustachian tube dysfunction	3	5
Otosclerosis	2	3
Acoustic trauma	8	12
TMJ dysfunction	2	3
Cervical	3	5
Migraine	1	1.5
Total		
Conclusive	48	75
Inconclusive	16	25

TMJ = temporomandibular joint.

rheumatological diseases; dyspeptic disease; osteoporosis). Table 2 shows the results of otoneurological evaluation, and Table 3 shows the results of vestibular tests of these conditions. The analysis of these results could lead to a probable etiological diagnosis in 48 cases (75%), and the results were not conclusive in the others 16 (25%).

Group 2 was composed of 131 patients with tinnitus linked to other complaints. Their ages ranged from 17 to 87 (average, 48.9). Fifty-two were men (40%), and 79 were women (60%). Tinnitus was unilateral in 31%, 29% had tinnitus bilaterally, and the remaining 40% could not identify the side of their malady. Table 4 shows complaints associated with their tinnitus (e.g., dizziness, hearing loss, fullness). Their chief complaint

Table 3. Results of Vestibular Tests in Group 1 Patients (n = 64)

Etiology	Test Results	No. of Patients
Vascular	Reduced caloric responses and improved rotational responses	14
	Improved rotational responses	3
	Vertebrobasilar deprivation nystagmus	2
Metabolic	Discrete reduced caloric responses	7
Cervical	Reduced caloric responses	3
	Cervical nystagmus	1
Acoustic trauma	Normal vestibular test results	8
Migraine	Normal vestibular test results	1
Presbycusis	Normal vestibular test results	5
TMJ dysfunction	Normal vestibular test results	2
Otosclerosis	Normal vestibular test results	2
Eustachian tube dysfunction	No value	3
Inconclusive	Normal vestibular test results	14
	Test results not compatible	2

TMJ = temporomandibular joint.

Table 4. Complaints Associated with Tinnitus in Group 2 Patients (n = 131)

Complaint	No. of Patients	Percentage
Hearing loss	74	56.4
Dizziness	96	73.2
Fullness	15	11.4

was dizziness. Table 5 shows previous diseases or symptoms cited by patients, the most frequent being hypertension and pain at the nape of the neck. Table 6 shows the results of otoneurological evaluation, and Table 7 shows findings of vestibular tests of these different conditions. The probable etiological diagnosis obtained from these data was conclusive in 94 cases (72%) and inconclusive in 37 cases (28%).

Statistical analysis using the Qui-square method showed in both group 1 and group 2 significant differences between conclusive and inconclusive diagnostic values ($p < .003$ for group 1; $p < .001$ for group 2).

DISCUSSION

Tinnitus is a frequent complaint heard in clinical practice. Pulec et al. [1] described tinnitus as a complaint in 80% of patients regularly referred to otolaryngologists. It may be considered a significant symptom when its intensity exceeds normal behavioral sounds.

A patient's clinical history is the most important part of tinnitus diagnosis. Examinations usually employed

Table 5. Associated Conditions of Patients in Group 2 (n = 131)

Condition	No. of Patients	Percentage
Noise exposure	12	9.1
Migraine	10	7.6
Allergic rhinitis	12	9.1
Hypertension	22	16.7
Diabetes	3	2.2
Hyperlipidemia	8	6.1
Previous otologic surgery	1	0.76
Pain at nape of neck	20	15.2
Familial hearing loss	2	1.5
Cardiopathy	1	0.76
Head injury	2	1.5
Sinusitis	2	1.5
Motion sickness	2	1.5
TMJ dysfunction	5	3.8
Facial paralysis	1	0.76
Thyroid diseases	3	2.2
Epilepsy	2	1.5
Other	15	11.4

TMJ = temporomandibular joint.

Table 6. Results of Otoneurological Evaluation of Group 2 Patients (n = 131)

Etiology	No. of Patients	Percentage
Metabolic	14	10.7
Presbycusis	5	3.8
Cervical	15	11.5
Ménière's disease	7	5.3
Vestibular migraine	4	3.1
Vascular	27	20.7
Central	2	1.5
Vestibular schwannoma	2	1.5
Vestibular neuronitis	2	1.5
Sudden hearing loss	4	3.1
Eustachian tube dysfunction	1	0.8
Otosclerosis	6	4.6
Head injury	1	0.8
Acoustic trauma	3	2.3
TMJ dysfunction	1	0.8
Total		
Conclusive	94	72
Inconclusive	37	28

TMJ = temporomandibular joint.

to evaluate a patient complaining of tinnitus include tonal and vocal audiometry, tympanometry, electrocochleography, and brainstem evoked potential response. However, vestibular tests have been proposed for use in this evaluation because of the anatomical and functional relation of vestibular and cochlear systems. Moreover, many patients complaining of tinnitus have altered vestibular test results even in the absence of such vestibular symptoms as vertigo. This fact should signal the need for a complete evaluation of audiological and vestibular systems in patients with tinnitus [4,5].

Otoneurological Evaluation

In this study, we used a method called *otoneurological evaluation* in which vestibular tests are included in the tinnitus evaluation. These tests are regularly used in evaluating dizziness deriving from several etiologies. In our country, they have not been used in the study of tinnitus. However, several studies [4–10,20–27] have proposed the use of vestibular tests in evaluating patients with tinnitus even in the absence of vestibular symptoms because the cochleovestibular system works as a unit. Thus, in our research we used vestibular tests together with audiological tests (audiometry and tympanometry), physical examination, and recording of patients' history. In this way, the vestibular tests do not establish the diagnosis alone but work in conjunction with all the information obtained by this complete method.

Then, in this study, otoneurological evaluation was performed on the patients in the two groups. In group 1

Table 7. Results of Vestibular Tests in Group 2 Patients

Etiology	Test Results	No. of Patients
Vascular	Reduced caloric responses and improved rotational responses	27
	Vertebrobasilar deprivation nystagmus	6
Metabolic	Discrete reduced caloric responses	14
Cervical	Reduced caloric responses	15
	Cervical nystagmus	9
Acoustic trauma	Normal vestibular test results	3
Ménière's disease	Directional preponderance to affected ear	4
	Reduced caloric responses	2
	Normal vestibular test results	1
Migraine	Normal vestibular test results	3
	Directional preponderance	1
Presbycusis	Reduced caloric and rotational responses	5
TMJ dysfunction	Normal vestibular test results	1
Sudden hearing loss	Reduced caloric responses	4
Otosclerosis	Reduced caloric responses	2
	Normal vestibular test results	4
Head injury	Reduced caloric responses	1
Eustachian tube dysfunction	No value	1
Vestibular neuronitis	Reduced caloric responses	2
Vestibular schwannoma	Reduced caloric responses and areflexia	2
Central	Alterations on optokinetic nystagmus and on fixation index	2
Inconclusive	Normal vestibular test results	22
	Incompatible test results	15

TMJ = temporomandibular joint.

(with tinnitus as an isolated complaint), the probable etiology was conclusive in 75% of cases. In group 2 (tinnitus associated with other symptoms), the probable etiology was conclusive in 72%. The most frequent causes of the disorder in group 1 patients were vascular disorders (26.5%), acoustic trauma (12%), and metabolic disorders (11%); in group 2 patients, causes of tinnitus were vascular disorders (20.7%), cervical disorders (11.5%), and metabolic disorders (10.7%). Bento et al. [2] posited that vascular disorders are the second leading cause of tinnitus, the first being otological disorders. Approximately one-third of patients with severe tinnitus have one or more cardiovascular disorders, the most frequent of which is hypertension [2]. In our study, we found a history of hypertension in 14 patients in group 1 and 22 in group 2. The most frequent alterations were reduced caloric results due to transitional ischemia of the inner ear. This finding must be secondary to circulatory disease in the internal ear. We also found vertebrobasilar deprivation nystagmus in some patients in both groups.

Metabolic Disorders

Metabolic causes also play an important role in tinnitus etiology. *Hyper*thyroidism may cause tinnitus by increasing cardiac debit, and *hypo*thyroidism may cause tinnitus by increasing inner-ear pressure. Reports in the literature cite the use of otoneurological evaluation in cases of tinnitus related to metabolic disorders, mainly hypothyroidism [21,22]. In 1981, Schleuning [31] stated that the most common disorder is the reduced caloric output due to an occlusion of capillaries of stria vascularis, leading to biochemical alterations on endolymph. This author also reported spontaneous nystagmus and normal examination results [31]. We too found reduced caloric results (mainly directional preponderance of the nystagmus) in both groups.

Cervical Disorders

The cervical disorders causing tinnitus are related to stimulation of the posterior cervical sympathetic plexus, proprioceptive disorders, and vascular disorders secondary to altered bone canals that reached vertebral arteries (e.g., arthrosis, bone malformations, and trauma) [2]. In our study, these alterations were most frequent in group 2 patients, possibly because vertigo is a significant complaint and the most common findings are caloric test result alterations and cervical nystagmus related to stimulation on the neck.

Vestibular Schwannoma

Some authors [6,7] reported that the use of otoneurological evaluation is important in defining the disorder's site and in determining the appropriate imaging study for a patient with tinnitus. Alternatively, even the exclusive use of audiological and vestibular tests may sometimes be enough to establish a diagnosis. Some authors [8,9] cited otoneurological evaluation as part of a screening in suspected cases of vestibular schwannoma or others tumors of the cerebellopontine angle [10]. Some other authors [13,14] concluded that no reliable vestibular tests can determine a suspected tumor and that magnetic resonance imaging is indicated for all cases.

In our study, the otoneurological evaluation suggested vestibular schwannoma in two patients in group 2; the findings were unilateral hyporeflexia and areflexia on caloric tests and corneal hypoesthesia and sensorineural hypoacusia on high frequencies at the affected side. However, in one patient, the otoneurological evaluation was inconclusive (normal vestibular tests) but related to important complaints, so an imaging examination was proposed and showed a vestibular schwannoma. This approach is justified because the otoneurological study results may be normal in up to one-half of small tumors [12]. However, results usually are positive in 95% of cases [11].

Central Disorders

In cases of central disease, otoneurological evaluation localized the lesion on the cortical level in two patients in group 2. An imaging examination was indicated for both patients and showed tumor. Both patients had pulsed Romberg test results, altered optokinetic nystagmus, and important alterations on the fixation index. All other test results were normal.

Ménière's Disease

In the diagnosis of Ménière's disease, otoneurological evaluation is used to help in staging the disease [20]; to study vestibular function after the use of intratympanic gentamicin [17] or after vestibular neurectomy (19); or even to evaluate the effect of diphenidol in treating the disease [18]. In our study, we found seven cases of Ménière's disease in group 2 patients. The most common finding on caloric testing was directional preponderance to the affected ear related to endolymphatic hydrops. In some cases, we also found reduced caloric results and normal examination results. This outcome is compatible with the literature and demonstrates the possibility of normal examination results in some phases of the disease (or progressive hyporeflexia), but areflexia is rare [32].

Migraine

Some other studies proposed the use of otoneurological tests in the evaluation of patients with tinnitus associated with headache [23,24]. In our study, we found migraine in one patient in group 1 and in four in group 2. Migraine is a vascular syndrome, and the most frequent findings in the literature are pathological nystagmus and disorder displayed on caloric tests [23]. In our study, we obtained normal results with a consistent history of migraine from most of the patients in both groups. On caloric testing, our most common finding in altered examination results was directional preponderance of the nystagmus, as is usual in vascular syndromes.

Noise Exposure

In regard to patients who have experienced noise exposure, one study showed the presence of vestibular alterations, indicating that noise can affect the vestibular

function because of the anatomical proximity of the vestibular labyrinth and the stapes; the common arterial blood irrigation to the cochlea and vestibular end organs; the similarity in cochlear and vestibular hair-cell ultrastructure; and the ability of the semicircular canal cristae to respond to high-intensity noise. In 1994, Shupak et al. [26] described the destruction of the membranous partition between the pars superior (utricle and semicircular canals) and pars inferior (saccule and cochlea); the separation of the ampullary sensory epithelium from the underlying connective tissue; hair-cell edema; fusion or complete degeneration of the stereocilia; and decreased density of myelinated nerve fibers in certain study animals. The most frequent findings were spontaneous and positional nystagmus and reduced caloric output. The low incidence of clinical symptomatology might be explained by the central nervous system's ability to compensate for peripheral vestibular malfunction.

In our study, analysis of patients in both groups indicated 24 patients with a history of noise exposure, and the otoneurological evaluation results were conclusive in 15; 11 of the 15 had diagnosed acoustic trauma. We did not find vestibular alteration in either group, the diagnosis being based only on history of noise exposure and audiometric findings.

Otological Disorders

In 1998, Bento et al. [2] theorized that the most frequent cause of tinnitus is otological. Affected patients may present with neurosensory hearing loss at high frequencies associated with noise exposure or with presbycusis. We found presbycusis in only five patients in group 1 and in five in group 2; in group 1, all patients produced normal vestibular test results. We found altered results on caloric and rotational testing in group 2. In otosclerosis, 4% of patients report significant tinnitus [2]. We found two cases in group 1 and six in group 2. Vestibular test findings are usually normal or they may show reduced caloric output and positional nystagmus. This finding may be related to vascular and biochemical alterations on the liquids of the internal ear [33]. In our study, we received normal answers from most of the patients in both groups.

Head Injury

A history of head injury may be present in patients with tinnitus [2]. In our study, only one patient had diagnosed head injury as the etiology of tinnitus, and we found caloric hypoexcitability on the affected side after the trauma. The pendular test showed vestibular compensation, which is compatible with the literature [34].

Eustachian Tube Dysfunction

Eustachian tube dysfunction may also cause tinnitus synchronous to nasal breathing, usually associated with reverberation and autophonia. In our study, Eustachian tube dysfunction occurred in three patients in group 1 and in one patient in group 2. In the latter case, the vestibular test results did not contribute to diagnosis, because they had no value during middle-ear disease. Diagnosis was based on audiometry and tympanometry, relating to otoscopy and patient clinical history.

Sudden Neurosensory Hearing Loss

Sudden neurosensory hearing loss is also a cause of tinnitus. It may be of viral, vascular, or idiopathic etiology. Its incidence in our evaluation was four cases in group 2, and the main finding was caloric hyporeflexia on the affected side secondary to cochlear or neural lesion [35].

Odontogenic Disorders

Regarding odontogenic causes of tinnitus, nearly 45% of patients with severe tinnitus had temporomandibular joint dysfunction and, of these, 38% reported worsening both of tinnitus and the dysfunction [2]. The relation of this joint to tinnitus seems to stem from a group of ligaments that extends from the joint disk to the malleus. However, these structures cannot explain the high frequencies tinnitus. The incidence of temporomandibular joint dysfunction in our series was two cases in group 1 and one case in group 2. Vestibular test results are usually normal, so diagnosis is based on patient history and physical examination of the articulation.

Vestibular Neuronitis

Vestibular neuronitis is not considered a cause of tinnitus because of its definition as a sudden dizziness in the absence of audiological symptoms. However, in our series, two patients in group 2 had vestibular neuronitis. The anatomical and functional union of cochlear and vestibular systems could explain this disorder. Vestibular examination showed caloric hyporeflexia in the affected ear in both cases. The finding was secondary to neural lesion with vestibular compensation shown on rotational tests.

Inconclusive Cases

In inconclusive cases in both patient groups, we found vestibular test results were incompatible with patients' complaints or we found examination results to be of poor quality, causing difficulty in interpreting graphics.

Vestibular Tests

On the basis of these data, we noted that on vestibular examinations, caloric test results showed the most common alterations in both patient groups. However, a similar alteration was seen in different diseases, which demonstrates that it is not just one part of an examination that may provide a diagnosis but the analysis of all different steps of the otoneurological evaluation in both groups.

Specifically, vestibular alterations were significantly present in metabolic, vascular, and cervical diseases in patients in group 1. In patients in group 2, vestibular alterations were likewise present in metabolic, vascular, and cervical diseases but additionally in presbycusis, Ménière's disease, sudden hearing loss, otosclerosis, cranioencephalic trauma, vestibular neuritis, acoustic neuroma, and central cortical lesions. Vestibular tests did not contribute to diagnosis in temporomandibular joint dysfunction, Eustachian tube dysfunction, acoustic trauma, and migraine, but they were useful to rule out the possibility of association with other diseases. Thus, the use of otoneurological evaluation can possibly be supported for diagnosing tinnitus even in a patient having a known cause of the tinnitus (e.g., temporomandibular joint dysfunction).

CONCLUSION

Our study allows us to conclude that otoneurological evaluation is an efficient method of studying tinnitus and must be included in tinnitus assessment. We also concluded on the basis of this study that otoneurological evaluation allowed the establishment of the probable etiological diagnosis in a significant number of patients with tinnitus and vestibular symptoms but also in patients complaining of tinnitus only.

REFERENCES

1. Pulec JL, Hodell SF, Anthony PF. Tinnitus: Diagnosis and treatment. *Ann Otol Rhinol Laryngol* 87(6):821–833, 1978.
2. Bento RF, Minitti A, Marone SAM. *Tratado de Otologia*. São Paulo: EDUSP, 1998:322–384.
3. Tyler RS, Babin RW. Tinnitus. In CW Cummings, JM Fredrickson, LA Harker, et al. *Otolaryngology—Head and Neck Surgery* (2nd ed). Baltimore: Mosby–Year Book, 1993:3031.
4. Seabra JC. The medical audiological evaluation of tinnitus patients. *Int Tinnitus J* 5(1):53–56, 1999.
5. Seabra JC, Diamantino H, Faria E, Almeida J. Neurootological evaluation of tinnitus. *Int Tinnitus J* 1(2):93–97, 1995.
6. Biedert S, Weidauer H, Reuther R. Differential diagnosis of tinnitus and vertigo. A review. *Nervenarzt* 56(10):535–542, 1985.
7. Kumar A, Valvassori G. An algorithm for neurotologic disorders. *Neurol Clin* 2(4):779–796, 1984.
8. Mathew GD, Facer GW, Suh KW, et al. Symptoms, findings, and methods of diagnosis in patients with acoustic neuroma. *Laryngoscope* 88(12):1893–1903, 1978.
9. Valente M, Peterein J, Goebel J, Neely JG. Four cases of acoustic neuromas with normal hearing. *J Am Acad Audiol* 6(3):203–210, 1995.
10. Asawavichjanginda S, Vaewvichit K, Taecholarn C. Cerebellopontine angle meningiomas with primary otologic symptoms. *J Med Assoc Thai* 80(9):603–608, 1997.
11. Portmann M, Dauman R, Duriez F, et al. Modern diagnostic strategy for acoustic neuromas. *Arch Otorhinolaryngol* 246(5):286–291, 1989.
12. Flood LM, Brammer RE, Graham MD, Kemink JL. Pitfalls in the diagnosis of acoustic neuroma. *Clin Otolaryngol* 9(3):165–170, 1984.
13. Ferguson MA, Smith PA, Lutman ME, et al. Efficiency of tests used to screen for cerebello-pontine angle tumours: A prospective study. *Br J Audiol* 30(3):159–176, 1996.
14. Harner SG, Laws ER Jr. Diagnosis of acoustic neurinoma. *Neurosurgery* 9(4):373–379, 1981.
15. Atterholm I, Hedstrom SA, Kahlmeter G, Kamme C. Tobramycin in patients with various infections: A clinical evaluation. *Scand J Infect Dis* 10(3):229–234, 1978.
16. Kobayashi H, Ohashi N, Watanabe Y, Mizukoshi K. Clinical features of cisplatin vestibulotoxicity and hearing loss. *ORL J Otorhinolaryngol Relat Spec* 49(2):67–72, 1987.
17. Moller C, Odkvist LM, Thell J, et al. Vestibular and audiologic functions in gentamicin-treated Ménière's disease. *Am J Otol* 9(5):383–391, 1988.
18. Futaki T, Kitahara M, Morimoto M. Ménière's disease and diphenidol. A critical analysis of symptoms and equilibrium function tests. *Acta Otolaryngol Suppl* 330:120–128, 1975.
19. Kubo T, Doi K, Koizuka I, et al. Assessment of auditory and vestibular functions after vestibular neurectomy for Ménière's disease. *Acta Otolaryngol* 115(2):149–153, 1995.
20. Denia A, Jenkins HA, Baloh RW. The spectrum of audiologic and vestibular findings in patients with Ménière's disease. *Bull Los Angeles Neurol Soc* 43(2–4):60–65, 1978.
21. Bhatia PL, Gupta OP, Agrawal MK, Mishr SK. Audiological and vestibular function tests in hypothyroidism. *Laryngoscope* 87(12):2082–2089, 1977.
22. Pulec JL, Pulec MB, Mendoza I. Progressive sensorineural hearing loss, subjective tinnitus and vertigo caused by elevated blood lipids. *Ear Nose Throat J* 76(10):716–720, 1997.
23. Dursteler MR. Migraine and the vestibular apparatus. *J Neurol* 24; 210(4):253–269, 1975.
24. Fari A, Enrico A, Lacilla M, Sartoris A. Tinnitus during headache: Clinical-instrumental evaluation. *Acta Otorhinolaryngol Ital* 19(2):70–75, 1999.

25. Zuev VA. Cochleovestibular disorders in chronic alcoholics. *Zh Nevropatol Psikhiatr Im S S Korsakova* 84(2): 238–240, 1984.

26. Shupak A, Bar-El E, Podoshin L, et al. Vestibular findings associated with chronic noise induced hearing impairment. *Acta Otolaryngol* 114(6):579–585, 1994.

27. Goldstein B, Shulman A. Tinnitus classification: Medical audiologic assessment. *J Laryngol Otol Suppl* (4):33–38, 1981.

28. Rubin W, Brookler KH. Initial Patient Encounter. In *Dizziness: Etiologic Approach to Management*. New York: Thieme Medical, 1991:20–27.

29. Rubin W, Brookler KH. Objective Confirmation of Symptoms. In *Dizziness: Etiologic Approach to Management*. New York: Thieme Medical, 1991:28–63.

30. Maudonnet O. Avaliação otoneurológica. In *Avaliação Otoneurológica*. São Paulo: BYK, 1999:47–77.

31. Schleuning A. Neurotologic evaluation of subjective idiopathic tinnitus. *J Laryngol Otol* 4:99–101, 1981.

32. Tran BA, Huy P, Brette MD, Chic M. Maladie de Ménière. *Oto Rhino Laryngol* 20(205):18, 1989.

33. Virolainen E. Vestibular disturbances in clinical otosclerosis. *Acta Otolaryngol Suppl (Stockh)* 306:1–34, 1972.

34. Pearson BW, Barber HO. Head injury. *Arch Otolaryngol* 97:81–84, 1973.

35. Bohmer A. Sudden unilateral deafness and geotropic positional nystagmus—a special form of acute cochleovestibular disorders? *HNO* 38(2):59–62, 1990.