
SPECT of Brain and Vertigo - A Case Report

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Abstract: Vertigo has been identified as a complaint associated with the symptom of tinnitus; as well as a specific clinical type of tinnitus i.e., vestibular tinnitus. Classically, the clinical diagnosis of Ménière's Disease includes a quadrad of complaints, highlighted by episodic vertigo, ear blockage, a gradual progressive sensorineural hearing loss, and an associated complaint of a "low frequency tinnitus". Diagnostic and etiologic difficulties for Ménière's Disease have resulted in multiple diagnostic entities, e.g., Ménière's Syndrome, Cochlear Ménière's Disease; Vestibular Ménière's Disease, etc.

Single Photon Emission Computed Tomography (SPECT) imaging of brain is a technique which has been reported to improve the diagnostic accuracy of patients with the symptom of tinnitus; and has now been applied for recurrent persistent vertigo. A case report, diagnosed classically as Ménière's Disease, is presented to demonstrate the increased diagnostic accuracy provided by SPECT of brain for the chief complaint of vertigo. SPECT revealed significant perfusion asymmetries in brain. The medical significance of the SPECT findings and its application for both diagnosis and treatment are presented.

INTRODUCTION

Single Photon Emission Computed Tomography (SPECT) of brain with the radiopharmaceutical technetium 99m Hexamethyl propyleneamine oxine (Tc-99m-HMPAO) is an imaging technique which has been introduced in an attempt to improve the accuracy of the neurotologic diagnosis of a balance disorder by identification of abnormalities of regional cerebral blood flow (rCSF).

A case report is presented of a 48-year-old male patient with the chief complaint of vertigo clinically diagnosed to have classical Ménière's Disease to illustrate the increased diagnostic accuracy provided by SPECT of brain. The medical significance of the SPECT findings and its application for both diagnosis and treatment is presented.

CASE REPORT

A 48 year-old-male physician was seen in neurotologic

consultation for the chief complaint of ear blockage right of fluctuant intensity, and constant duration of three weeks. Significant associated complaints included upper respiratory infection; ear blockage right greater than left; frontal occipital headache; hearing loss ear right; tinnitus - ear right of constant duration, fluctuant intensity, tonal high pitch; and a balance disorder described as "unsteadiness" and "occasional". The ear blockage was an accompaniment of a upper respiratory infection, described as a sinus infection three- to- four months prior to consultation. Initially, the family physician was consulted; a sinus infection was diagnosed and treated with erythromycin. No ear infection was reported.

At the time of initial otologic/neurotologic consultation June 10, 1995 the concern was primarily of right ear blockage and occasional "unsteadiness". Significant past history included ENT consultation for evaluation/treatment of recurrent sinus infections which responded to conservative antibiotic/decongestant medication. Audiometric screening tests were reported well within the limits of normal bilateral. Systematic review of systems was positive for hypertension, and colitis which had its onset approximately six months prior to initial otologic/neurotologic consultation. Medication being taken included the systemic antibiotic erythromycin and antihypertensive medication.

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Initial neurotologic evaluation revealed hearing well within the limits of normal for language and speech bilateral with a high frequency sensorineural hearing loss at 8 kHz; tuning fork tests revealed Weber test no lateralization, Rinne test-positive air greater than bone bilateral; bilateral chronic catarrhal otitis media; subacute bilateral pansinusitis; allergic rhinosinusitis. Pneumatic otoscopy negative for fistula test bilateral; slight reduction in right ear blockage ear, transient in duration. The Romberg and Fukuda Step Test were negative. No spontaneous sign(s) of labyrinthine irritation. Extraocular eye movements revealed no nystagmus.

The original chief complaint of right ear blockage persisted two weeks following control infection allergy of the upper respiratory tract. Repeat neurotologic examination was normal; and a cochleovestibular test battery was recommended. Site of lesion audiometric testing revealed a mild/moderate sensorineural right hearing loss 250 - 8000 Hz with a mild conductive component at 250 Hz; ear left-mild sensorineural hearing loss 50 - 500 Hz; recruitment right ear; SISI elevated bilateral right greater than left; a upward sloping audiometric configuration was noted bilateral (Fig. 1). The vestibular test battery was highlighted by positive postural positional testing consistent with a diagnosis of central vertigo, and involvement of the right peripheral vestibular labyrinth. Caloric and rotary chair testing were declined. Auditory brain stem response (ABR) was within the limits of normal bilateral. Impedance test battery revealed tympanometry well within the limits of normal bilateral with borderline interference in Eustachian tube dysfunction in left ear.

Correlation of the clinical history and cochleovestibular test battery suggested peripheral and central interference in vestibular function bilateral - right greater than left. The right ear diagnosis was speculated to be Ménière's Disease. The patient was alerted to the complaint of vertigo and tinnitus. Follow-up neurotologic consultation was advised with particular respect for complaint(s) of vertigo, hearing loss, tinnitus - either alone and/or in combination.

The patient reported on June 29, 1995 a sudden onset of severe vertigo described as "rotation", with an accompanying increase in right ear blockage; and tinnitus of high frequency pitch with hyperacusis of the ear. Neurotologic examination highlights included classical horizontal LB nystagmus; tuning fork tests unchanged; Fukuda Step Test positive on the right ear; Romberg test positive on right; tympanometry normal. No infection(s) noted of the upper respiratory tract to the limits of examination. Autonomic complaints of nausea and vomiting were reported with the acute vertigo.

The neurotologic diagnosis was Ménière's Disease of the right ear. Treatment with a diuretic, vestibular suppres-

sant-antihistamine medication and diet resulted in control of the acute vertigo. The patient however reported a persistence and fluctuation in intensity of right ear blockage no subjective hearing loss; but presence of hyperacusis; and tinnitus in the right ear. Follow-up examination with the internist reported an elevated and fluctuating hypertension.

The clinical course between June 29, 1995 and August 1, 1995 was of occasional acute episodic vertigo followed by persistence of unsteadiness with an occasional sensation of rotation; fluctuating sensorineural hearing loss ear right greater left at 8 kHz; and increasing auditory complaints of dysacusis and tinnitus. Diuretic, vestibular suppressant and antihypertensive medication were continued. Persistence of the cochleovestibular complaints were the basis for recommendation of MRI of Brain and IAC's with Gadolinium, which, if negative, to be followed by SPECT of Brain and neurologic consultation to improve the accuracy of the vertigo diagnosis.

The MRI of Brain performed July 19, 1995 reported:

a. Essentially within the limits of normal with exceptions:

1. Mild cortical atrophy; IAC's no mass lesion.
2. Dilated perivascular spaces in white and grey matter most notable on the right side (centrum ovale; inferior basal ganglia, mid brain).

SPECT imaging of brain November 22, 1995 reported the following highlights (Fig. 2):

1. Hypoperfusion in the temporal region bilateral right more than left;
2. Hypoperfusion in the occipital region bilateral left more extensive than right extending to the left parietal area;
3. Focal perfusion abnormality in the right frontal and right parietal regions. A diamox study February 6, 1996 with SPECT revealed multifocal cerebral diaschisis or neuronal loss.

Neurologic consultations of September 22, 1995 and January 4, 1996 concluded no CNS disease to the limits of examination. Transcranial doppler study of the intracranial arteries reported normal studies; and no evidence of major arterial occlusion or hemodynamic stenosis. Minor vessel irregularity however could not be ruled out by this study. Carotid doppler study January 12, 1996 revealed normal flow in both vertebral arteries. No significant plaque or stenosis was visualized.

In summary, SPECT of Brain on November 22, 1995 revealed significant perfusion asymmetries particularly right global, suggesting findings compatible with cerebrovascular small vessel disease. Continuation of cochleovestibular complaints with reported "stable"

blood pressure was the basis for the SPECT Diamox test for vascular reserve performed on February 8, 1996 (Fig. 3). Diamox 1 gram, was administered I.V. followed 20 minutes later by intravenous 20 mCi Tc 99m HMPAO. SPECT data acquisition of brain was performed with display of orthogonal tomographic images in the transverse, coronal, and saggital planes. From these a surface map rendering of brain cortex was reconstructed from the SPECT slices and compared to those from the previous examination performed on November 22, 1995 without Diamox. Post Diamox findings revealed persistent lack of radio tracer uptake in small areas of the occipital and temporal regions bilaterally. These defects were distinctly smaller than corresponding locations on the previous examination without Diamox. Other abnormalities noted in previous baseline studies were not appreciated. The conclusion and impression was that the findings with or without Diamox were compatible with multi-focal cerebral diaschisis or neuronal loss. Continued lack of vascular reserve was detected in the areas of the occipital and anterior temporal regions bilaterally.

DISCUSSION

This case report is of a patient who presented initially an abnormal auditory sensation i.e., ear blockage and whose clinical course was subsequently highlighted by the development of a chief complaint of a balance disorder and tinnitus.

Classical neurotologic diagnosis with cochleovestibular testing was of Ménière's Disease right ear. Significant is that the clinical impression of bilateral peripheral and central cochleovestibular dysfunction, was supported initially by the original neurotologic cochleovestibular test battery; and subsequent follow-up SPECT of Brain. Although the initial neurotologic evaluation diagnosis was Ménière's Disease right ear or Secondary Endolymphatic Hydrops right ear what became clinically significant was positive support of the central findings with vestibular testing and ENG recording not by the Magnetic Resonance Imaging (MRI) to the limits of its examination; but rather by the SPECT imaging of brain. Significant perfusion asymmetries in multiple cortical regions of interest were identified, which although

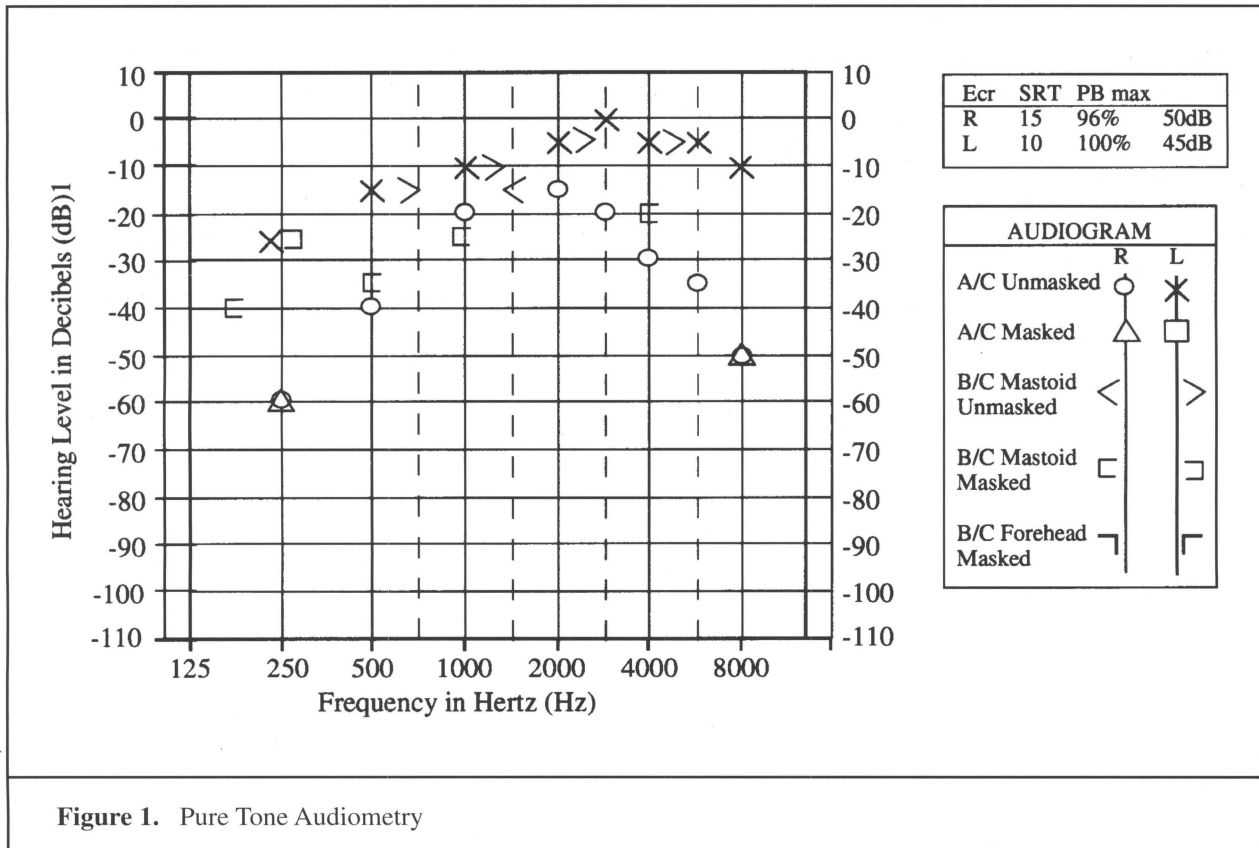


Figure 1. Pure Tone Audiometry

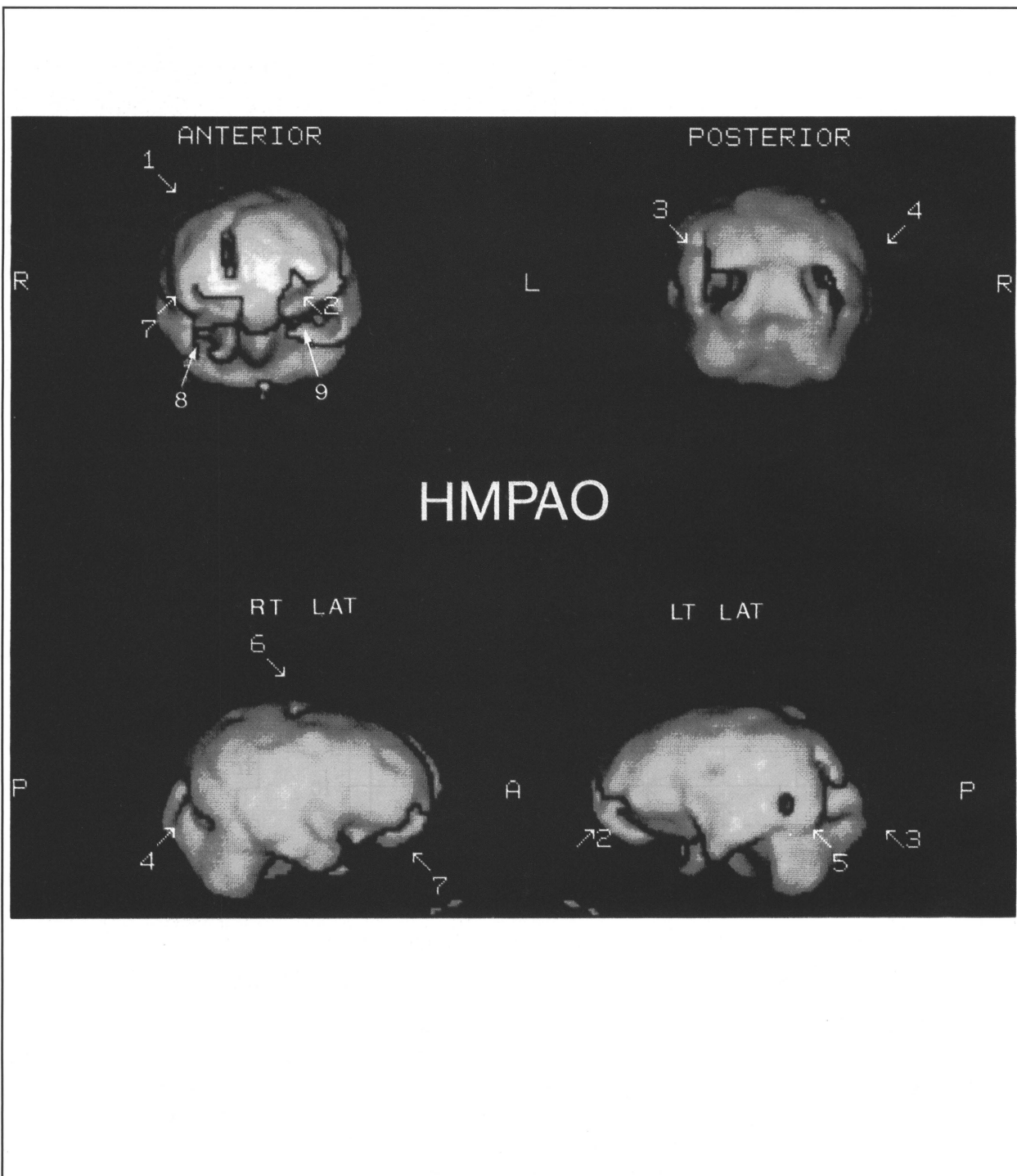


Figure 2. Tc-99m-HMPAO Cerebral Perfusion SPECT, Surface Rendering of Brain (11/22/95)
Upper Row - R = Right, L = Left;
Lower Row - R = Right Lateral, L = Left Lateral, A = Anterior, P = Posterior

1 = "Watershed"-Frontal-Right	6 = Defect Parasagittal Parietal Right
2 = Hypoperfusion Defect - Pre-Frontal Left	7 = Hypoperfusion Defect Prefrontal Right
3 = Defect Occipital Parietal Left	8 = Hypoperfusion Defect Temporal Lobe Right
4 = Defect Occipital Right	9 = Hypoperfusion Defect Temporal Lobe Left.
5 = Defect Temporoparietal Left	

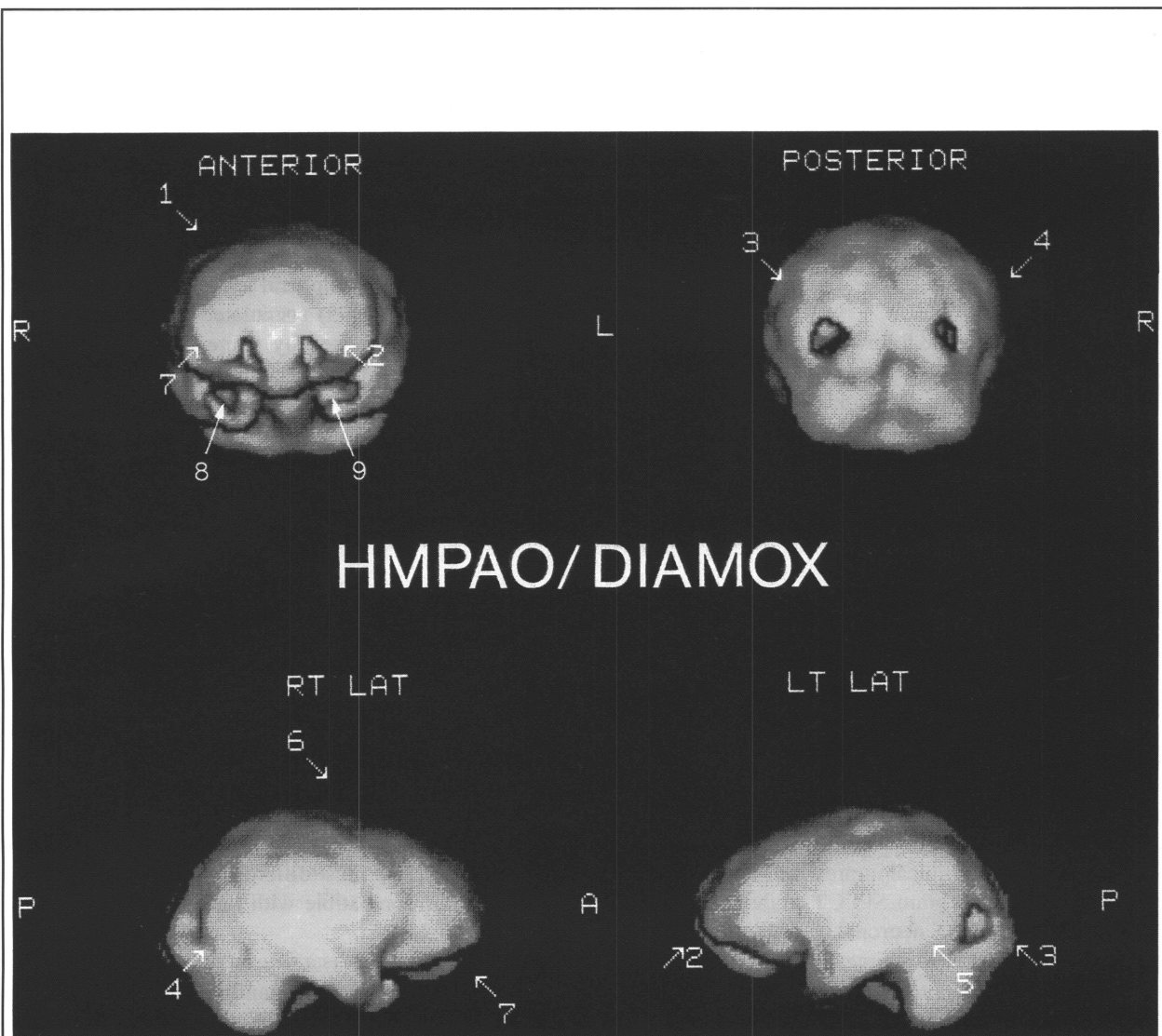


Figure 3. Technetium 99-HMPAO Cerebral SPECT with Diamox
Surface Renderings of Brain 2/5/96

- 1 = Elimination Watershed Effect Frontal Right
- 2-8 = Hypoperfusion Defects - Reduced.

reduced following Diamox administration, persisted and were consistent with early cerebrovascular change and early neuronal loss, predominant in the right hemisphere. Ménière's Disease has evolved as a peripheral ear disease, understood pathophysiologically to be an idiopathic endolymphatic hydrops. It is defined in terms of its pathology; and the clinical course is highlighted by episodic vertigo; ear blockage; low frequency tinnitus; and long term gradual progressive sensorineural hearing loss.

To be considered are the following:

1. Ménière's Disease - Pathophysiology:

The present conceptualization and understanding, clinically that complaints of hearing loss, tinnitus, vertigo, ear blockage alone and/or in combination, which we now identify with endolymphatic hydrops, may not always be limited to peripheral vestibular dysfunction. Rather, endolymphatic hydrops in some patients may reflect a peripheral extension of alteration in the cerebrovascular hemodynamics within the central nervous system. Are all cases of classical Ménière's Disease limited to the ear; and how many of such cases clinically manifest as peripheral ear problems, also involve brain?

2. Tinnitus:

In this patient the symptom of tinnitus is considered to be a "soft" sign both for inner ear disease bilateral as well as CNS Disease i.e., cerebrovascular and early neuronal loss.¹ This clinical impression is considered to be confirmed by the brain SPECT findings. Although the etiology of the CNS neuronal loss in this patient has not been identified at this time, it is speculated to be secondary to a fluctuation in blood pressure.² Significant is that the clinical course of the patient following adjustment of hypertensive medication resulted in a significant reduction in the incidence of episodic vertigo; reduction in the intervals of unsteadiness; and also reduction in tinnitus intensity and frequency of occurrence. However, the complaint of right ear blockage persisted although reduced in degree. One can speculate what serial SPECT findings would reveal to support the role of hypertension control.

Vestibular tinnitus (VT) has been described as a clinical type of tinnitus reflecting dysfunction of the vestibular labyrinth.^{3,4} Vestibular tinnitus is located in the ear and usually is tonal in quality. The quality of VT is primarily tonal and of high frequency. The tinnitus may be the forerunner and/or the most sensitive symptom for identification of an early idiopathic endolymphatic hydrops (Ménière's Disease). The incidence of occurrence of VT in our tinnitus series was originally reported and persists to this day in approximately 25-35% of patients. It has been described that the tinnitus patient

may be symptomatic or non-symptomatic for vertigo or other balance disorders. Secondary Endolymphatic Hydrops has been reported in our series to have a incidence of occurrence of $\pm 35\%$.

It has been speculated that the clinical entity of Secondary Endolymphatic Hydrops, identified in the tinnitus patient with VT, has a clinical significance for both treatment and hearing conservation.^{4,5} The clinical contention is that there is the potential existence of subgroups of vestibular tinnitus peripheral and/or central in location. Claussen et al. (1995) speculated that some cases of tinnitus can be caused by some abnormal forms of spontaneous activity in the central nervous system.⁶ This is supported by the results of Brain Electrical Activity Mapping (BEAM) and Vestibular Evoked Potentials (VestEP) testing in acoustic tumor patients with tinnitus in response to a rotary stimulus. The results reported an ipsilateral reduction of the typical VestEP component latencies and an increased amplitude in the negative shift of the rotational evoked cortical activity. These findings suggest that there exists in tinnitus patients a state of central dysinhibition over broad cortical levels. It further supports the original speculation that in some patients tinnitus can originate at a site of vestibular dysfunction, peripheral and/or central, and reflect the presence of subtypes of vestibular tinnitus.^{2,4}

3. SPECT of Brain:

In the clinical evaluation of SPECT of brain perfusion asymmetries, one must differentiate between perfusion asymmetries compatible with lack of vascular reserve and neuronal loss.⁷

The diaschisis effect is a neuronal disconnect effect not a vascular effect.⁷ A long standing vascular effect may result in a neuronal loss. Diamox, a diuretic is also a vasodilator. It is a test for vascular reserve. Its administration or that of inhalation of CO₂ is a method used to demonstrate diaschisis, i.e., neuronal disconnect. Specifically a positive Diamox effect will result in elimination of perfusion defects and/or asymmetries following SPECT imaging of brain i.e., a sufficient vascular reserve. A negative Diamox effect reflects no change in perfusion defects i.e., a insufficient vascular reserve and/or neuronal loss.

The "watershed effect" was demonstrated in this patient by a "linear" appearance defect in the frontal lobe right greater than left. The vascular supply to the frontal lobe area is from the frontal branches of the middle cerebral artery; and the anterior cerebral artery. Such a defect reflects the most distal part of circulation of major arteries, the arteriolar capillary junction. Such an area is known as the "watershed".⁷

It is an effect demonstrated by SPECT for areas of hypoperfusion in brain which reflect the arteriolar

capillary junction of two or more major arteries in a particular region of interest of brain. It is a characteristic distribution of ischemia.

CONCLUSIONS

1. SPECT Imaging of Brain should be considered in patients with persistent vertigo to identify the presence or absence of CNS disease with particular emphasis on cerebrovascular and neuronal loss.
2. Diamox test with SPECT is a test for vascular reserve in brain.
3. Abnormal auditory sensation and/or any form of dysacusis should be considered in the neurotologic evaluation to have a peripheral and/or central site of lesion.
4. Ménière's Disease patients not responsive to conventional treatment are recommended to be evaluated for CNS involvement with particular emphasis on the diagnosis of early cerebrovascular disease.
5. The medical significance of this case report of a patient with complaints of ear blockage, vertigo, tinnitus, may be early cerebrovascular disease with neuronal loss in multiple regions of brain.

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