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Tinnitus

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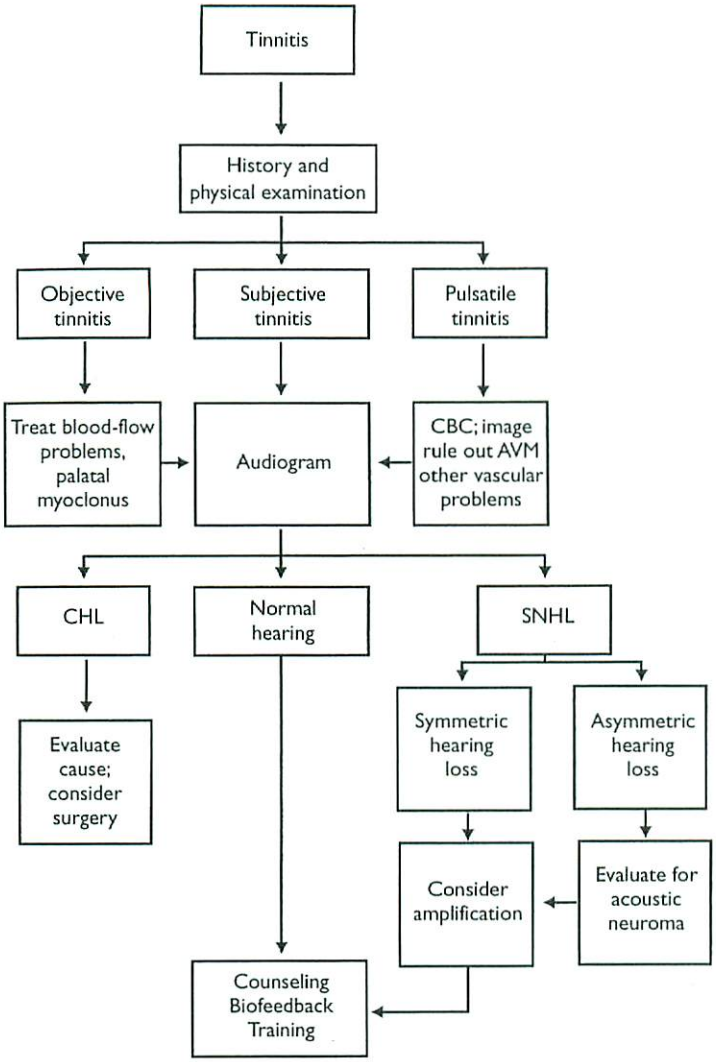
Tinnitus is an auditory perception of sound that is not present in the external environment. It is common, affecting up to 7% of the U.S. population, with the incidence increasing with age. Tinnitus is usually minor and noted only in quiet environments, such as at bedtime. For some patients, however, awareness of tinnitus can result in severe dysphoria that can lead to depression and, rarely, suicide.

Most patients presenting with tinnitus describe the noise as a ringing, buzzing, or humming, whereas others report sounds such as a rhythmic ocean rumble or a chirping cricket. One half of patients with tinnitus localize sound to one ear, and the other half hear noise either from both ears or from the head in general. Twenty percent of tinnitus sufferers complain of significant effects on their quality of life, including difficulty sleeping and concentrating and problems in social interaction and daily work. Depression is often associated with tinnitus, especially in the elderly. Approximately three quarters of patients with ear disease have associated tinnitus, making common the associated otologic complaints of hearing loss, vertigo, and aural fullness.

Anatomy and Physiology

The pathophysiology of tinnitus can be divided into two main categories: para-auditory noises (arising from structures outside of the auditory system)



Algorithm Management of tinnitis. CHL = conductive hearing loss; SNHL = sensorineural hearing loss.

and sensorineural auditory noises (arising from structures within the auditory system [e.g., cochlea, cochlear nerve]).

Tinnitus of para-auditory origin is seen with vascular neoplasms, vascular malformations (e.g., acquired conditions such as carotid stenosis) palatal my-

oclonus, increased intracranial pressure (benign intracranial hypertension), and conductive hearing loss. The mechanism of tinnitus occurring with vascular disorders is thought to be mechanical energy from the increased blood flow or turbulence that is transmitted to the auditory system, which explains why this type of tinnitus is often pulsatile and changes with blood pressure. The rhythmic muscular contractions of palatal myoclonus can cause a clicking sound. Increased intracranial pressure allows transmission of pulses from Circle of Willis vessels to the cerebrospinal fluid and dural sinuses, resulting in pulsatile tinnitus. A conductive hearing loss is caused by imposing a physical change on the mechanical system of the outer or middle ear (e.g., cerumen impaction). Tinnitus results from attenuation of background sounds, making normally inaudible skull sounds audible.

Sensorineural tinnitus is associated most frequently with hearing loss, but the mechanism that causes this type of tinnitus is unknown. Theories include hyperactivity of hair cells or nerve fibers, cell injury, efferent cochlear neuron loss, or increased endolymphatic fluid pressure. Recent investigation suggests that, in some cases, the perception of sound may arise within the cochlear nucleus in the brainstem.

History

A thorough history is essential for evaluating a patient with tinnitus. Basic information includes age of onset, mode of progression, and precipitating events. The subjective history includes pitch, loudness, and location of tinnitus, although these correlate poorly with the underlying cause. Associated audiovestibular complaints (e.g., hearing loss, vertigo, aural fullness, otalgia, otorrhea) and a history of noise exposure or head trauma are also important. A dietary history can reveal heavy caffeine intake, the cessation of which may improve the tinnitus. Allergic and other forms of rhinosinusitis can contribute to eustachian tube dysfunction that worsens the patient's otologic symptoms.

The patient should be questioned about headaches, visual changes, focal neurological complaints, weight loss, possibility of pregnancy, symptoms of thyroid dysfunction, and depression (Case 7.1). Recent weight loss can be associated with a patulous eustachian tube, and the resultant transmission of pharyngeal sounds may be interpreted by the patient as a sound in the ear.

Tinnitus can interfere with sleep, work, and enjoyment of social situations. Tinnitus handicap questionnaires are available for evaluating the lifestyle effect of tinnitus. Certain medications, especially aspirin, can result in tinnitus; other drugs (e.g., aminoglycosides, antimalarials, loop diuretics) can cause hearing loss.

Case 7.1 **Elderly Man with Tinnitus Exacerbated by Depression**

A male veteran 75 years of age complains of a constant, high-pitched "whine" that is gradually increasing in intensity. The noise increased only recently and is now keeping him awake at night. He is not aware of any hearing loss, but he does have some difficulty understanding conversational speech in noisy environments. He has hypertension, which is well controlled. He is a nonsmoker with no other known medical problems. He has had only minimal noise exposure since his combat experience in WWII. Review of systems was negative, but questioning revealed that he first began having difficulties with tinnitus keeping him awake when his wife of 52 years died 6 months previously.

The physical examination is normal, with no evidence of bruits or other head and neck abnormalities. An audiogram reveals significant high-frequency hearing loss, with levels of 60 and 70 dB at 4000 Hz. Speech discrimination scores are 87% and 88%.

The patient is thought to have tinnitus secondary to his hearing loss that was exacerbated by depression occurring after the loss of his wife. He is counseled about the relationship between tinnitus and hearing loss. An amplification trial is suggested, but he is not interested. However, he does agree to see a mental health professional for treatment of his suspected depression, and he responds well to counseling and a short course of mood-elevating medication.

Discussion

Sensorineural tinnitus is the most characteristic form of tinnitus encountered in the typical practice. The recent exacerbation associated with depression is common and often requires additional history to uncover. Most patients perceive that the tinnitus is the cause of sleeplessness, so the diagnosis of depression must be suspected by their physician. (Contributed by Dr. David Eibling.)

Other disease states can cause or be related to tinnitus, so past medical histories of the following may be useful: atherosclerotic carotid disease, hypertension, diabetes, thyroid dysfunction, anemia, otosclerosis, otitis media, Meniere's disease, presbycusis, multiple sclerosis, hyperlipidemia, neoplasms, and syphilis. Family history may reveal tinnitus associated with disease processes such as otosclerosis, neurofibromatosis, or familial hearing loss.

Physical Examination

The external ear and mastoid are inspected, palpated, and auscultated. Erythema, tenderness, audible sounds, and bruits are noted. The external

canal is inspected with an otoscope for infection and obstruction due to cerumen, osteomas, tumors, or foreign bodies. Auscultation of the external canal may reveal objective tinnitus. This auscultation is easier to perform with a powered electronic stethoscope (Auscultear), although a regular stethoscope will suffice. Asking the patient to stop breathing during auscultation is helpful.

Pneumatic massage is used to assess tympanic membrane mobility, effusions, retractions, perforations, masses, infection, and other abnormalities. With mild eustachian tube dysfunction and minimal negative middle ear pressure, mobility of the tympanic membrane may be diminished. Asking the patient to autoinsufflate (i.e., "Hold your nose and pop your ears") often overcomes the mild eustachian tube dysfunction, returning the middle ear pressure and the tympanic membrane mobility to normal.

Tuning fork tests are performed to assess both conductive and sensorineural hearing loss. The oropharynx is evaluated, looking for palatal myoclonus or masses. The nose is inspected for masses or evidence of infection. The neck examination includes auscultation for bruits. When a bruit is found, carefully palpate for a thrill. Pulsatile tinnitus is compared with the patient's heart rate–a process that is simplified by asking the patient to mimic the sound while you palpate the pulse.

Gently applying pressure on the neck, being careful not to occlude the carotid, sometimes relieves tinnitus of venous origin. The neck is carefully palpated for any masses. Fundoscopic examination is performed to rule out evidence of increased intracranial pressure (as with benign intracranial hypertension). A complete **neurological examination** is performed with special attention to cranial nerves V, VI, VII, and VIII because they have an intimate relationship to the petrous bone within which reside the cochlea and the middle and external ear.

Differential Diagnosis

There are many classification systems for tinnitus, the most straightforward of which divides tinnitus into objective and subjective forms (Table 7.1). Objective tinnitus, which is audible to both patient and examiner, is uncommon but dramatic when encountered (Case 7.2). Sounds in this category are usually pulsating, rapid clicking, or blowing. Tinnitus noise is typically audible only to the patient, commonly occurs with intrinsic ear disease, and usually is described as ringing or buzzing. The causes of subjective tinnitus can be otologic (e.g., cerumen impaction, noise-induced hearing loss) (Case 7.3), pharmacologic (e.g., aspirin use), or metabolic (e.g., hyperlipidemia) (*see* Table 7.1).

Table 7.1 Objective and Subjective Causes of Tinnitus*

Objective Tinnitus	Subjective Tinnitus
Vascular Neoplasms	*Otologic Causes*
Glomus jugulare	Presbycusis
Glomus tympanicum	Noise-induced
Vascular Abnormalities	Cerumen impaction
Arteriovenous malformation	Middle ear effusion
Venous hums	Meniere's disease
Dehiscent jugular bulb	Otosclerosis
Hypertension	Neoplasm (e.g., acoustic neuroma)
Atherosclerotic carotid artery disease	Syphilis
Vascular loop	*Pharmacologic Causes*
High-riding carotid artery	Aspirin-containing drugs
Increased Intracranial Pressure	Aminoglycosides
Mechanical Abnormalities	Nonsteroidal anti-inflammatory drugs
Patulous eustachian tube	*Metabolic*
Palatal myoclonus	Hyper- or hypothyroid
TMJ problems	Hyperlipidemia
Multiple Sclerosis	*Depression*

TMJ = temporomandibular joint
* All forms of objective tinnitus can be included under the heading of subjective tinnitus.

Additional Diagnostic Evaluation

Investigating the causes of tinnitus using diagnostic tests can be focused by information from the history and physical examination. Audiologic evaluation is performed on all patients with tinnitus. This evaluation consists of pure-tone audiometry, speech audiometry (speech discrimination and speech-reception threshold), and impedance audiometry (tympanometry and acoustic reflex). Vestibular tests include electronystagmography, rotational studies, and posturography and are used when there is evidence of vestibular pathology in the initial work-up. With pulsatile tinnitus, a complete blood count may be warranted to rule out anemia as a contributing factor.

A variety of imaging modalities can be used to evaluate a tinnitus patient, depending on its suspected origin. Imaging is not required if the history and audiologic examination suggest uncomplicated hearing loss as the cause. High-resolution **computed tomography** of the head and temporal bone can be used to evaluate abnormal findings on physical examination. Contrast-enhanced magnetic resonance imaging of the cerebellopontile angle is helpful in excluding posterior cranial fossa tumors (e.g., acoustic neuroma). **Magnetic resonance angiography** allows visualization of vascular pathology. **Vascular studies** are indicated for the work-up of objective pulsatile tinnitus, including duplex carotid ultrasound, carotid angiography, and venography. **Electro-**

Case 7.2 **Woman with Objective Tinnitus Caused by an Arteriovenous Malformation**

A woman 38 years of age complains of low-pitch, roaring tinnitus that is gradually increasing in intensity. The roaring fluctuates, is worse on the left side, and occasionally seems to be pulsatile. She has no history of noise exposure, familial hearing loss, associated medical problems, or dizziness. She denies otalgia, previous ear disease, and drainage. Physical examination is normal. An audiogram reveals a binaural, flat sensorineural hearing loss, with thresholds of 35 dB in her right ear and 45 dB in her left. Speech discrimination scores are 100% bilaterally.

A hearing aid is fitted on her worse hearing ear. She returns 3 months later, stating that she can hear better with her aid but that the roaring has persisted. In fact, it is now so loud that her husband can hear it. Auscultation in her left ear canal and over her mastoid reveals a loud venous hum that changes in pitch with pressure of the stethoscope bell over the mastoid. Imaging shows an arteriovenous malformation (AVM) of the posterior fossa dura and temporal bone on the left, with a large draining mastoid emissary vein. She undergoes surgical excision of the dural AVM in a combined procedure with the otolaryngology and neurosurgery departments. Postoperatively, she has normal hearing and no longer requires the hearing aid.

Discussion

This case illustrates the importance of an adequate history and physical in the evaluation of tinnitus. In retrospect, this patient had been clearly describing a venous hum with a pulsatile component, yet auscultation of the skull was not performed at the initial examination. Moreover, the noise created by the venous flow resulted in "masking" of the presented sounds during the initial audiogram, leading to the false assumption that she was experiencing tinnitus due to hearing loss, when in fact she had normal hearing. (Contributed by Dr. David Eibling.)

physiologic tests, such as electromyography, are used to evaluate palatal myoclonus, and the auditory brainstem response test is used to evaluate cochlear nerve or brainstem function. Studies that are required less commonly include lumbar puncture to evaluate cerebrospinal fluid pressure (for disease processes such as benign intracranial hypertension) and allergy testing for food and environmental agents.

Management and Follow-Up

Treatment of tinnitus is difficult, and therapy is often frustrating for both patient and physician. Potentially curable causes of tinnitus are rare and include vascular anomalies, otosclerosis, otitis media, cerumen impaction, and neo-

Case 7.3 **Young Man with Tinnitus Caused by Noise-Induced Hearing Loss**

A man 22 years of age complains of high-pitched tinnitus that becomes worse at night, occasionally keeping him awake. He first noted the ringing several months ago and also has a periodic sensation of "blocked ears," worse on the left. He denies hearing loss, head trauma, or ear infection. He has no history of significant medical problems or familial hearing loss. However, he does have a history of significant noise exposure from recreational music and shooting. Furthermore, he works in a small, excessively noisy fabrication shop with stamping machines, grinders, and other equipment. He does not wear ear protection and notes occasional ear pain during shooting. He also notes that, when driving in his stereo-equipped car, he has to shout to be heard by his friends and that communication is all but impossible in the fabrication shop. In the past, he has noted tinnitus after exposure to noise, but it always ceased by the next day. Now, however, he notes that it is more or less continuously present and worse when in a quiet location. He states that his tinnitus recently became acutely louder when he was shooting his pistol next to a building that seemed to reflect the sound toward his left ear.

Physical examination and an audiogram are normal, with the exception of a binaural dip in hearing thresholds at 4000 Hz to 25 dB on the right and to 40 dB on the left. Speech discrimination scores are normal. Auditory-evoked potentials are normal. He is counseled on the necessity to avoid loud noises and on the significance of hearing protection. The other three men working in the shop are contacted and advised to obtain a baseline audiogram and to use ear protection, both at work and when engaged in recreational activities. The employer was contacted and it was recommended that he enroll his employees in a hearing-conservation program.

Discussion

This young man has developed noise-induced hearing loss that is probably permanent. Although previous episodes of tinnitus most likely indicated temporary threshold shifts, the persistent nature of his tinnitus now suggests significant hair cell damage.

The Occupational Health and Safety Act (OSHA) requires that all employees who work in a noise-hazardous area (defined as exposure to 85 dB averaged over 8 hours) must be enrolled in a formal hearing-conservation program. Unfortunately, not all businesses are required to comply with OSHA regulations, and it is not uncommon to find cases such as this. Education about the long-term sequelae of exposure to hazardous noise should be a part of patient wellness counseling. (Contributed by Dr. David Eibling.)

plasms. Unfortunately, most tinnitus falls into the "noncurable" category; thus, successful elimination of the symptom is elusive. Many therapies have been tried over the years, including masking, hearing aids, biofeedback, med-

ical therapy, acupuncture, electrical stimulation, behavior modification, and surgery. None has had dramatic success.

The first and foremost treatment for tinnitus is reassurance. Once the patient has had a thorough medial evaluation that fails to reveal a specific cause for the tinnitus, the patient should be told that the tinnitus is unlikely to represent a tumor or life-endangering disease process. This is the most important aspect of managing most cases of tinnitus. Patients who are severely bothered by their tinnitus may become clinically depressed, and sleeplessness may be attributed to the tinnitus rather than to the depression. Recognizing and treating such depression is vital, but it may or may not affect the tinnitus. The management of tinnitus is outlined in the Algorithm.

Nonmedical therapy, including avoidance of loud noises, abstinence from drinking caffeinated beverages, cessation of smoking, and elimination of precipitating drugs (e.g., aspirin, nonsteroidal anti-inflammatory drugs, antimalarial agents), if possible. Other forms of therapy such as hypnotherapy, acupuncture, and yoga have shown limited success.

Masking is a technique of applying an external noise to the patient to "cover up" the tinnitus and make it inaudible. This can include simply setting the bedside clock radio between stations at night when the tinnitus is loudest (to compensate for the lack of natural masking by ambient external sounds) or using a combined hearing aid/masking unit. Masking devices provide relief for only 10% to 15% of patients. Hearing aids (with or without a masking unit) are an option for patients with associated hearing loss, because they amplify ambient noise, thereby masking the tinnitus.

Medical therapy has had limited success. The following drugs have been studied: nortriptyline, alprazolam, carbamazepine, lidocaine, procaine, tocainide, and various calcium-channel blockers. The overall evidence of tinnitus relief, however, is conflicting and limited. Lidocaine is one of the few drugs that has been proven to suppress tinnitus subjectively; however, it is limited by its short duration of action, intravenous-only route of administration (for this purpose), and potential side effects. Carbamazepine seems promising and is thought to act similarly to how it acts with trigeminal neuralgia; however, side effects and the lack of well-controlled studies have limited its use.

Biofeedback is used to approach tinnitus from a more psychological perspective. This therapy focuses on the patient's emotional reaction to tinnitus and assumes that stress plays an important role in its severity. Patients who benefit most from this type of therapy are those with the highest agitation levels due to their tinnitus. Relaxation techniques are key to this type of treatment. Self-monitoring of vital signs, body temperature, and electromyography are the most common forms of feedback. The goal in this form of therapy is not necessarily the elimination of tinnitus, but rather a better understanding

and a mitigation of the factors related to the stress associated with tinnitus. Although there is no evidence from controlled studies that biofeedback works for tinnitus, some patients find it helpful. The usefulness of this modality is impaired by cost and by the fact it is not covered by medical insurance.

Habituation, one of the newest approaches to tinnitus, seems promising and involves directive counseling combined with low-level, broad-band noise produced by wearable generators. The directive counseling is designed to educate the patient about tinnitus and its possible causes. The background-noise generator facilitates habituation. According to the theory behind this therapy, masking is counterproductive because it prevents habituation. Reported results show a greater than 80% symptomatic improvement; however, habituation therapy has not been investigated under controlled experimental conditions and is not currently covered by third-party payers.

Surgery plays a role in some cases of tinnitus, such as that caused by cerebellopontile-angle lesions, neoplasms, vascular abnormalities, otosclerosis, infectious complications, and other causes of conductive hearing loss. Lumbar-peritoneal shunting can help with tinnitus that is caused by elevations in intracranial pressure resulting from benign intracranial hypertension. Tinnitus associated with Meniere's disease occasionally can be relieved by surgery. Surgery (e.g., cochlear implantation, cochlear nerve sectioning) has been studied in only a very small subset of patients.

Appropriate follow-up for patients with tinnitus depends on the underlying cause. A patient with an unremarkable examination and normal audiologic studies may be followed yearly with an annual audiogram if there are no further complaints. The patient with a defined underlying disease process, worsening symptoms, or severe lifestyle disruption should be followed more closely.

Danger Signs

Tinnitus is rarely an emergency; however, when it presents with a symptom that suggests intracranial pathology (e.g., unilateral vestibular weakness, focal neurologic deficits, severe headaches, visual changes, and profuse vomiting), emergent treatment is warranted. Tinnitus that is accompanied by uncontrolled ear infections, abnormalities on otoscopy, head and neck masses, bruits, thrills, or other suspicious lesions should prompt a thorough evaluation. Because tinnitus is relatively common, the primary danger is the temptation for the physician to skip to the work-up stage and proceed to patient reassurance. Every patient with persistent tinnitus deserves, at minimum, an accurate audiologic evaluation and, if interaural hearing asymmetry is present, an auditory brainstem response test and/or magnetic resonance imaging.

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SUGGESTED READINGS

Jastreboff PJ, Gray WC, Gold SL. Neurophysiologic approach to tinnitus patients. *Am J Otol.* 1996;17:236–40.

This article reviews the neurophysiology of this symptom complex and discusses the physiology and mechanics of habituation treatment.

Merchant SN, Rauch SD, Nadol JB Jr. Meniere's disease. *Eur Arch Otorhinolaryngol.* 1995;52:63–75.

This article provides an up-to-date review of the vast literature about this often-puzzling disease. Details include the natural history, pathogenesis, diagnosis, and treatment.

Seidman MD, Jacobson GP. Update on tinnitus. *Otolaryngol Clin North Am.* 1996;29: 455–65.

This article gives a good basic overview of tinnitus and includes a thorough review of the varying origins of this subjective symptom, detailing approaches to treatment.