Tinnitus

Grand Rounds

Edward Buckingham, M. D.
Jeff Vrabec, M. D., Faculty Sponcer
Francis Quinn, M.D., Series Editor
Introduction

- Def. - Perception of sound produced involuntarily within the body
- Symptom of threatening disease process or benign annoyance
- Psychological effects can be severe, even precipitate suicide
Definition and Epidemiology

- Objective, paraauditory tinnitus - vascular or myoclonic sources, less prevalent
- Subjective, sensorineural tinnitus - auditory system, more prevalent
- Prevalence increases with age
- Equal sex distribution
- Severity of symptoms increases with age
Objective Tinnitus

- Strictly defined as audible to physician or observer
- Encompasses all paraauditory causes
- Pulsatile or non-pulsatile
- Vascular abnormalities - neoplasm, AVM, arterial bruit, venous hums
- Palatomyoclonus
Objective Tinnitus - 2

- H & P
- Relation to the heart rate, light exercise
- Thorough ENT exam, particularly otoscopy
- Exam for retro tympanic mass
- Auscultate ext. canal, orbit, mastoid, skull, and neck
- Audiogram
Pulsatile Tinnitus

- Many causes
- Possible algorithm from Sismanis
- H & P most important
- BIH, ACAD, Glomus tumors 2/3 of causes
Benign Intracranial Hypertension (pseudotumor cerebri) Syndrome

- Most common cause in Sismanis’s study
- Increased ICP, no focal neuro deficit except occas. 6th or 7th nerve palsy
- Mech. systolic pulsation of CSF to medial aspect of dural venous sinuses, compression of walls, turbulent blood flow
- Head imaging, r/o IC lesion
- Diagnose by LP, ICP > 200 mm H2O
Female 20 - 50 yrs old and overweight
Ipsilateral IJV digital pressure subsides
Poss. blurred vision, fronto-occipital HA, lightheadedness-disequilibrium
Poss. LF HL with good discrimination, which normalizes with IJV pressure
BIH - Treatment

- Weight loss
- Acetazolamide, furosemide
- Subarachnoid-peritoneal shunt
- Occas. gastric bypass for weight reduction
Vascular Neoplasms

- Classic tumors - Glomus jugulare and tympanicum
- Bruit not altered by neck pressure, head position, posture, or Valsalva
- Tympanometry - regular perturbations
- Otoscopy - bluish or redish mass poss. pulsation and paling with pos. pressure
Vascular Neoplasms - 2

- Dif. Diag. - hemotympanum, dehiscent jugular bulb, carotid artery abnormality
- Radiograph prior to myringotomy
- Check H & N for masses
- Cranial nerve and cerebellar function
- If suspected CT scan, mass in ME or eroded jugular spine.
Vascular Neoplasms - 3

- Arteriography
- MRI
- Treatment is usually surgical
Arteriovenous Malformations

- Developmental abnormalities
- Often larger than symptoms suggest
- May enlarge rapidly and tend to recur
- May impinge on adjacent structures
- Posterior fossa occipital artery and transverse sinus AVM most common
- AVM of mandible uncommon but notorious cause of tinnitus
Carotid artery/cavernous sinus from trauma
Pulsatile tinnitus often initial complaint
HA, papilledema, bruit with thrill,
Heart rate may slow with compression
AVM - Treatment

- Surgical
- Preceeded by angiography with embolization
- Tend to be larger than appear on angio.
- Max benefit if surgery follows within 72 hrs
Venous Hum

- Eddy currents in IJV
- Normal in children, some adults, esp. young women
- Attributed to Trans. proc. C2, increased CO (anemia, thyrotoxicosis, pregnancy)
- Often presents with hearing loss
Venous Hum - 2

- Gentle ant. neck pressure may relieve
- Head toward uninvolved side decreases and to involved side increases
- Deep breathing and Valsalva increase
- Treat by reassurance, and correcting underlying cause
Palatomyoclonus

- Irregular clicking sound, 20-400 bpm
- Occurs intermittently
- Palatal musculature and ET mucous membrane
- Also ear fullness, hearing distortion
- May have other muscle spasms
- Diagnose with Toynbee tube in ear canal
Palatomyoclonus -2

- Tympanogram movement synchronous with contraction
- EMG of palatal muscles confirms
- Observable palatal fasciculation - MRI
- Hypertrophic degeneration inferior olive
- Differentiate from tensor tympani spasm, usually transient
Palatomyoclonus -3

- Treatment: clonazepam, diazepam, warm liquids, stress mgmt.
- Botulinum toxin injection in severe cases
Idiopathic Stapedial Muscle Spasm

- Rough, rumbling, or crackling noise
- Triggered by external noises
- Brief and intermittent
- Rarely disruptive and prolonged
- Variable intensity tympanometry to induce spasm
Idiopathic Stapedial Muscle Spasm - 2

- Acoustic reflex - prolonged continued increased impedance during and after sound stimulus
- Treatment - clonazepam, diazepam
- Symptoms may last only months
- Surgery to divide tendon as last resort
Subjective Tinnitus

- Tinnitus originates within auditory system
- More common
- Little known about physiologic mechanism
- Hyperactive hair cells or nerve fibers
- Chemical imbalance
- Reduced suppressive influence of CNS
Auditory Pathway

- Cochlear hair cells, bipolar neurons of spiral ganglion make up 8th nerve, terminate on cochlear nucleus
- Three pathways - dorsal acoustic stria, intermediate acoustic stria, trapezoid body
- Superior olivary nuclei
- Lateral lemniscus
Auditory Pathway - 2

- Bilateral auditory input from outset
- Central auditory lesions do not cause monoaural disability
- Inferior colliculus arranged tonotopically
- Medial geniculate body, ipsilateral
- Primary Auditory Cortex, Sup. Temp. Gyrus (Brodmann’s areas 41 and 42)
Auditory Brainstem Response

- Auditory evoked responses
- Electrophysiologic recordings of response to sound
- Can be recorded from all levels of auditory pathway
- ABR most applied clinically
- Waves from 8th nerve, caudal and rostral brainstem
Wave I - synchronously stimulated compound action potentials from distal (cochlear) end of 8th nerve

Wave II - Also 8th nerve but near brainstem

Wave I & II - ipsilateral to ear stimulated

Later waves have multiple generators

Wave III - caudal pons with cont. cochlear nuclei, trapezoid body, sup. olivary complex
Wave V - most prominent and rostral
Lateral lemniscus near inferior colliculus probably on contralateral side to ear stimulated
Little difference in ABR in tinnitus
Evaluation - Subjective Tinnitus

- Etiologic factors - otologic, cardiovascular, metabolic, neurologic, pharmacologic, dental, psychological
- H/O noise exposure and related symptoms - hearing loss, vertigo
- Exact characterization of tinnitus quality
- Perceptual location
Evaluation - Subjective Tinnitus

- Head injury, whiplash injury, meningitis, multiple sclerosis
- Medications - aspirin, aspirin compounds, aminoglycoside antibiotics, NSAIDS, heterocycline antidepressants
- TMJ, dental abnormalities prevalent
- Psychologic factors, somatoform disorder
- Depression
Evaluation - Subjective Tinnitus

- Audiometry - assymetrical hearing loss, unilateral tinnitus - MRI r/o post fossa
- Complete questionnaire for perceived severity
Measurement of Tinnitus

- Pitch, loudness, minimum masking level, residual inhibition/post masking
- Minimum masking level most clinical use
- Pitch - match most prominent pure tone, poor reliability, octave difference
- Loudness - Adjust pure tone to tinnitus
- Most < 7 dB SL, may be 2 dB
Measurement of Tinnitus

- Minimal masking level - number of decibels to cover tinnitus
- Residual inhibition - response of patients tinnitus post masking
Diagnostic Tests

- None available to objectively measure or confirm tinnitus
- ABR, PET, SpOAE, magnetic activity
Otoacoustic Emissions

- Low-intensity sounds produced by cochlea as response to acoustic stimulus
- Outer hair cell motility affects basilar membrane - intracochlear amplification, cochlear tuning
- Generates mechanical energy propagated to ear canal
- Vibration of TM produces acoustic signal measured by sensitive microphone
Spontaneous Otoacoustic Emissions

- Measurable without stimulation
- Present in 60% with normal hearing
- Twice as common in females
- No relationship yet in tinnitus
Distortion Product Otoacoustic Emissions

- Produced when two pure-tone stimuli, different frequency simultaneously
- Present in all normal hearing
- Damaged outer hair cells - no DPOAE
- 30% damage without audiogram change
- Will have abnormal OAE
- No correlation in tinnitus yet
DPOAE

- Norton - oscillating or prolonged evoked emission in 5/6 tinnitus patients and 0/2 without

- They suggest that evoked emission and the tinnitus might be related to the same underlying pathology, but the former is not the cause of the latter
Tinnitus Treatment - Counseling

- Etiologic factors
- After work-up, unlikelihood of tumor or life-endangering disease
- 25% improve or go away, 50% decrease, 25% persist, very small portion increase
- Avoid loud noise, wear ear protection
- Avoid caffeinated beverages, stimulants (coffee, tea, colas, chocolate)
- Stop smoking
Avoid previously mentioned medicines

Nicotinic acid (B<sub>6</sub>), carbamazepine, baclofen, others; none beneficial

Lidocaine beneficial - IV, short 1/2 life, poor side effects

Oral analogs - tocainide, flecainide acetate - no benefit
Tinnitus Treatment - Meds

- Melatonin - 3.0 mg qhs does not relieve tinnitus
- Sleep disturbance - 46.7% vs. 20% placebo benefit (p=0.04)
- Benzodiazepines - clonazepam, oxazepam, alprazolam may provide benefit esp. with concurrent depression
- Alprazolam - 76% had reduction in loudness 5% of placebo
Tinnitus Treatment - Meds

- Overall, meds should not be major strategy, certain sufferers may benefit in conjunction with other therapy
Environmental Masking

- For mild tinnitus esp. bothersome in quiet
- Home environmental maskers
- Broad-band noise, between FM stations
- Particularly useful at night
- Required noise soft usually does not disturb family members
Hearing Aids and Maskers

- Saltzmann and Ersner (1947) - hearing aids amplified background noise, mask tinnitus
- If hearing loss try HA, less interference with speech, no noise to produce damage, improve speech understanding
- Commercial tinnitus maskers with or without HA
- Complete or partial mask
- No clear guidelines for use
Hearing Aides and Maskers

- Narrowband noise (less 1/2 octave) tonal character, more annoying
- Conservative approach - lowest level with adequate relief, need not be worn continuously
- No protocol which ear, unilateral, bilateral
Electrical Stimulation

- DC (direct current) to round window or promontory could reduce tinnitus
- DC may produce permanent damage, cannot be used clinically
- AC (alternating current)
- External stim to tympanic membrane, transtympanically on promontory, tanscutaneously in pre and post auricular region
Electrical Stimulation

- Ext. AC stim. results mixed, some promising
- One commercial extracochlear wearable device marketed 1985
- 1986 Dobie 1 in 20 benefited
Intracochlear Electrical Stimulation

- Observations that cochlear-implant patients reduction in tinnitus while listening to speech
- Few received CI explicitly for tinnitus
- 1984 House 5 patients severe to profound HL, CI placed for tinnitus relief, no stim. only one reported benefit listening to speech.
Intracochlear Electrical Stimulation

- 1989 Hazell - six totally deaf, CI implant and trials with sinusoidal stim.
- Able to reduce tinnitus in all 6 with 100 Hz sinusoid
- Two forego speech processor and used just for tinnitus relief
- One turn on current, turn off tinnitus “like a light switch”
Surgery

- Effective in treating conditions, tinnitus is a symptom e.g. otosclerosis, acoustic neuroma, glomus jugulare.
- Literature discusses cochlear neurectomy and microvascular decompression of the cochlear nerve.
- Results not consistent.
- Few otologists advocate use of surgery.
- Validates hypothesis: tinnitus is a general central issue.
Neurophysiological Approach to Tinnitus and Habituation

- New theory
- Previous theories share belief that process producing tinnitus restricted to auditory pathway and cochlea
- Models focused on tinnitus generation, treated auditory pathway as passive, unchangeable transmitters of signal to auditory cortex
Neurophysiological Model

- Diagnostic efforts concentrated on psychoacoustical description (loudness, pitch, maskability)
- These no help in predicting treatment outcome, no explanation why same description produced drastic different annoyance
- This model postulates - tinnitus results from multiple interactions of a number of subsystems in nervous system
Neurophysiological Model

- Auditory pathway role in development and appearance of tinnitus as sound perception
- Other systems, limbic system, tinnitus annoyance
- Problem - perception becomes associated with neg. emotions, fear, and threat
- Limbic system activates autonomic nervous system resulting in annoyance
Neurophysiologic Model

- Because annoyance primarily dependent on limbic system which is a perception by the individual and an associated emotional state, psychoacoustical characterization of tinnitus irrelevant
Habituation

- **Def.** - The disappearance of reactions to sensory stimulus because of repetitive exposition of a subject to this stimulus and the lack of positive or negative reinforcement associated with this stimulus.

- **Brain ordering of tasks**
  1) importance of signal esp. if danger
  2) novelty

- If signal not assoc. with event or indicate danger, not new, undergoes habituation, and after repetition in not perceived.
Habituation

- Accomplished by directive counseling - educate patient of potential mechanisms of tinnitus, discuss results of all audiologic and medical tests and relevance
- Once patient understands, level of annoyance decreases
- Repetative visits reinforce and eliminate negative association evoked by tinnitus
Habituation

- Directive counseling essential but not sufficient to achieve permanent habituation
- Need to enhance auditory background ie. partial masking, particularly in quiet envir.
- Increased background spontaneous and evoked activity in auditory pathways, reduces contrast of tinnitus to background noise facilitating habituation
- Must avoid masking tinnitus completely
Habituation

- By def. once signal is masked it cannot be habituated to
- Reconditioning of connections in subcortical centers cannot occur if stimulus (tinnitus) is absent
- Tinnitus masking 15 yrs no changes in tinnitus, evidence of habituation, decreased annoyance
- One year habituation therapy - aware only small percent of time, annoyance decreased
Habituation - Technique

- Fitted binaurally with broad-band noise generator
- Use for at least 6 hrs per day, part. in quiet
- If HL, HA are also used
- Process requires 12 months
- Jastreboff insists 6 more months to ensure plastic changes in brain established
- After that time noise generators discontinued
Jabstrebboff reports 83% of patients exhibit significant improvement with combined therapy
Summary

- Important to differentiate types of tinnitus
- Must recognize when tinnitus part of symptomatology of underlying disease versus merely auditory annoyance
- Patience and understanding of patient’s experience important
- Para-auditory tinnitus treatable by standard medical/surgical therapy
- Subjective tinnitus treatment advancing