

Imaging of the Patient with Tinnitus

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Goals

- To understand tinnitus and its causes
- To determine which patients with tinnitus will benefit from imaging
- To select the appropriate imaging modality for evaluating different forms of tinnitus
- To review the typical appearance of pathologies which cause tinnitus

What is tinnitus?

- The perception of a sound which is not present in the external world.
- Unlike auditory hallucinations, tends to be unformed and repetitive: buzzing, screeching, hissing, pulsing, whooshing.

How common is the problem?

- Roughly 15% of the population experiences tinnitus.
- Up to 4% have very intense tinnitus.
 - Can lead to chronic disability and suicide
 - “my ears whistle and buzz continually, day and night ... such a condition is truly frightful” Ludwig van Beethoven
- Most of us have experienced it at one time or another
 - Transient tinnitus
 - Noise induced tinnitus following noise exposure

Who is at risk?

- Three major risk factors:
 - Hearing impairment
 - Increasing age
 - Male gender
- Probably increasing in incidence due to:
 - Increased age of the population
 - War
 - Many common military experiences (interior of a Chinook helicopter, interior of tank, deck of aircraft carrier) are over 100 dB.
 - Blast injuries cause damage to both middle and inner ear. Soldiers reluctant to wear ear protection.

Tinnitus Classification

- Subjective
- Objective
 - Pulsatile
 - Non-pulsatile

Subjective tinnitus

- Most common type of tinnitus
- Associated with hearing loss.
 - Associated symptoms depend on cause
 - Vertigo – SSCD, Meniere's
 - Conductive hearing loss – otosclerosis, SSCD
 - SNHL – vestibular schwannoma, presbycusis, noise induced hearing loss

Objective Tinnitus

- An actual sound made by the human body.
- Can be due to vascular sounds
- Can be due to other physiologic sounds
 - Muscular contractions (palatal myoclonus – clicking)
 - Respiration (patulous eustachian tube)
 - Venous hum (flow murmurs)
 - "normal" tinnitus
- Frequently can be perceived by an observer.

Pulsatile tinnitus

- Can be altered with compression of arterial or venous structures.
- Can be perceived by the examiner if stethoscope placed in the right location.
- Can be venous or arterial
- Tends to produce whooshing sound.
- Pulse synchronous

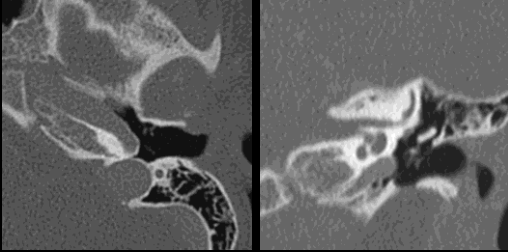
Pulsatile tinnitus - causes

- Hypervascular states
 - Graves disease
- Vascular tumors
 - Paragangliomas: glomus tympanicum or glomus jugulare
- Arteriovenous malformations and fistulas
 - Dural AVMs or AVFs frequently involving transverse sinus
- Congenital malformations
 - Aberrant carotid, high-riding jugular bulb, diverticula
- Narrowing of the transverse sinus
 - IIH
 - Transverse sinus thrombosis
- Carotid dissection, carotid atherosclerosis

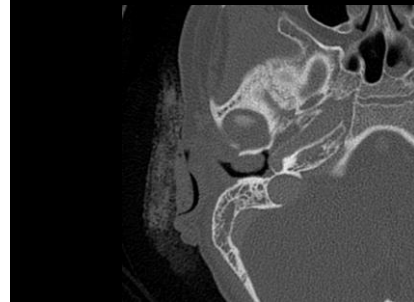
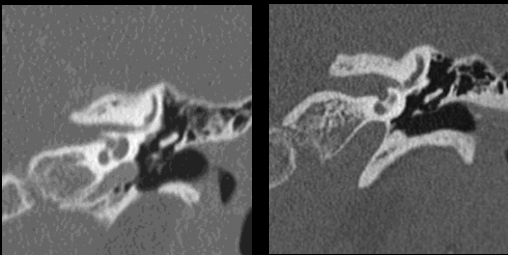
Congenital causes of pulsatile tinnitus

The screenshot shows the website 'whooshers.com' with a search bar and a navigation menu. The main content area displays a search result for 'Pulsatile tinnitus is the perception of a rhythmic noise that is synchronous with the patient's heartbeat.' The result includes a date range from 2013-11-01 to 2013-08-01 and a snippet of text describing the condition. The text reads: 'Pulsatile tinnitus is the perception of a rhythmic noise that is synchronous with the patient's heartbeat.' Below this, there is a search bar and a 'Show' button. The page also features a sidebar with a navigation menu and a main content area with a search result for 'Pulsatile tinnitus is the perception of a rhythmic noise that is synchronous with the patient's heartbeat.' The result includes a date range from 2013-11-01 to 2013-08-01 and a snippet of text describing the condition. The text reads: 'Pulsatile tinnitus is the perception of a rhythmic noise that is synchronous with the patient's heartbeat.'

Aberrant Carotid



- Rare anomaly
- Enters tympanic cavity through enlarged inferior tympanic canaliculus
- Travels through middle ear
- Enters petrous canal through defect in carotid plate.



Persistent stapedial artery

- Rare congenital cause of pulsatile tinnitus
- May accompany a lateralized carotid



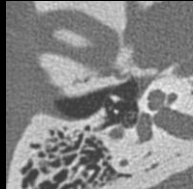
Persistent stapedial artery

- Travels from infracochlear carotid



PSA

- Passes through stapedial obturator foramen



PSA

- Enlarges tympanic segment of facial canal

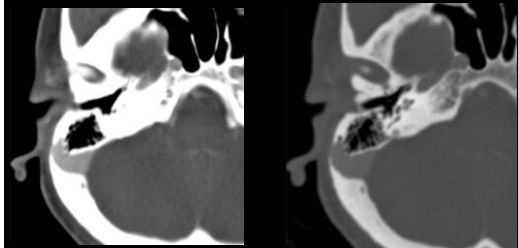


PSA

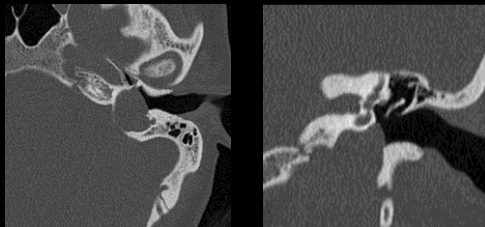
- Terminates as middle meningeal



Sigmoid sinus dehiscence



High riding, dehiscent jugular bulb



Acquired causes of pulsatile tinnitus

Dural Arteriovenous Fistulas

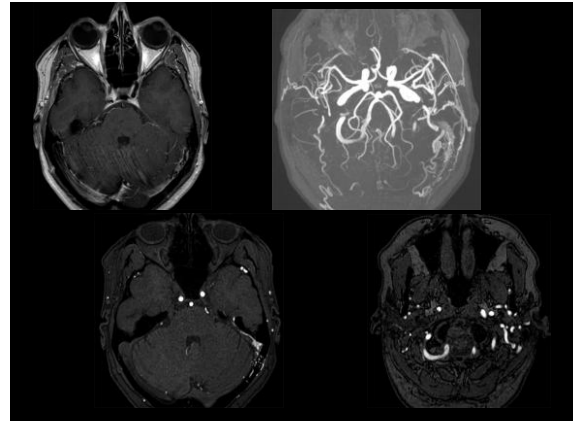
- Idiopathic
- Related to trauma, prior craniotomy or dural sinus thrombosis.
- Classified according to direction of flow and presence or absence of cortical venous drainage
- In absence of CVD, very low risk of hemorrhage, do not require treatment
- Most common locations cavernous, transverse, sigmoid sinuses.

MRI findings

- Flow related enhancement in venous structure on 3D TOF MRA.
- Prominent flow voids in transverse sinus
- Prominent meningeal arteries
- Prominent vascular channels across calvarium to transverse sinus.

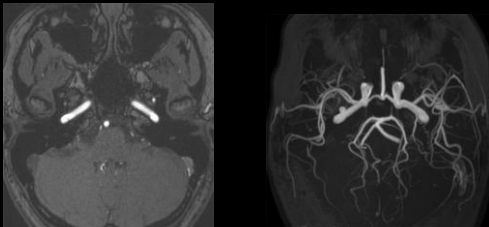
CTA findings

- Asymmetric arterial feeding vessels
- Shaggy appearance to the dural sinus or tentorium
- Prominent transcalvarial venous channels



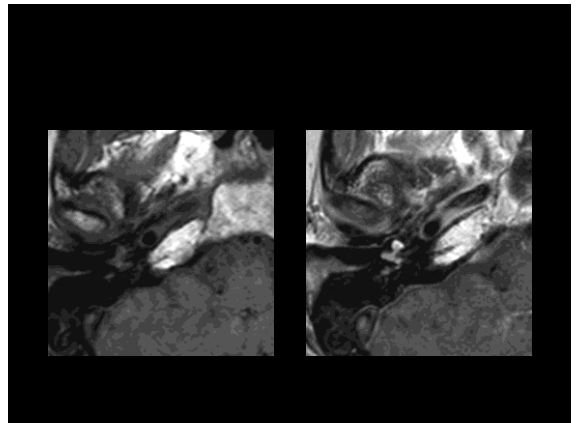
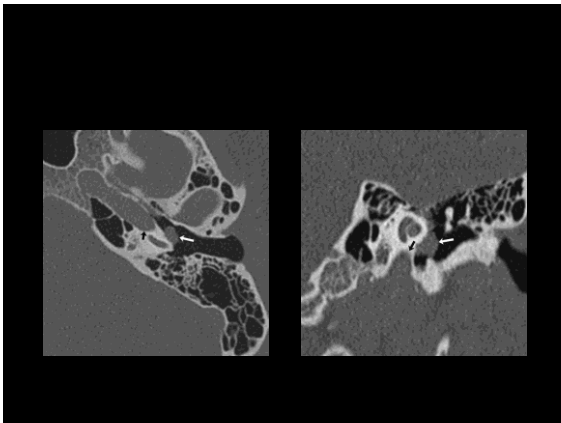
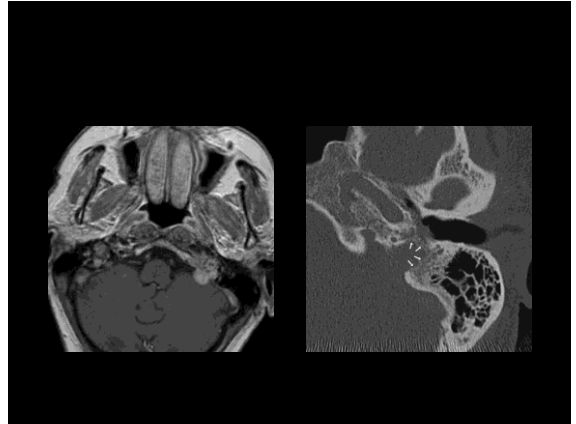
Paragangliomas

- Extra-adrenal pheochromocytomas
- Can be limited to the middle ear
 - Along Jacobson's nerve (tympanic branch of glossopharyngeal)
 - Glomus tympanicum
- Can involve the jugular foramen
 - Along Arnold's nerve (auricular branch of vagus)
 - Glomus jugulare or jugularetympanicum



Paragangliomas

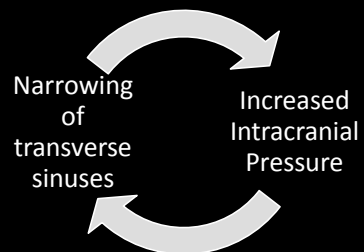
- More common in women than men
- 10% multiple
 - Glomus vagale, carotid body tumors
- Slow growing
- Highly vascular



Idiopathic Intracranial Hypertension

- Increase in CSF pressure in the absence of mass lesion.
- Most commonly in obese women of childbearing age.
- Causes papilledema, and visual field loss, may ultimately lead to blindness.
- Tinnitus is a result of compression of the distal transverse sinuses.

Feedback loop of IIH



IIH - findings

- Empty sella
- Prominent CSF in optic nerve sheath
- Flattening of globes
- Narrowing of distal transverse sinuses on MRV/CTV



Pulsatile tinnitus - summary

- Look for most common causes: paraganglioma, dural AVM/AVF, IIH
- Look for rare but important causes:
 - Aberrant carotid.
- For the most part would be fine with MRI temporal bone, MRA, MRV
 - Include MRA neck if suspect atherosclerotic disease, carotid dissection

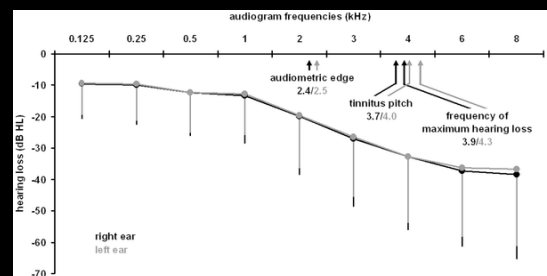
Subjective tinnitus

Why is tinnitus associated with hearing loss?

- Tinnitus is the phantom limb phenomenon of hearing.
- Decreased auditory input + neuronal plasticity = abnormal activity = tinnitus
- Hearing loss leads to tinnitus as the brain "fills in" the absence of sound



Figure 2. Relationship of audiogram and tinnitus pitch averaged for the whole sample, for the right and left ear.



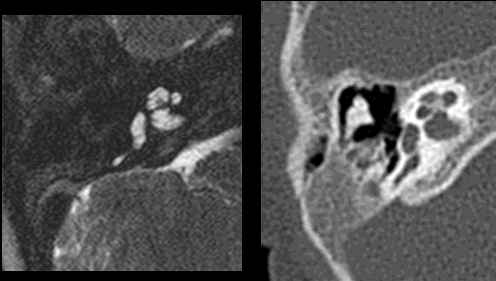
Schecklmann M, Vietmeier V, Steffens J, Lindgrebe M, et al. (2012) Relationship between Audiometric Slope and Tinnitus Pitch in Tinnitus Patients: Insights into the Mechanisms of Tinnitus Generation. *PLOS ONE* 7(4): e34878. doi:10.1371/journal.pone.0034878

If hearing improves, so does tinnitus

- Stapes implant improves tinnitus for patients with otosclerosis.
- Cochlear implant improves tinnitus for patients with SNHL.

So the goal of a radiologist in subjective tinnitus is – identify the cause of hearing loss.

CT is better than MRI for bone.



So CT is better for diseases that affect cortical bone

- Ossicular abnormalities
- Cholesteatoma
- Otospongiosis

Otospongiosis

- Cause unknown
- Autosomal dominant inheritance with variable expressivity
- 65-72% female preeminance
- Peak incidence 2nd/3rd decade
- Bilateral in 80% of patients
- Tinnitus often present at presentation, sometimes more troublesome than hearing loss.



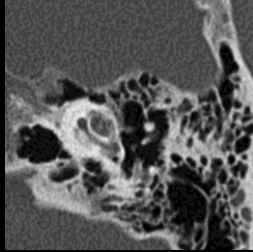
Fenestral Otospongiosis

- Resorption of enchondral bone
- Replacement by spongy bone
- Stapes footplate becomes fixed
- Conductive hearing loss
- Improved by stapedotomy



Retrofenestral or cochlear otospongiosis

- Involvement of bone surrounding cochlea
- Described as 4th turn
- Causes mixed hearing loss



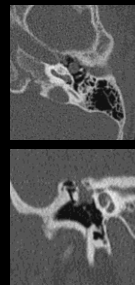
Cholesteatoma



Cholesteatoma

- Collection of squamous debris which acts like a mass causing bony erosion
- Most are acquired – pars flaccida
- Minority are congenital – live anywhere

Congenital cholesteatoma

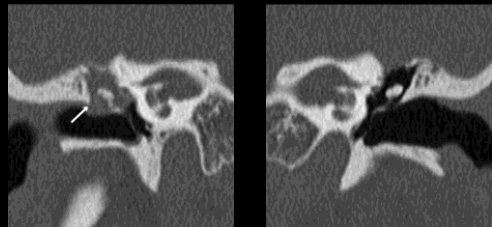


- Soft tissue mass in middle ear
- Non-enhancing
- May demonstrate restricted diffusion (if large enough)
- In the imaging DDX of glomus tympanicum
 - But no red mass on exam
 - Tinnitus is non-pulsatile

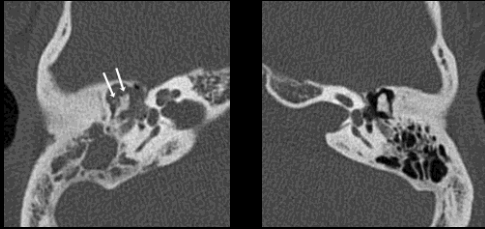
Acquired cholesteatoma

- Pars flaccida to epitympanum
- Erosion of scutum or ossicles
- Important landmarks to check
 - Facial nerve
 - Lateral SCC

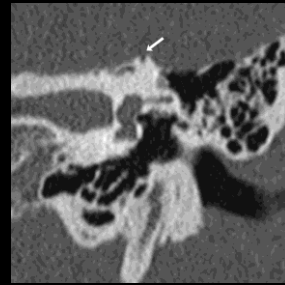
Acquired cholesteatoma



Acquired cholesteatoma



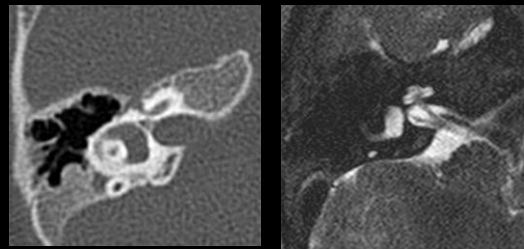
Superior Semicircular Canal Dehiscence



Superior Semicircular Canal Dehiscence

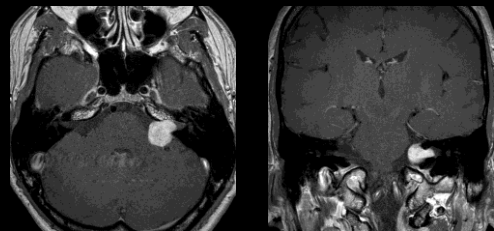
- Leads to conductive hearing loss
 - Loss of pressure wave at dehiscence
- Associated with vertigo, particularly in the setting of loud noise (Tulio's phenomenon)

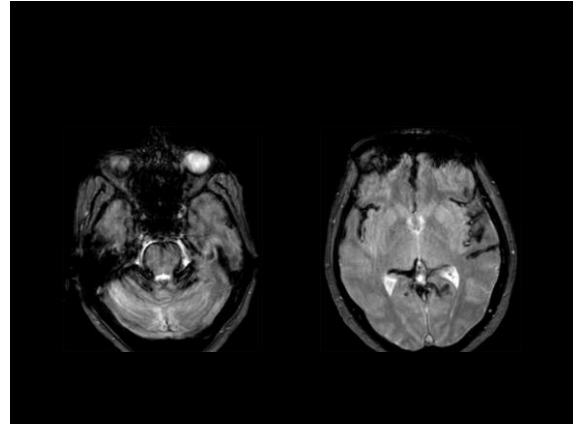
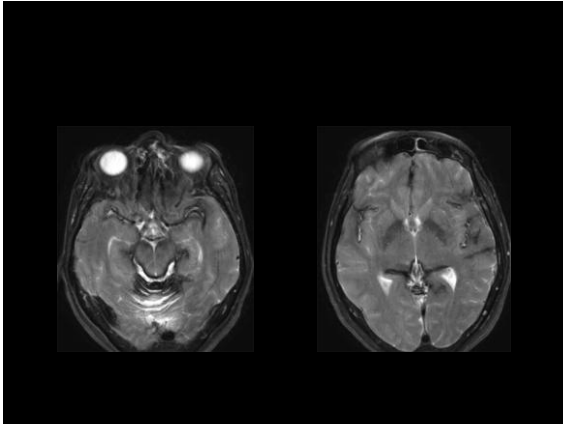
MRI is better than CT for nerves/brain



Vestibular Schwannoma

- Most common temporal bone tumor.
- Most common IAC tumor
- Involves and widens the porus acusticus
- If bilateral, then NF2





Superficial Siderosis

- Insidious onset of hearing loss, dysequilibrium and tinnitus
- Chronic repeated hemorrhage in neuro-axis leading to deposition of hemosiderin
- Search for cause typically involves MRA and catheter angiography of entire neuroaxis
- A minority of patients will have no cause identified.

Use MRI for sensorineural hearing loss

- Vestibular schwannoma.
- Labyrinthitis
- Superficial Siderosis

What's the best way to image tinnitus?

- Is the tinnitus pulsatile or not?
- Yes - MRA/V or CTA/V
- No – CT temporal bone for conductive loss, MR temporal bone for SNHL

Tinnitus and conductive hearing loss

Non-pulsatile

- Otitis media
- Cholesteatoma
- Otosclerosis
- Ossicular disruption
- SSCD

Pulsatile

- Paranglioma (glomus tympanicum or jugularetympanicum)
- Aberrant carotid
- Persistent stapedial
- High riding dehiscant jugular bulb

Sensorineural hearing loss and tinnitus

- Labyrinthitis
- Vestibular schwannoma
- Presbycusis
- Noise induced hearing loss

Pulsatile tinnitus without hearing loss

- Paraganglioma
- Dural AV fistula
- IIH
- Dural venous thrombosis

SUMMARY: A simple approach to imaging in tinnitus

- If objective tinnitus – look for the cause of the sound.
- If subjective tinnitus – look for the cause of the hearing loss.