

## 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?

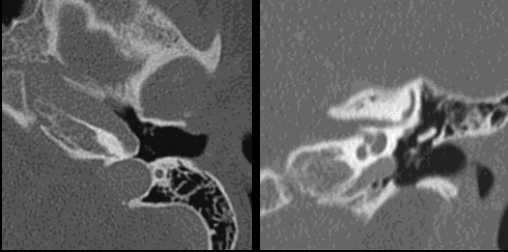
- Three major risk factors:
  - Hearing impairment
  - Increasing age
  - Male gender
- Probably increasing in incidence due to:
  - Increased age of the population
  - War
    - Many common military experiences (interior of a Chinook helicopter, interior of tank, deck of aircraft carrier) are over 100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

## Tinnitus Classification

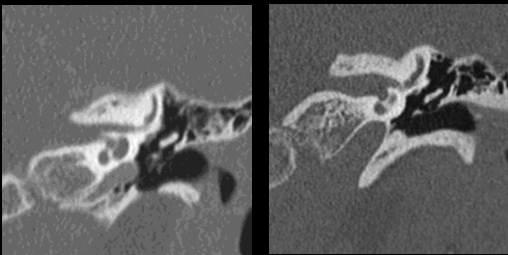
- Subjective
- Objective
  - Pulsatile
  - Non-pulsatile



## 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



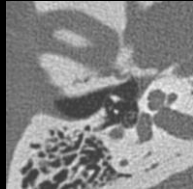
## Persistent stapedial artery

- Travels from infracochlear carotid



### PSA

- Passes through stapedial obturator foramen



### PSA

- Enlarges tympanic segment of facial canal

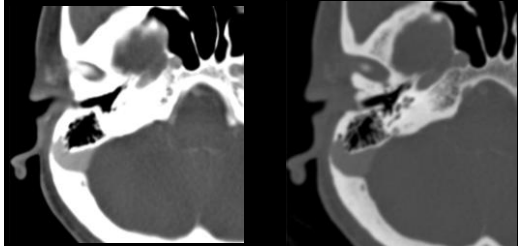


### PSA

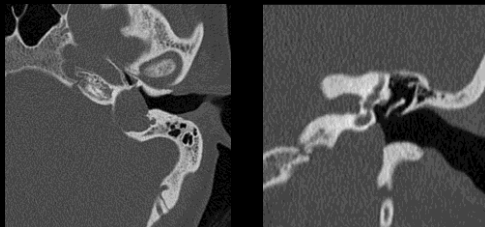
- Terminates as middle meningeal



### Sigmoid sinus dehiscence



### High riding, dehiscent jugular bulb



Acquired causes of pulsatile tinnitus

## Dural Arteriovenous Fistulas

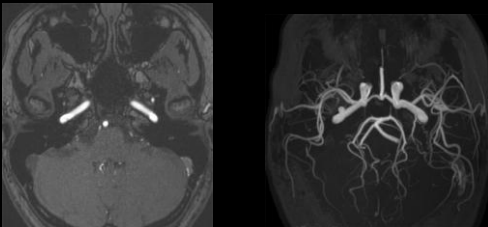
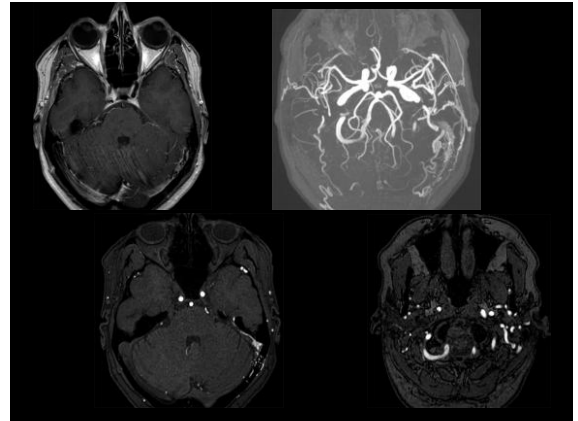
- Idiopathic
- Related to trauma, prior craniotomy or dural sinus thrombosis.
- Classified according to direction of flow and presence or absence of cortical venous drainage
- In absence of CVD, very low risk of hemorrhage, do not require treatment
- Most common locations cavernous, transverse, sigmoid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

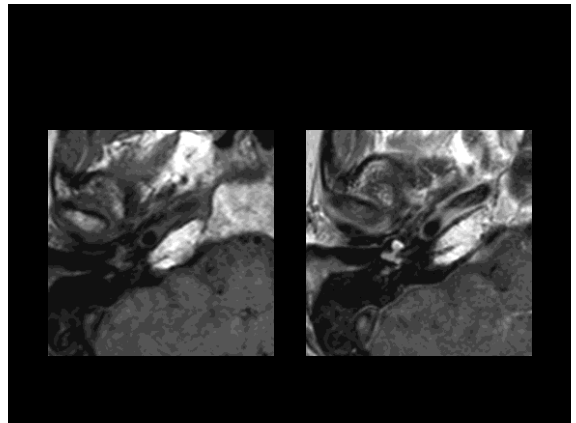
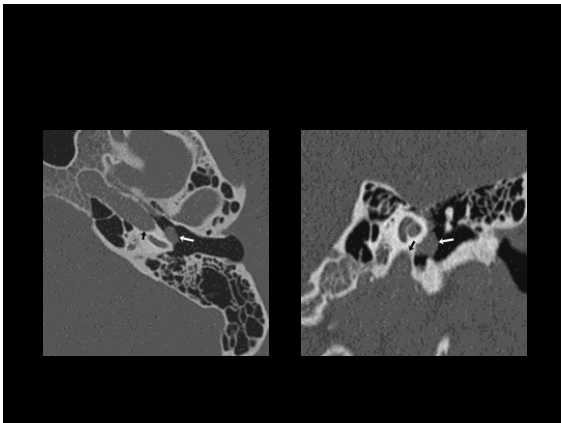
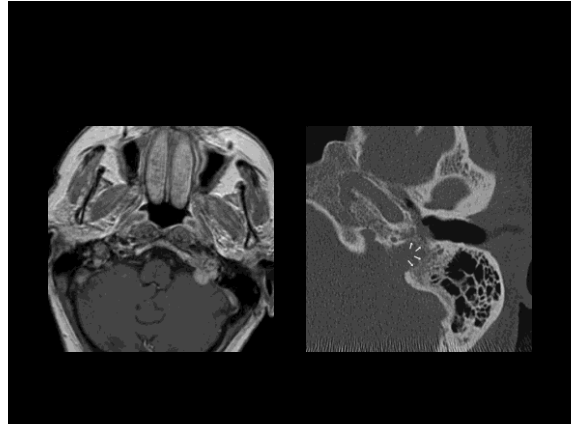


## Paragangliomas

- 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 jugulare tympanicum

## Paragangliomas

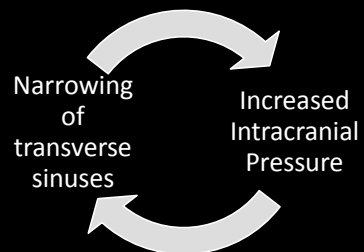
- More common in women than men
- 10% multiple
  - Glomus vagale, carotid body tumors
- Slow growing
- Highly vascular



## 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

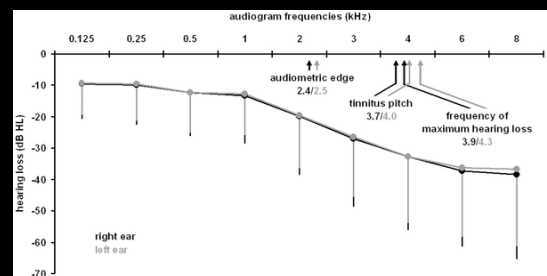
## Subjective tinnitus

## 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.



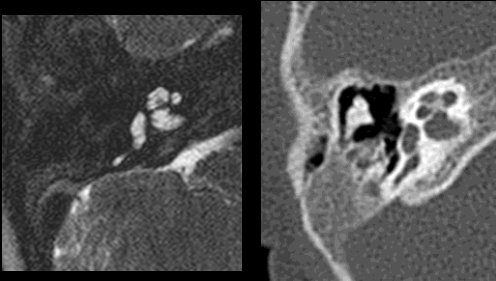
Schecklmann M, Vietmeier V, Steffens T, Lindgrebe M, et al. (2012) Relationship between Audiometric Slope and Tinnitus Pitch in Tinnitus Patients: Insights into the Mechanisms of Tinnitus Generation. *PLoS ONE* 7(4): e34878. doi:10.1371/journal.pone.0034878

## 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.

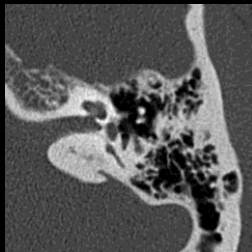


## So CT is better for diseases that affect cortical bone

- Ossicular abnormalities
- Cholesteatoma
- Otospongiosis

## Otospongiosis

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



## Fenestral Otospongiosis

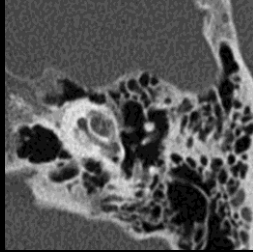
- Resorption of enchondral bone
- Replacement by spongy bone
- Stapes footplate becomes fixed
- Conductive hearing loss
- Improved by stapedotomy



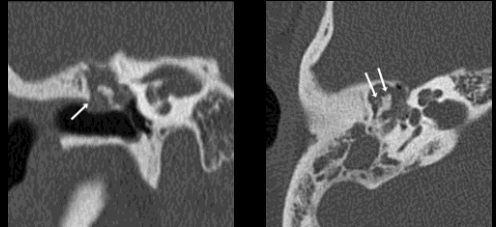


### Retrofenestral or cochlear otospongiosis

- Involvement of bone surrounding cochlea
- Described as 4<sup>th</sup> turn
- Causes mixed hearing loss



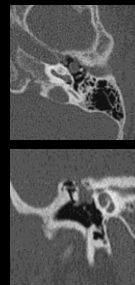
### Cholesteatoma



### 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

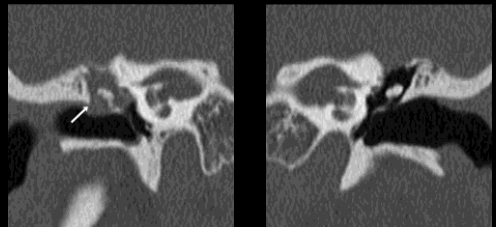


- Soft tissue mass in middle ear
- Non-enhancing
- May demonstrate restricted diffusion (if large enough)
- In the imaging DDX of glomus tympanicum
  - But no red mass on exam
  - Tinnitus is non-pulsatile

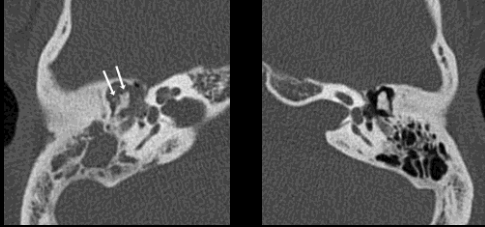
### Acquired cholesteatoma

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

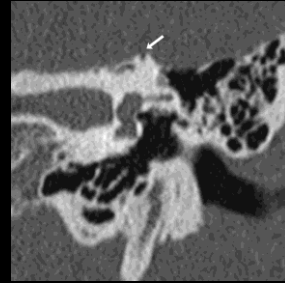
### Acquired cholesteatoma



## Acquired cholesteatoma



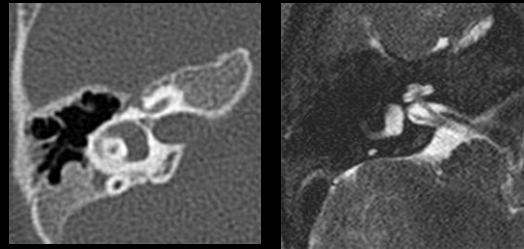
## Superior Semicircular Canal Dehiscence



## Superior Semicircular Canal Dehiscence

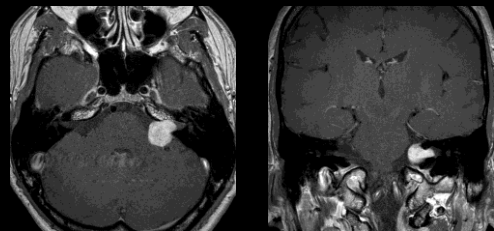
- Leads to conductive hearing loss
  - Loss of pressure wave at dehiscence
- Associated with vertigo, particularly in the setting of loud noise (Tullo's phenomenon)

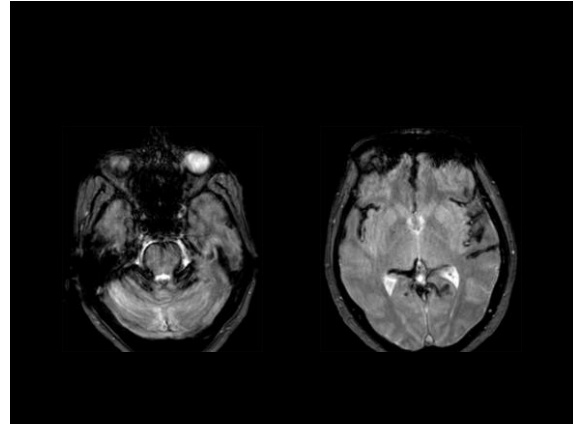
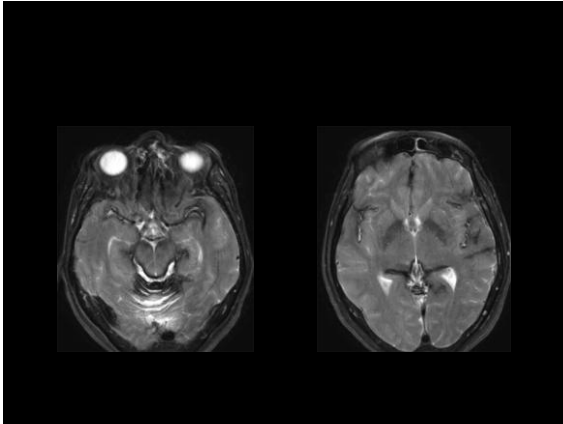
## MRI is better than CT for nerves/brain



## 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

- Paraganglioma (glomus tympanicum or jugularetympanicum)
- Aberrant carotid
- Persistent stapedial
- High riding dehiscent 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.