Everything you wanted to know about the temporal bone and might notice on CT spine but didn’t learn in residency and were afraid to ask

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4/15/2011
Outline

External Auditory Canal (EAC)
Middle Ear
Inner Ear

- Normal anatomy
- Congenital anomalies
- Inflammatory lesions
- Benign neoplasms
- Malignant lesions
- Trauma
Temporal bone gross anatomy

Formed from eight ossification centers (not including ossicles and inner ear)

At end of fetal life consists of three principle parts
- Squamosal
- Petromastoid
- Tympanic ring
Embryology Slide

Eg. EAC atresia
- Inner ear usually normal
- If not, suspect isolated malformation or craniofacial syndrome

Inner ear formation

1st Branchial arch
- pharyngeal pouch
- branchial cleft

2nd Branchial arch

Cartilaginous EAC
- Pinna
- Incus
- Malleus
- Stapes

Middle ear cavity

Tympanic membrane

Time
The External Auditory Canal
EAC: Congenital Anomalies

**Atresia** - Bony and/or soft tissue stenosis
- Small dysmorphic pinna
- Narrowed, stenosed, or completely atretic EAC (membranous and bony portions)

**Middle ear malformations correlate with severity of pinna deformity**
- Small middle ear
- Fusion and rotation of incus and malleolus
- Oval window atresia
- Aberrant course of CN VII common
microtia
EAC: Congenital Anomalies

EAC Atresia: Middle ear malformations

Small middle ear
- Reduced pneumatization of mastoid air cells
- Small middle ear cavity

1960’s: Thalidomide embryopathy - 1 in 900
Today: Congenital Rubella and inherited syndromes - 1 in 10000
EAC Atresia: Middle ear malformations

Ossicle malformation, rotation, fusion, or absence
- Underpneumatized MACs
- Small fused incus and malleus
EAC: Congenital Anomalies

EAC Atresia: Middle ear malformations

Oval window atresia
- Oval window replaced by ossified web
- Stapes malformed (arrow)
- Abnormal inferomedial position of CN VII in front of oval window (open arrow)
EAC: Congenital Anomalies

EAC Atresia: abnormal course of CN VII

Tympanic portion
- Dehiscent. Crossing over too low, overlying oval or round windows
- ♠ Important for surgeon to know before repairing EAC and middle ear ossicles.

Mastoid portion
- Anteriorly displaced
- May exit into glenoid fossa
EAC: Congenital Anomalies

EAC Atresia

DDx

• Acquired exostosis (surfer’s ear)
  – Cold water exposure - bilateral
  – Benign broad base overgrowth

• Osteoma
  – 20% of cases are surfers
  – Benign, focal, pedunculated. At osteocartilage jcn of EAC
First Branchial Cleft Cyst

- 1st BC has ventral and dorsal components.
- Failure of regression of ventral component results in cyst
- Fistula with EAC at osteocartilage junction
  - Type I: near pinna
  - Type II: behind/below mandible

Khanna, 2006
EAC: Inflammatory Lesions

Malignant otitis externa

Keratosis obturans
- Painful keratin plugs bilaterally in middle aged adult

Surfer’s/swimmer’s ear
- Acute otitis externa
- Usually pseudomonas infection
EAC: Inflammatory Lesions

Malignant otitis externa

- Pseudomonas infection
  - HIV and diabetic patients
- Clinical symptoms
  - Otalgia
  - Temporal headache
  - Cranial neuropathies
- Early findings
  - Bony erosion of EAC floor and skull base

⚠️ Don’t miss sigmoid or cavernous sinus thrombosis. TBD later.
Malignant otitis externa

Begins at junction of cartilaginous and bony EAC
- Vertically oriented fissures in cartilage allow inferior route of infectious spread
- Aggressive spread to:
  - Parotid, masticator, parapharyngeal spaces
  - MACs
  - Middle ear and petrous apex
  - Temporomandibular joint

Air fluid level in right Petrous apex, MAC fluid

Erosion of roof and floor of EAC

Extension into TMJ with anterior Displacement of mandibular condyle
EAC: Inflammatory Lesions

Ossification/Calcification of EAC

Tissue injury
- Frostbite
- Mechanical trauma
- Radiation
- Polychondritis

Metabolic/endocrine
- Hypercalcemia
- Sarcoid
- Hyperparathyroidism
- Milk alkali syndrome
- Vit D intoxication
- Diabetes
- Ochronosis
- Gout
- Adrenal insufficiency

Other
- Syndrome related
- Senile
- idiopathic
EAC: Benign Neoplasms/Masses

Many

Expand EAC without destruction

EAC cholesteatoma - TBD later
Hemangioma
Ceruminoma
Medial canal fibrosis - post surgical/post infectious
Polyp/papilloma
Nevi
Wax ball
EAC: Malignant Lesions

Squamous Cell Carcinoma
- By far the most common neoplasm.
- Secondary involvement of the EAC by a superficial SCCa is more common than Primary SCCa.

♦ Involvement of middle ear and/or TMJ is rare and associated with poor prognosis

Findings
- Unilateral EAC mass with underlying bone erosion
EAC: Malignant Lesions

SCCa DDx:

EAC cholesteatoma, Malignant otitis externa
- Both cause bone erosion and should be considered SCCa until proven otherwise.

Medial canal fibrosis
- Post surgical or infectious fibrosis
- Often bilateral
- No bone destruction

Keratosis obturans
- Bilateral
- No bone destruction
EAC: Cholesteatoma

- exfoliated keratin within stratified squamous epithelium

Findings
- Focal unilateral mass in EAC
- Scalloping of bony EAC, most commonly in posterior, inferior aspect
- Matrix with bony flecks
- Progressive enlargement
- Can demonstrate +CE of rim

Etiology
- Congenital - ectodermal rest, rare
- Spontaneous - abnormal migration of ectoderm
- Acquired - postsurgical, post-traumatic
The Middle Ear
Middle Ear: Normal Anatomy
Middle Ear: Anatomy

Overview
• Space containing ossicles and air
• Bounded laterally by the tympanic membrane, medially by inner ear structures
• Connected to other spaces
  – Mastoid air cells
  – Nasopharynx - via eustacian tube

Spaces
• Epitympanum (attic)
  Roof - tegmen tympani
  Floor - line between scutum and tympanic portion of facial nerve
  Lateral - Prussak space
  Posterior - Aditus ad antrum leads to mastoid antrum
Middle Ear: Anatomy

Spaces contin.

- **Mesotympanum**
  - Roof - epitympanum
  - Floor - line between inferior edge of tympanic membrane and cochlear promontory
  - Anterior - Eustacian tube
  - Posterior - 3 key structures
    - Facial nerve recess
    - Pyramidal eminence
    - Sinus tympani
  - Medial
    - Lateral semicircular canal
    - Oval and round windows
    - Tympanic segment CN VII

- **Hypotympanum**
  - Shallow space in floor of middle ear cavity
Middle Ear: Anatomy

Conductive chain
Tympanic membrane, ossicles, oval window

Tympanic membrane
• Pars flaccida - upper 1/3
  – Two layers
• Pars tensa - lower 2/3
  – Three layers: ectoderm, mesoderm, and endoderm.
  – More rigid than pars flaccida
  – Conducts vibrations to ossicles
Middle Ear: Anatomy

Conductive chain

Ossicles

- Malleus (hammer)
  attached to TM at umbo and lateral process
- Incus (anvil)
- Stapes (stirrup)

Amplify sound pressure by two mechanisms
1. catenary lever - sound energy transmitted to center of TM
2. Force funneling (hydraulic lever)
3. ossicular lever

pressure at oval window is increased by ratio of (TMsa/OWsa) and lever ratio of malleus/incus.

Pov = 17 * 1.3 Ptm = 22 Ptm
Middle Ear: congenital anomalies

Previously discussed

Ossicular fusion, hypoplasia, maldevelopment
- Most commonly occurring with EAC and external ear anomalies
- Coexisting abnormality of CN VII course in middle ear

Oval window atresia

Congenital Cholesteatoma, aka epidermoid
- Usually pediatric population
- Arise in variety of places in temporal bone.
- Middle ear involvement
  - Bone erosion occurs late in disease
  - Anterosuperior middle ear, adjacent to eustachian tube & anterior tympanic ring, medial to ossicles

DDx (discussed later)
- pars tensa acquired middle ear cholesteatoma
  - Ossicles commonly eroded
- Glomus tympanicum paraganglioma
  - No bony erosion
  - +CE on MRI
- Schwannoma of tympanic portion of CN VII
Middle Ear: Inflammatory lesions

Otitis Media

Opacification of tympanic recess
Bacterial - strep, m.cattarhalis, H flu, pneumoc.
Eustacian tube obstruction by URI in kids

- Acute or Chronic Uncomplicated
  - A/F level in middle ear, +/- mastoid air cells

- Coalescent otomastoiditis

- Coalescent otomastoiditis with abscess
Middle Ear: Inflammatory lesions

- Coalescent otomastoiditis
  - Destruction of mastoid trabeculae and cortex

Petrous apicitis
  Classic triad - CN6 palsy, deep facial pain, ipsalateral otorrhea (Gradenigo Syndrome)

- Coalescent otomastoiditis with abscess

Erosion of lateral cortex and sigmoid plate (check for sigmoid sinus thrombosis)
Floating sequestrum.

Opacification of middle ear and mastoid air cells. Erosion of right petrous apex.
Middle Ear: Inflammatory lesions

- Coalescent otomastoiditis with abscess
  - Extratemporal (subperiosteal, epidural, subdural) abscess/empyema complicating coalescent otomastoiditis

Erosion of cortex with **subperiosteal** abscess on soft tissue windows

Erosion of cortex with **epidural** abscess on soft tissue windows
Middle Ear: Inflammatory lesions

- **Coalescent otomastoiditis with abscess**
  - Extratemporal (subperiosteal, epidural, subdural) abscess/empyema complicating coalescent otomastoiditis

**Bezold Abscess**

Cortical erosion at the mastoid tip resulting in abscess extending into the neck.
Middle Ear: Inflammatory lesions

Acquired Cholesteatomas

- “Erosive collections of keratinous debris from ingrowth of stratified squamous epithelium through a perforated tympanic membrane.”
- Patients with chronic otomastoiditis

80% - pars flaccida type “attic cholesteatoma”
  - Most common middle ear mass lesion
    - Prussak space mass
    - Erosion of scutum
    - Ossicle erosion (lateral to medial) in 70%

20% - pars tensa type “sinus cholestatoma”
  - Soft tissue mass that involves sinus tympani & facial nerve recess of posterior mesotympanum
  - Ossicle erosion from medial to lateral
Glomus Tympanicum paraganglioma

- Arises from glomus bodies at cochlear promontory
  - Margin abutting cochlear promontory is flat

Engulfs, not erodes ossicles

DDx

aberrant course of carotid artery, pars tensa cholesteatoma, epidermoid

Aberrant internal carotid artery

Glomus Jugulare paraganglioma

Dehiscent jugular bulb
Middle Ear: Benign lesions

Aberrant internal carotid artery

- Pulsative tinnitus
- Can look exactly like glomus tympanicum on coronal images
  - Check for TUBULARITY on axials!
- DON'T BIOPSY!

Lateral course through middle ear with dehiscence of overlying bone

“7” sign
Middle Ear: Benign lesions

Glomus Jugulare paraganglioma
- Jugular foramen mass with permeative destruction of the adjacent bone and extension into hypo/mesotympanum
Dehiscent jugular bulb
Enlarged jugular bulb with dehiscence of sigmoid plate and protrusion of jugular vein into the posterior aspect of the middle ear.
Middle Ear: clues to masses

- In tympanic cavity with or without osseous erosion.
- Most are similar in appearance.
- Location can give clues to the diagnosis.

Medial to ossicles
- pars tensa cholesteatoma - mesotympanum mass, ossicle erosion (medial to lateral)
- epidermoid - late ossicle erosion
- glomus tympanicum paraganglioma(schwannoma) - no ossicle erosion
- aberrant course of ICA

Lateral to ossicles
- pars flaccida - scutum erosion, ossicle erosion (lateral to medial)
Middle Ear: Malignant lesions

Rare and beyond scope of this lecture

Adults
Metastases - lung and breast
EAC SCCa with secondary invasion
Perineural spread of parotid tumor along CN7
adenoma
Endolympathic sac tumor

Kids
Rhabdomyosarcoma
LCH
Inner Ear: Anatomy

Superior to inferior

See what you remember so far…
Inner Ear: Anatomy

- epitympanum
- Superior semicircular canal
- Mastoid antrum
Inner Ear: Anatomy

Labyrinthine segment of CN7
Horiz. Semicircular canal
IAC
Aditus ad antrum
Vestibular aqueduct
Inner Ear: Anatomy

tympanic segment of CN7
malleus
vestibule
Vestibular aqueduct
Inner Ear: Anatomy

tympanic segment of CN7
incus
cochlea
vestibule
Vestibular aqueduct
Inner Ear: Anatomy

- Cochlea: apical turn
- Cochlea: middle turn
- Cochlea: basal turn
- Eustacian tube
- Cochlear promontory
- Round window
- Posterior semicircular canal
Inner Ear: Anatomy

- Carotid canal
- Eustacian tube
- Cochlea: basal turn
- Cochlear aqueduct
- Mastoid segment of CN7
Inner Ear: Anatomy

Perilymph
- Csf like extracellular fluid
- Between membranous and bony labyrinths
- Contiguous with the subarachnoid space
- No appreciable “flow”

Endolymph
- Fluid that fills the membranous labyrinth.
- Unique in body - high K+
- “sealed” compartment maintained by ion exchange in endolymphatic sac

Crossection of cochlea

Organ of Corti hair cells
Inner Ear: Anatomy

- Pressure wave transmitted by stapes to incompressible perilymph and then to cochlear duct and basilar membrane.
- Basilar membrane has variable resonant frequency and vibrates displacing hair cells and causing them to depolarize, modulating action potentials in cochlear nerve.
- Round window is membranous and allows wave to propagate.
Inner Ear: congenital anomalies

- Sensorineural hearing loss (SNHL)
- Abnormalities of bony or membranous labyrinth.
- While most abnormalities confined to membranous labyrinth, CT used in diagnosis of bony labyrinth anomalies

Jackler 1987 – detailed classification system based on embryological development (wks 4-8).

- Michel aplasia – complete labyrinthine aplasia
- Large vestibular aqueduct (LVA)
- Cystic cochleovestibular anomaly
- Semicircular canal dysplasia
- Common cavity deformity
- Cochlear aplasia/hypoplasia
Inner Ear: congenital anomalies

Michel aplasia – complete labyrinthine aplasia
  – Bilateral absence of middle ear structures.
  – Profound SNHL
  – Growth arrest before fourth week of gestation
  – thalidomide exposure, anencephaly, and Klippel-Feil syndrome

Note normal EAC and middle ear
Inner Ear: congenital anomalies

Cochlear anomalies

Large vestibular aqueduct syndrome (LVA), Mondini
- Most common abnormal imaging finding in SNHL

Incomplete partitioning of cochlea
- Cochlea lacks 2.5 complete turns. Has 1.5 turns
- Apical turn is dysmorphic
- Bilateral
- Etiology for SNHL is proposed as trauma to fragile cochlea
Inner Ear: congenital anomalies

Cystic cochleovestibular anomaly
- SNHL from birth
  - Snowman shaped inner ear with cystic featureless cochlea and dilated cystic vestibule

Semicircular canal dysplasia
- Lateral SCC most often affected.
  - Forms common cavity with dilated vestibule
- CHARGE syndrome
  - All SCCs absent
  - Oval window atresia

Common cavity
- Cystic cavity representing rudimentary vestibule and cochlea

Cochlear aplasia/hypoplasia
- No cochlea is present but vestibule, semicircular canals & internal auditory canal (IAC) are present in some form
Inner Ear: inflammatory lesions

Labyrinthine ossificans

Cochlear Otosclerosis/otospongiosus

Fenestral Otosclerosis/otospongiosus

Semicircular canal dehiscence
Inner Ear: inflammatory lesions

Labyrinthine ossificans

- Ossification of membranous labyrinth as healing response to infection, trauma, surgery
- Classic presentation is bilateral SNHL in child after meningitis
- Bone deposition in fluid spaces of vestibule, semicircular canals and cochlea
Inner Ear: inflammatory lesions

Cochlear Otosclerosis/otospongiosus

- Young adult with bilateral mixed hearing loss
  - Focal lytic plaques in pericochlear bony labyrinth
  - 85% bilateral symmetric
  - Unknown etiology
  - Treated with flouride

Lucent halo surrounding basal turn of cochlea
Inner Ear: inflammatory lesions

Fenestral Otosclerosis/otospongiosus

- Adults with conductive hearing loss
- More common than cochlear otosclerosis
- Similar process involving the oval and round window region
- Unknown etiology
- Flouride treatment slows hearing loss.

Plaque near oval window
Inner Ear: inflammatory lesions

Semicircular canal dehiscence

- thinning or absence of bony roof over superior or posterior semicircular canal
- Noise induced vestibular symptoms
- Unknown etiology
- Affects adults
Inner Ear: benign and malignant lesions

Benign
- CN VIII schwannomas
- Petrous apex
  - Chordoma
  - Meningioma
  - Cholesterol granuloma
- Pagets
- LCH

Malignant
- Metastases
- Endolymphatic sac tumor
- Perineural spread of malignancy
  - Skin
  - Parotid
  - Pharynx
- Rhabodomyosarcoma
- lymphoma
Chinese palace
Temporal bone fractures

Complications of temporal bone fractures

- facial nerve paresis or paralysis, cerebrospinal fluid (CSF) leakage, conductive hearing loss (CHL), sensorineural hearing loss (SNHL), and dizziness or balance dysfunction

Classic teaching discusses two main fracture orientations

1. **Longitudinal** - parallel to petrous ridge
   Conductive hearing loss
   - 4-5x more common than transverse
   - More commonly associated with **ossicle dislocation**
     - Incudostapedial is the weakest
     - Challenging to see on CT
     - EAC and glenoid fossa extension
   - 20% have facial nerve injury (at geniculate ganglion)

2. **Transverse**
   Sensorineural hearing loss
   - CN7 injury at transverse portion
Temporal bone fractures

Most fractures are combined longitudinal and transverse
• Traditional classification poor at predicting complications

New classification
  – fracture does, or does not violate otic capsule (bony labyrinth of inner ear)
  – Better prediction of complications
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