Temporal bone trauma

- Epidemiology
- Pathophysiology
- Evaluation
- Symptoms
- Treatment
Epidemiology

- 20% of all skull fractures
- Mechanism of injury
  - Motor vehicle collision
  - Assault
  - Falls
- Gender
  - 3 male : 1 female
- Age
  - 70% in 2nd, 3rd, 4th decades
- Pediatrics
  - Bimodal distribution
  - 2-3 years = falls
  - 15 years = MVC
Epidemiology

[Bar chart showing the percentage distribution of different causes of injury: Automobile (30%), Assault (15%), Fall (14%), Motorcycle (13%), Pedestrian (10%), Bicycle (7%), Gunshot (3%), Misc (4%).]
Pathophysiology

- **Application of force**
  - Requires 1875 pounds of lateral force
  - Fractures along structurally weakest points

- **Structures at risk**
  - Cranial nerves VII, IX, X, XI
  - Cochlea
  - Labyrinth
  - Ossicles
  - Tympanic membrane
  - Carotid artery
  - Jugular vein

- **Open fractures (60%)**
  - Bloody otorrhea, brain herniation, or CSF in external auditory canal, eustachian tube, or site of penetrating injury
Evaluation

- Multiply injured patient
  - Airway
  - Ventilation
  - Circulation
  - Neurologic status
    - Glasgow coma scale
    - Cervical spine immobilization
    - Documentation of movement of face and extremities
Evaluation

- Neuro-otologic examination
  - Subjective
    - Disequilibrium
    - Hearing loss
    - Vertigo
    - Prior otologic history
  - Mechanism of injury
    - Direction of force
    - Site of impact
  - External ear
    - Lacerations
    - Hematoma
    - Otorrhea
    - Bony deformity
- Otoscopic examination
  - Tympanic membrane
  - Middle ear
- Cranial nerves
  - Tuning forks
- Characterization of otorrhea if present
- Radiology
Neuro-otologic examination

- **Nystagmus**
  - Peripheral vertigo
    - Horizontal or rotatory
    - Suppressible with fixation
    - Most common vertigo after head trauma is BPPV
  - Central vertigo
    - Vertical or direction-changing
    - Fails to suppress with fixation

- **ENG**
  - As outpatient if symptoms do not resolve

- **Fistula test**
  - Not performed acutely
  - Risk of iatrogenic injury and introducing contaminants into inner ear outweigh benefits

- **Hearing**
  - Assess initially with tuning forks
  - Audiogram
    - Formal audiogram prior to surgical intervention
    - Not necessary in acute setting if symptoms/clinical evaluation consistent with CHL
Battle’s sign

- Extravasated blood from posterior auricular artery
Otoscopic examination

- Hemotympanum
- EAC laceration
- TM perforation
- Ossicular disruption
Imaging

- Imaging follows acute stabilization of life-threatening injuries
- Screening head CT to rule out intracranial injuries
- High-resolution CT scan of temporal bones if fracture suspected
- High-resolution CT scan of temporal bones required if:
  - Facial paralysis
  - CSF leak
  - Disruption of superior wall of EAC
  - Suspected vascular injury
Classification

- **Traditional**
  - Longitudinal
  - Transverse
  - Oblique

- **Newer classification scheme**
  - Disruption of otic capsule
  - Sparing of otic capsule
Longitudinal fractures

- 70-90% of temporal bone fractures
- Parallel to long axis of petrous apex
  - Starts in squamous part of temporal bone
  - Through posterior/superior EAC
  - Through roof of middle ear (anterior to membranous labyrinth)
  - Into carotid canal, ending at foramen lacerum
- Injury to temporoparietal region
Longitudinal fractures: Complications

- Facial nerve palsy
  - 20% of longitudinal fx
- Hearing loss
  - Conductive
  - Tympanic disruption
  - Ossicular derangement
  - Hemorrhage into middle ear
Transverse fractures

- 10-30% of temporal bone fractures
- Perpendicular to long axis of temporal bone
  - Start at foramen magnum
  - Perpendicularly across petrous pyramid
  - Through labyrinthine capsule
  - Into middle cranial fossa
  - End in foramen lacerum
- Impact at frontal or occipital area
Transverse fractures: Complications

- Facial nerve palsy
  - 50%
- Hearing loss
  - Sensorineural
- CSF leak
  - Fracture extends intracranially
Oblique fractures

- Injury pattern similar to longitudinal fractures
- From superior EAC, parallel to petrous bone
- Turns superior/oblique to cross petrotympanic fissure
  - Remains lateral to otic capsule
Otic capsule sparing fractures

- 94-98% of temporal bone fractures
- Squamosal portion of temporal bone
- Posterosuperior wall of EAC
- Through mastoid air cells and middle ear
- Fractures tegmen tympani
- Results from a blow to temporoparietal region
Otic capsule disrupting fractures

- 2.5-5.8% of temporal bone fractures
- Fracture proceeds from foramen magnum across petrous pyramid and otic capsule
- Often passes through jugular foramen, IAC, and foramen lacerum
- Do NOT typically affect ossicular chain or EAC
- Results from blow to occipital region
Why change classification scheme?

- Otic-capsule-disrupting fractures have:
  - SNHL
  - Higher incidence of CN VII palsy (30-50% v. 6-13%)
  - 2-4X higher risk of CSF leak
  - Higher risk of delayed meningitis

Dahiya: J Trauma, Volume 47(6).December 1999.1079
Penetrating trauma

- Mostly GSW
- Injuries depend on direction/velocity of missile
Complications

- Sensorineural hearing loss
- Conductive hearing loss
- Cholesteatoma
- CSF fistula
- Facial nerve injury
- Vascular injury
Sensorineural hearing loss

- **Severe-Profound SNHL**
  - Otic-capsule-disrupting fractures
- **Mixed hearing loss**
  - Incus dislocation
  - 50% of patients with incus dislocation have >10dB SNHL
- **Prognosis**
  - Profound SNHL has poor prognosis
  - Moderate SNHL may have some recovery

- **Mechanism**
  - Disruption of membranous labyrinth
  - Avulsion /trauma to cochlear nerve
  - Interruption of cochlear blood supply
  - Hemorrhage into cochlea
  - Perilymphatic fistula
    - May be suggested by fluctuating or progressive HL
Conductive hearing loss

- 80% CHL resolves spontaneously
- Hemotympanum
- Resolution of hemotympanum affected by
  - Endotracheal intubation
  - Associated facial fractures
  - Presence of CSF leak
- Ossicular discontinuity (20%)
- Common injuries
  - Incudostapedial joint (82%)
  - Dislocation of incus (57%)
  - Fracture of stapes crura (30%)
- Suggested by residual CHL following resolution of hemotympanum
  - Exploratory tympanotomy indications: 30dB CHL persisting > 2m after injury
  - Contraindications: CHL in only hearing ear
  - Relative contraindication: mixed hearing loss
Cholesteatoma

- Delayed complication
- Pathogenic mechanisms
  - Epithelial entrapment in fracture line
    - Epitympanum, antrum
  - Ingrowth of epithelium through fracture line
    - Epitympanum, antrum
  - Traumatic implantation of TM skin into ME
    - Mesotympanum
  - Trapping of epithelium medial to stenosis of EAC
    - EAC
CSF fistula

- Complicates 17% of temporal bone fractures
  - CSF otorrhea
    - With TM disruption
  - CSF rhinorrhea
    - If TM intact
- Otic capsule sparing
  - Floor of middle cranial fossa
- Otic capsule disrupting
  - From posterior cranial fossa through otic capsule
- Delayed CSF leak
  - Herniation of dura/brain into defect
  - Hematoma obstructing outflow of CSF
CSF fistula

- **Symptoms**
  - Clear watery drainage from the nose or ear
    - Flow increases when patient leans forward with neck flexed
  - Headache
- **Laboratory tests**
  - ↑ Glucose
  - ↓ Protein
  - ↓ Potassium
  - β-2 transferrin
- **Radiology**
  - HRCT
  - CT cisternography

- **Other**
  - Intrathecal fluorescein
  - Used for localizing fistulas when all other methods have failed
CSF fistula

- Meningitis
  - 2-88%
- Duration of leak
  - < 7 days 5-11%
  - > 7 days 33-88%
- Prophylactic antibiotics
  - No benefit without CSF fistula
  - Questionable benefit with CSF fistula
- Risk of meningitis increases with concurrent infection
- Pathogens
  - H. influenzae
  - S. pneumoniae
CSF fistula

- **Treatment**
  - **Conservative management 7-10 days**
    - Total bedrest
    - HOB elevated
    - Stool softeners
    - No noseblowing, sneezing, straining
    - Repeat lumbar punctures or lumbar drain

- **Operative management**
  - Approach depends on hearing status, location of fistula, and presence of brain herniation
  - Otic capsule disrupting
    - Obliteration of mastoid and middle ear
  - Otic capsule sparing
    - Lateral – complete mastoidectomy
    - Medial - combined middle cranial fossa approach
Facial Nerve Injury

- Complicates 7% of temporal bone fractures
- 25% of injuries are complete facial paralysis
- Onset
  - Immediate- 27%
    - Patients examined in ER before muscle relaxants
  - Delayed- 73%
    - Crucial to differentiate between ‘delayed onset’ and ‘delayed diagnosis’
  - Unestablished onset
    - Should be treated as immediate onset
Facial nerve injury

House-Brackmann

- I – Normal
- II – Mild dysfunction
  - Normal symmetry at rest
  - Slight weakness on close inspection
  - Slight synkinesis
- III – Moderate dysfunction
  - Normal symmetry at rest
  - Noticeable (but not severe) synkinesis
  - Obvious (but not disfiguring) weakness
  - *COMPLETE eye closure
- IV – Moderately severe dysfunction
  - Normal symmetry at rest
  - Obvious and disfiguring weakness
  - *INCOMPLETE eye closure
- V – Severe dysfunction
  - Asymmetry at rest
  - Barely perceptible motion
- VI – Total paralysis
Facial nerve injury

Prognosis

- Important factors
  - Onset
  - Degree of paresis

- Incomplete paresis rarely fails to resolve spontaneously

- Delayed onset >95% return to House-Brackmann I or II without intervention
Facial nerve injury
Sunderland classification

- **Neuropraxia**
  - 1\textsuperscript{st} degree- Anatomically intact nerve with conduction blockade

- **Axonotmesis**
  - 2\textsuperscript{nd} degree- Transection of axons but endoneurium intact

- **Neurotmesis**
  - 3\textsuperscript{rd} degree- Transects axon and endoneurium but perineurium intact
  - 4\textsuperscript{th} degree- Transect entire nerve trunk but epineural sheath intact
  - 5\textsuperscript{th} degree- Complete transection of entire nerve trunk and epineurium
Facial nerve injury

- Nerve excitability test (NET)
  - Compared to healthy side
  - The lowest current eliciting a twitch is the threshold of excitement
  - Difference of 3.5 mA = severe degeneration
  - Can only be used after 3 days and before 2-3 weeks
  - Determines (in total paralysis) whether degeneration is occurring
Facial nerve injury

- Maximum stimulation test (MST)
  - Increasing current is delivered until maximal movement is seen
  - Compared to healthy side
  - Subjectively expressed as percentage of healthy side
Facial nerve injury

- Electroneurography (ENOG)
  - Bipolar stimulating electrode at stylomastiod foramen
  - Responses to maximal electrical stimulation of 2 sides compared
  - Recorded electrically (not subjective)
  - Normal < 3% difference between sides
Facial nerve injury

- **Surgical decompression**
  - > 90% degeneration within 6 days
  - > 95% degeneration within 14 days

- **Site of injury**
  - Perigeniculate ganglion in 80-93%

- **Surgical approach**
  - Decompression, nerve rerouting with direct anastomosis, cable grafting
  - Translabyrinthine approach
  - Combined transmastoid/middle cranial fossa
Vascular injury

- **Carotid injury**
  - 5% chance of carotid injury if canal intact
  - 18% chance of carotid injury if canal disrupted

- **Carotid ligation or embolism**
  - Indicated if hemorrhage from EAC cannot be controlled by packing
    - Packing ONLY indicated with significant hemorrhage!

- **Arteriography**
  - Indicated if neurologic deficits