1. Longitudinal vs. transverse fractures: Draw the "prototypical" fracture lines and their relationship to important temporal bone structures. Temporal bone trauma can result in significant morbidity and, rarely, mortality. The temporal bone houses or encapsulates many important structures, all of which are at risk of injury with trauma to the temporal bone: These include the facial nerve, vestibulocochlear nerve, cochlea and labyrinth, ossicular chain, tympanic membrane, external auditory canal, temporomandibular joint, lower cranial nerves, jugular vein, and carotid artery.
Internal aspect of the skull base that represents, in black and blue colors, the pathway of the longitudinal temporal bone fracture lines.
Internal aspect of the skull base: arcuate eminence (AE), cochlea (C), foramen magnum (FM), internal auditory canal (IAC), foramen lacerum (L), foramen ovale (O), foramen rotundum (R), foramen spinosum (SP), sigmoid sinus (SS), transverse sinus (TS), vestibular system (V).

Axial cut high-resolution computed tomography demonstrating a longitudinally oriented fracture that is sparing the otic capsule. Black arrows point along the fracture line.
2. Longitudinal vs. transverse fractures: Which is more common? What do you expect to see on otoscopic exam? What kind of hearing loss is associated with each? What is their association with CN VII injury? AL

**Longitudinal fractures**
Longitudinal fractures typically result from trauma to the temporal or parietal region and
commonly involve fractures of the temporal squamosa or parietal bone. The line of force runs roughly from lateral to medial. A fracture line may extend through the facial nerve canal, thereby damaging the facial nerve, designated as cranial nerve (CN) VII. Associated injury, such as transection or intraneural hemorrhage, may cause facial nerve paralysis, as can damage from displaced bone fragments. The fracture may also disrupt the ossicular chain, resulting in conductive hearing loss.

Longitudinal fractures are reported to comprise 70% to 90% of temporal bone fractures with the remaining 10% to 30% categorized as transverse (11,24,26,28,29,30,31). In two large series using the newer classification scheme, only 2.5% to 5.8% of fractures disrupted the otic capsule (2,25). This would suggest that many fractures that are oriented perpendicular to the petrous ridge do not actually cross the otic capsule. Many of the otic capsule disrupting fractures are actually oriented in the longitudinal plane.

**Transverse fractures**

Transverse fractures typically result from trauma to the occiput or cranial-cervical junction, with the line of force running roughly anterior to posterior. A fracture passing through the vestibulocochlear apparatus can cause sensorineural hearing loss and equilibrium disorders. Transverse fractures also commonly injure CN VII, because their path often takes them close to the nerve's labyrinthine segment.

**Mixed fractures**

Oblique (or mixed) fracture patterns, which extend both longitudinally and transversely, are common, and some case series report that these occur more often than do isolated transverse or longitudinal fractures.

The ear canal is inspected for fractures along the roof, CSF otorrhea, degree of hemorrhage, and the presence of brain herniation. The ear is examined as aseptically as possible. Blood and cerumen in the ear canal should never be debrided with irrigation. Following stabilization in the emergency room and transfer to the ward or intensive care unit, the ear can be more carefully examined with the aid of an operating microscope. Typical findings include fractures along the scutum and roof of the external auditory canal and/or tympanic membrane perforations. Hemotympanum or bloody otorrhea are almost invariably present and are two of the most common signs of temporal bone fracture. The integrity of the tympanic membrane is assessed, as is the presence of hemotympanum. Hemotympanum and any associated serous effusion generally resolve spontaneously, with resolution of concomitant conductive hearing loss, within 4 to 6 weeks and simply require observation. Traumatic tympanic membrane perforations generally heal spontaneously as well, and consequently no acute intervention is necessary.
Otoscopic image demonstrating a nondisplaced fracture along the scutum (black arrow). Blood is layering out inferiorly.

Otoscopic image demonstrating a displaced fracture along the scutum.
3. You are called to the Trauma Unit for a patient who suffered blunt trauma to the head who now has blood from the ear. CT scan shows a longitudinal temporal bone fracture. On exam, you see an EAC laceration and tympanic membrane perforation. What is your initial management? What do you tell the patient about prognosis regarding spontaneous closure of the perforation? TT

4. How do you diagnose perilymphatic fistula? What is your initial management? What are indications for surgery? TT

5. A patient presents to the ER at 1 AM after being "pistol whipped" on the side of his head. He complains of severe hearing loss and vertigo with nystagmus and a tympanic membrane perforation on exam. Do you call in Dr. (your otologist) from his warm and cozy bed for an immediate exploration? What are you likely to find? HH

6. Your junior resident calls you from the Trauma Unit. He is evaluating an otherwise stable patient with a temporal bone fracture and complete ipsilateral facial nerve paralysis. He wants to know what to do? TT

7. How do you diagnose CSF otorrhea? Do you start antibiotics? What is your initial management? What if it persists? AL
A CSF fistula is suspected when clear watery drainage is noted in the ear canal or from the nose. Otorhinorrhea will often drain down the back of the throat. The rate of flow of the discharge will usually increase with exertion or leaning forward. Consequently, when evaluating a patient for a suspected CSF fistula, the patient is asked to lean forward with the neck flexed, collecting nasal discharge into a sterile container. Patients often complain of headaches that are dull, continuous, and bilateral. The origin of aural and nasal drainage is often obscured by concurrent bleeding or lysis of old blood clot. Once a nasal discharge is suspected of being CSF, it can be differentiated from watery rhinitis, lacrimal secretions or serosanguinous discharge on the basis of its composition. CSF has elevated glucose, decreased protein, and decreased potassium concentration levels than nasal
secretions. Qualitative tests such as those using glucose oxidase test strips (Clinitest) have been shown to lack specificity and result in a substantial proportion of false positives (87). Quantitative glucose, protein, and potassium determinations are more accurate in diagnosing a CSF fistula.

-protein electrophoresis for beta-2 transferrin

Recommended specimen volume is typically 0.5 mL, and beta-2 transferrin can be detected in sample specimens as small as 50 μL. False-positive results are rare and occur in patients with alcoholic cirrhosis, inborn errors of glycoprotein metabolism, or genetic transferrin variants, in which transferrin allelic variants with similar electrophoretic mobility to the beta-2 isoform are present in sera.

Other minimally invasive techniques for detection of CSF otorrhea or rhinorrhea are currently being developed, including detection of beta-trace protein, or prostaglandin D synthase.

Intrathecal fluorescein is a sensitive and specific test for investigating the presence of a CSF fistula. Following a lumbar puncture, 0.5 mL of a 5% solution of fluorescein is mixed with 10 mL of the patient's CSF and reinjected. Any subsequent otorrhea or rhinorrhea can be collected on micropadgets and examined under a Wood lamp for green fluorescence.

Because acute posttraumatic CSF fistulae are associated with a high probability of early spontaneous closure and a low incidence of meningitis, they can be treated conservatively for 7 to 10 days. This treatment includes total bed rest with elevation of the head of the bed; stool softeners; instructions to avoid nose blowing, sneezing, and straining; and repeat lumbar punctures or lumbar drain if the leak persists. All of these measures are directed at maintaining the CSF pressure gradient below the healing tensile strength of the healing barrier. Due to the increased risk of meningitis following persistent CSF fistulae, surgical closure of fistulae persisting greater than 7 to 10 days is recommended.

**Cerebrospinal Fluid Leak** Cerebrospinal fluid (CSF) leaks occur in temporal bone fractures if the subdural space communicates with the middle ear, mastoid, or eustacian tube as a result of the fracture. This may present with clear otorrhea or rhinorrhea, depending on whether or not the tympanic membrane is intact. Most traumatic CSF leaks will resolve spontaneously with conservative measures, such as bed rest, elevation of the head, and stool softeners. If the leak persists despite these measures, then placement of a lumbar drain may help resolve the leak. CSF leaks that continue after lumbar drain placement may require surgical repair of the leak. In this case a high-resolution CT of the skull base may be helpful in identifying the location of the leak. If the patient has a profound sensory-neural hearing loss then
obliteration of the middle ear cleft and closure of the external auditory canal is indicated. The patient with intact hearing would require a middle cranial fossa approach for repair of the leak. Prolonged CSF leaks are associated with an increased risk of meningitis. Therefore, prophylactic antibiotics are recommended in temporal bone fractures that are associated with CSF leaks.

8. Etiologies and management of traumatic tympanic membrane perforation. AL

Blunt Trauma:

Otic capsule sparing fractures extend along the roof of the EAC, often tearing the tympanic membrane in the region of the notch of Rivinus.

If the patient has profuse bleeding from the ear canal then it should be packed and an angiogram should be obtained. Irrigation or insufflation of the canal should be avoided in the acute setting. If there is clear otorrhea then it should be checked for beta-2-transferrin to determine if it is cerebrospinal fluid. Tuning fork tests should be done if and when the patient is awake. High resolution CT should be performed only if otologic surgery is planned. Audiogram can usually be obtained 4-6 weeks after the injury but must be performed before any otologic surgery.

Penetrating Trauma: stab wounds, gunshot wounds

Trauma to the tympanic membrane and the middle ear can be caused by overpressure (slap, fight, assault from security agents and road traffic injury (RTI)), thermal or caustic burns, blunt or penetrating injuries such as instrumentations and barotraumas [12,13]. Overpressure is by far the most common mechanism of trauma to the tympanic membrane [12]. Traumatic perforation of the tympanic membrane may be caused by direct impact of fluids and direct pressure from outside. The aim of the study is to profile the various aetiologies of traumatic tympanic membrane perforation

Traumatic perforations often occur in the healthy members of the community; and generally the prognosis is excellent [6,8]. The two main factors that predispose to failure of the perforation to heal are loss of tissue and secondary infection. Secondary suppurative otitis media occurred in 37.5% of the ears in this series. This resolved with both antibiotic impregnated topical wick ear dressing and systemic antibiotics with healing of the perforations.
The most effective management is masterly inactivity. Because of the risk of introducing infection, the ear should not be cleaned out. The ear must be kept dry by preventing water from entering the ear canal [6,8]. If the perforation fails to close spontaneously by 3-6 months (in the absence of secondary infection), surgical closure is indicated [6,8]. However all our patient in this study had conservative, non-touch technique or non-surgical treatment. The follow-up was observed to be an average of thrice among all the patients in the study. Healing with formation of neomembrane was observed only in five patients (7.8%) and it is among the under-five's this is not surprising as they are still growing.


10. On your Oral board exam, you are presented with this scenario: A 20 year-old male is admitted to the Trauma Unit after a GSW to the head. He was found obtunded in an alley, but with stable vital signs. There is no other information. You are called because he is bleeding profusely from the ear. What do you want to do? (hint...do not forget ABC’s!) HH