Basilar Skull Fractures

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Grand Rounds Presentation
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Objectives

* Incidence- overall
* Anatomy- Each section
* Evaluation
* Management
No drugs will cure skull base fractures.
I do not own stock in medical equipment.
However, I do drive a car, own a baseball bat and work at the TDC hospital.
In US, 2 million head injuries occur yearly.

Leading cause of death and disability of children.

Motor vehicle accidents are leading cause of head trauma in industrialized countries.

Up to 1/3 of motor vehicle injuries involve head and neck injuries and 28% of all fractures of involving MVA are of the head and neck region.

Skull base fractures occur in 3.5-24% of head injuries.

Traumatic Coma Data Bank states 25% of severe head injuries

They account for 2% of all traumas
Incidence

- Behbahani 2013- Retrospective study 1606 pt. in Tuscon.
Skull base fracture incidence is increased with orbital wall/rim fractures (36%) and ZMC Fractures (29.9%).

Infrequent with nasal bone (7.7%) and mandible fractures (4.0%).

The incidence of skull base fracture was directly associated with the number of facial fractures per patient; one facial fracture (21.0%), two facial fractures (30.4%), and three or more facial fractures (33.3%).

Temporal bone fractures are associated 18-40% of the time.

Frontal sinus fractures occur 15-20% of the time.


Examination of the skull and brain: method of removing the brain after it is severed from the body
Henry W. Cattell, 1903
Anatomy

Anterior Fossa

Middle Fossa

Posterior Fossa

Frontal bone

Sphenoid bone

Temporal bone

Occipital bone
Anatomy

https://www2.aofoundation.org/wps/portal/lut/p/co/o4_SB8K8xLLM9MSSzPy8xBzqCP0os3hng7BARydDRwN3QwMDA08zTzdvvxBjwN_I_2CbEdFADiMQM!/segment=Cranium&bone=CMF&classification=93-Skull%20base%2C%20Skull%20base%20fractures&teaserTitle=&showPage=diagnosis&contentUrl=/srg/93/01-Diagnosis/skull_base-skull_base.jsp
Anatomy
Anatomy

Posterior walls of the petrous bones

Grooves of the transverse sinuses
Anatomy

Anatomy: Fractures
Anatomy: Fractures
Anatomy: Fractures
Anatomy: Anterior Skull Base Fractures

- This includes posterior frontal sinus, roof of ethmoid, cribiform and orbital roof.
- Classification (Damianos):
  - Type 1- Cribriform fractures- linear through cribiform.
  - Type 2- Frontoethmoid fracture- Ethmoids and medial frontal sinus walls.
  - Type 3- Lateral frontal fracture- Through the lateral frontal sinus to the superomedial wall of orbit.
  - Type 4- Mixed- any combination of above.

Anatomy: Anterior Skull Base Fractures

Type I Fractures

Anatomy: Anterior Skull Base Fractures

Type II fractures

Anatomy: Anterior Skull Base Fractures

Type III fractures

Anatomy: Middle Skull Base
Anatomy: Middle Skull Base: Temporal Bone
Anatomy: Middle Skull Base: Temporal Bone

Abbreviations Used:
IAC - Internal auditory canal
ME - Middle ear
ET - Eustachian Tube
CN - Cranial nerve
Anatomy: Middle Skull Base:
Temporal Bone

Anatomy: Middle Skull Base: Temporal Bone

Anatomy: Middle Skull Base: Temporal Bone

- Hearing loss noted 78 pt.
  - 9 otic violating- with 8 (88.9%) having SNHL.
  - 68 otic sparing- with 18 (26.1%) having SNHL.

Little and Kesser 2006- Showed 5 fold increase in facial nerve injury, 25 fold increase in SNHL and 8 fold increase in CSF leaks with otic capsule violating fractures.

They also showed a correlation among OCV fracture and facial nerve paresis or paralysis, In a large series of 820 temporal bone fractures facial nerve paralysis occurred in 48% of OCV fractures versus only 6% in OCS fractures.

The incidence of otic capsule violating fracture is 2.5% to 5.6%.
Uncommon, 9/25000 (0.39%) recorded in one case series over 5 years.

All patients had cranial nerve defects (II, III, IV, V, VI, VII, VII), with VI and VII most common (66%).

Longitudinal fractures have worse prognosis, with 3 out of 5 patients died from verteobasilar injury.

Transverse had 1 out of 4 die from carotid artery injury.
Posterior Fossa: Clivus fractures

DOI 10.1007/s10143-004-0320-2
Posterior Fossa: Clivus fractures

DOI 10.1007/s10143-004-0320-2
Posterior Fossa: Occipital condylar fracture

* High energy blunt trauma with compression, rotational or lateral bending injuries to head.
* Type I- Axial compression with comminution of occipital condyle-stable injury with no displacement.
* Type II- Direct blow that occurs with skull base and occipital condyle- intact alar ligaments.
* Type III- Avulsion with lateral or rotational forces with torn alar ligaments and fractures.
Posterior Fossa: Occipital condylar fracture
Posterior Fossa: Occipital condylar fracture
Posterior Fossa: Occipital condylar fracture
Evaluation

http://www.missmassacre.net/?p=2460
Physical Exam

- Periorbital ecchymosis (raccoon eyes)
- Conjunctival hemorrhage
- Anosmia
- Mastoid ecchymosis (Battles sign)
- Vision changes
- CSF rhinorrhea or otorrhea
- Step off of supraorbital ridge
- Hearing loss
- Facial paralysis
- Facial numbness
Clinical signs

* Frontal bone fractures had the most clinical signs.
* Battle’s sign (100%) and unilateral Periorbital ecchymosis (90%), bloody otorrhea (70%) are highest predictive value for skull base fracture.
* Patients with GCS of 13-15, PPV for intracranial lesions was (78%) periorbital ecchymosis, (66%) Battle’s sign and (41%) bloody otorrhea.

Positive predictive values of selected clinical signs associated with skull base fractures. (PMID:11105835)
Pretto Flores L, De Almeida CS, Casulari LA
Journal of Neurosurgical Sciences [2000, 44(2):77-82; discussion 82-3]
Periorbital Ecchymosis

http://rlbatesmd.blogspot.com/2010/07/blepharoplasty-complications-article.html
Battle sign

* Battle sign - Think Basilar Skull Fracture

http://www.dooey.net/OMFS/
CSF Rhinorrhoea

http://amandela.sg/a-runny-nose-may-not-just-be-a-runny-nose/
Eighty percent of cerebrospinal fluid (CSF) leaks occur following nonsurgical trauma (16% surgical).

- Occur in 2% of all head traumas, and 12% to 30% of all basilar skull fractures, M>F.
- 50% appear in first 2 days, 70% in one week, and almost all seen in 3 months.
CSF Rhinorrhea

REtRoSPECTivE StuDy oF SKuLL BASE FRACtuRE: A StuDy oF iNCiDENtS, ComPLiCAtioNS, mANAgEmENt, AND outComE ovERviEW FRom tRAumA-oNE-LEvEL iNStitutE ovER FivE YEARS – Michael Iemole, Md, Mandana Behbahani, Ba (presenter), university of arizona college of Medicine
Cranial nerve injuries

http://kevinpremed.files.wordpress.com/2009/02/cranial-nerves.jpg
Cranial nerve injuries: Anterior Cranial Fossa

- CN I- anosmia- from anterior fossa injuries (cribriform). Sense of smell may return over several months. Workup is limited with CT scan.

- CN II- Blindness worst outcome- from damage to the optic canal or orbit. Sphenoid body with sella turcica damage can cause injury to the optic chiasm, causing bitemporal blindness.

Cranial nerve injuries: Middle Cranial Fossa

* CN III- Diplopia, impaired EOM.
* Noted dilated pupil, inability to move eye medially, superiorly, or inferiorly (down and out). Usually from direct frontal blow, which stretches the nerve at the posterior cavernous sinus as it enters the brain.
* Treatment consists of wearing a patch over the affected eye, as spontaneous recovery usually occurs in 4-6 weeks.

Cranial nerve injuries: Middle Cranial Fossa

* CN IV- diplopia-
* Least common injury site. Cause from stretching of nerve as it exits from the dorsal midbrain.
* Treatment same as CN III, with patch and spontaneous recovery.
* CN V- Sensory deficits to the face. V1-supraorbital, V2-maxillary, V3-mandibular.
* V1 most commonly damaged portion, with injury at supraorbital notch.
Cranial nerve injuries: Middle Cranial Fossa

- CN VI- diplopia. Damage to the clivus. Also stretched or avulsed when leaving the pons. Unable to abduct. Conservative treatment with spontaneous recovery.

- Superior orbital fissure fractures can damage CN III, IV, VI and V1- known as superior orbital fissure syndrome. When accompanied by blindness, it is known as orbital apex syndrome and involves optic foramen.

Cranial nerve injuries: Middle Cranial Fossa

* CN VII- facial paralysis. Most common temporal bone, 50% of transverse and 25% of longitudinal fractures as injuries. ENoG of 90% denervation should undergo surgery.

* CN VIII- Hearing loss, vestibular damage. Cochlear and vestibular nerve damage, or damage to otic capsule can lead to total degeneration with deafness and labyrinthine dysfunction. Workup with Audiogram, ABR, and ENG. Cochlear implants have 84% success rate of return to speech understanding.

Cranial nerve injuries: Posterior Cranial Fossa

- CN IX, X, XI- exit out of jugular foramen and CN XII exit out of hypoglossal foramen.
- Glossopharyngeal injury leads to dysphagia and loss of gag
- Vagus nerve results in ipsilateral cord or palate weakness with hoarseness.
- Spinal accessory nerve causes weakness with head rotation and shoulder elevation. Hypoglossal nerve injury causes atrophy of ipsilateral tongue.
- Treatment is usually supportive with therapy.

* New Orleans criteria
  * CT required for minor head trauma (Loss of consciousness with normal neurologic exam) if the following apply:
    * Headache, vomit, >60 yo, Drug/alcohol, seizure witness, anterograde amnesia, soft tissue injury

Evaluation: Imaging

- It is not recommended for most head traumas. It has some benefit for non accidental trauma in children.

Evaluation: Imaging: CT

- HRCT scan is the gold standard for skull base injury. It has the best modality to evaluate bony fractures.
- The slices should be 1-1.5 mm thick at the most.
- Helical CT scans are useful in the evaluation of occipital condylar fractures.
- CT Angiography is an excellent, quick, non-invasive technique for the assessment of cerebral vasculature.
Evaluation: Imaging: CT
Imaging: CT
### Table 40.1: Differences between fracture and sutures in radiology

<table>
<thead>
<tr>
<th>Suture</th>
<th>Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 2 mm in width</td>
<td>Greater than 3 mm in width</td>
</tr>
<tr>
<td>Same width throughout</td>
<td>Width at the center and narrow at the ends</td>
</tr>
<tr>
<td>Lighter on X-rays compared with fracture lines</td>
<td>Runs through both the outer and the inner lamina of bone, hence appears darker</td>
</tr>
<tr>
<td>At specific anatomic sites</td>
<td>Usually over temporoparietal area</td>
</tr>
<tr>
<td>Does not run in a straight line</td>
<td>Usually runs in a straight line</td>
</tr>
<tr>
<td>Curvaceous</td>
<td>Angular turns</td>
</tr>
</tbody>
</table>

Multidetector CT of Temporal Bone Fractures John M. Collins, Aswin K. Krishnamoorthy, Wayne S. Kubal, Michele H. Johnson, Colin S. Poon Seminars in ultrasound, CT, and MR 1 October 2012 (volume 33 issue 5 Pages 418-431
Imaging: CT

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Evaluation: Vascular injuries

Approximately 50% of patients with skull base fractures present with delayed ischemic brain damage. Carotid injuries include carotid disruption, compression by fracture fragments or associated hematoma, arterial wall contusion or hematoma, arterial dissection, carotid cavernous fistula, and occlusion.

Behbahani 2013- Retrospective study 1606 pt. in Tuscan, 16 patients had fractures extending to carotid canal, but no carotid injuries noted on angiographic studies.

A total of 249 patients underwent arteriography; 85 (34%) had injuries.

Independent predictors of carotid arterial injury were: Glasgow coma score ≤6, petrous bone fracture, diffuse axonal brain injury, and LeFort II or III fracture. Having one of these factors in the setting of a high-risk mechanism was associated with 41% risk of injury.
Evaluation: Vascular injuries

Evaluation: Vascular injuries
Imaging: MRI

- Provides greater soft tissue detail but less bony detail compared to CT.
- FSE T-1 or T-2 with post contrast enhancement are preferred methods to evaluate skull base.
- T-2 fat suppression with image reversal is used to highlight CSF.
- T2 weighted thin sliced images (FIESTA) is used to evaluate cranial nerves.

Imaging: MRI

Morani et al.
**Evaluation: CSF Rhinorrhea/Otorrhea**

- CSF evaluation
- Halo or Ring Sign
  - Bloody CSF placed on a piece of filter paper
  - Blood will separate out from the CSF (central blood with clear ring).
- The ring sign is not specific to bloody CSF
  - Blood mixed with water, saline, and other mucus will also produce a ring sign.

Evaluation: CSF
Rhinorrhea/Otorrhea
Evaluation: CSF Rhinorrhea/Otorrhea

* Beta-2-transferrin
  * Protein produced by enzymes **only in CNS.**
  * Test requires 0.5cc of fluid.
  * Highly sensitive and specific for CSF.

Beta-trace protein

- Found in CSF, heart, and serum.
- Not routinely ordered as it may be altered in many cases.
  - Elevated with renal insufficiency, multiple sclerosis, cerebral infarctions, and some CNS tumors.

Useful in detection of CSF leaks.

- Involve intrathecal administration of radiopaque contrast (metrizamide, iohexol, or iopamido) followed by CT scan.
- Up to 80% sensitivity.
- However results vary with intermittent leaks, and contrast may obscure visualization of leak site.

CSF Rhinorrhea
CSF Rhinorrhea

http://www.chatrath.com/featuredcases.html
CSF Rhinorrhea
CSF Rhinorrhea

- Treatment begins with conservative management of strict bed rest, HOB >30 degrees, no cough, sneezing, straining.
- Currently, after two separate meta-analysis showed conflicting data, a Cochrane review was done for evaluation of prophylactic antibiotics for CSF leaks.
- The analysis concluded that the evidence does not support the use of prophylactic antibiotics to reduce the risk of meningitis in patients with basilar skull fractures or basilar skull fractures with active CSF leak.

CSF Rhinorrhea

* Conservative management for 7 days has resolutions rate of 85%.
* Continued leakage is then treated with lumbar drainage of 10 ml/hr. This increases resolution rate to 90%.
* Therefore, surgical intervention is reserved for patients who do not resolve with the above measures.

Skull base injuries offer complex fractures that require thorough evaluations. Division in 3 cranial vaults provides a reasonable way for evaluation. Radiographic evaluation is important, along with history and physical exam. Treatment measure typically begin with conservative treatment, with surgical intervention saved for severe or persistent disease.
References

* Positive predictive values of selected clinical signs associated with skull base fractures. (PMID:11105835)
* Pretto Flores L, De Almeida CS, Casulari LA. Journal of Neurosurgical Sciences [2000, 44(2):77-82; discussion 82-3]
* https://www2.aofoundation.org/wps/portal?ut/p/c0/04_SB8K8xLLM9MSSzPy8xBzgCP00s3hng7BARydDRwN3QwMD A08zTzdxxBjIwN_I_2CbEdFADiM_QM!/?segment=Cranium&bone=CMF&classification=93-Skull%20base%20C%20Skull%20base%20fractures&teaserTitle=&showPage=diagnosis&contentUrl=/srg/93/01-Diagnosis/skull_base-skull_base.jsp
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References

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