

Head injuries

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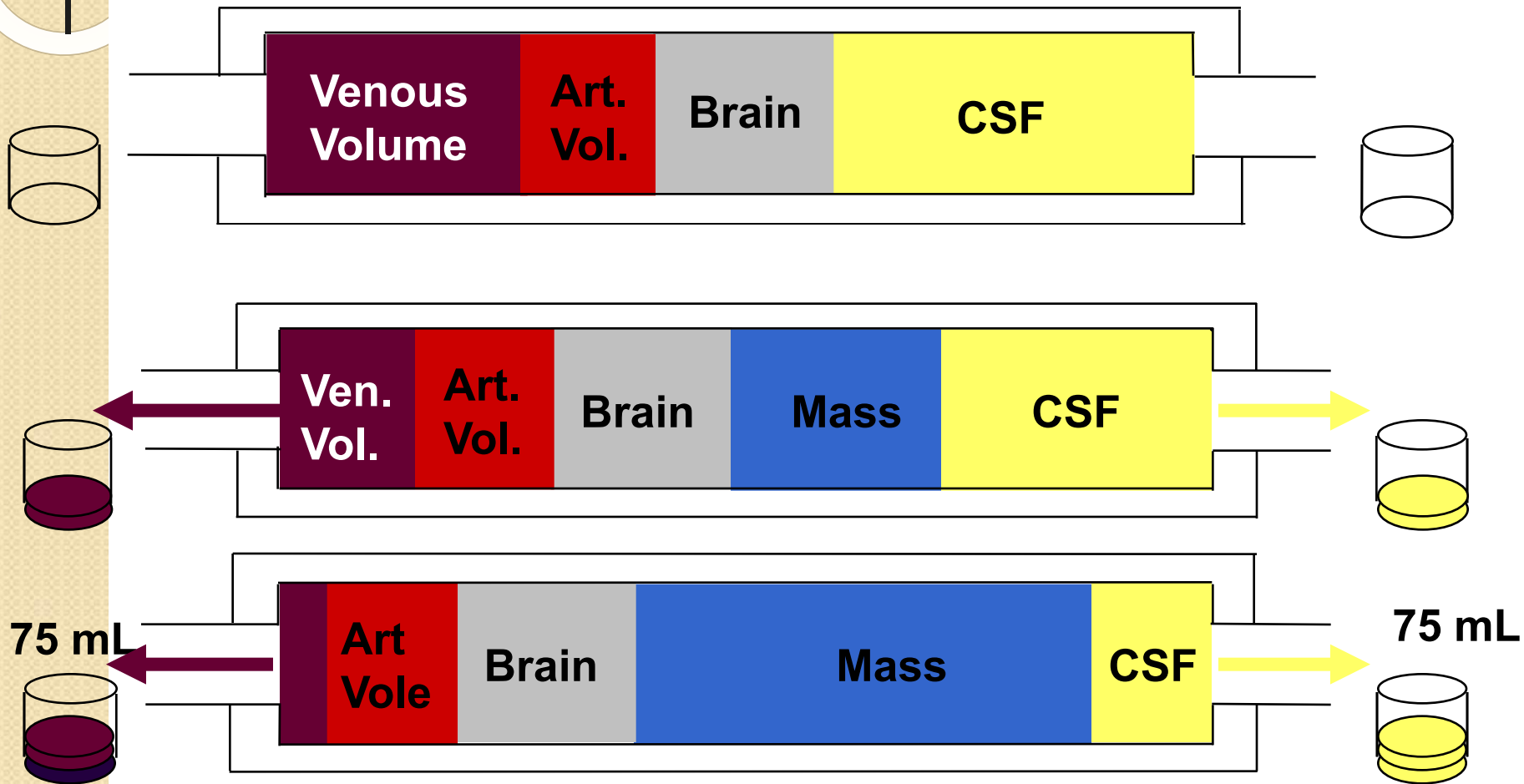
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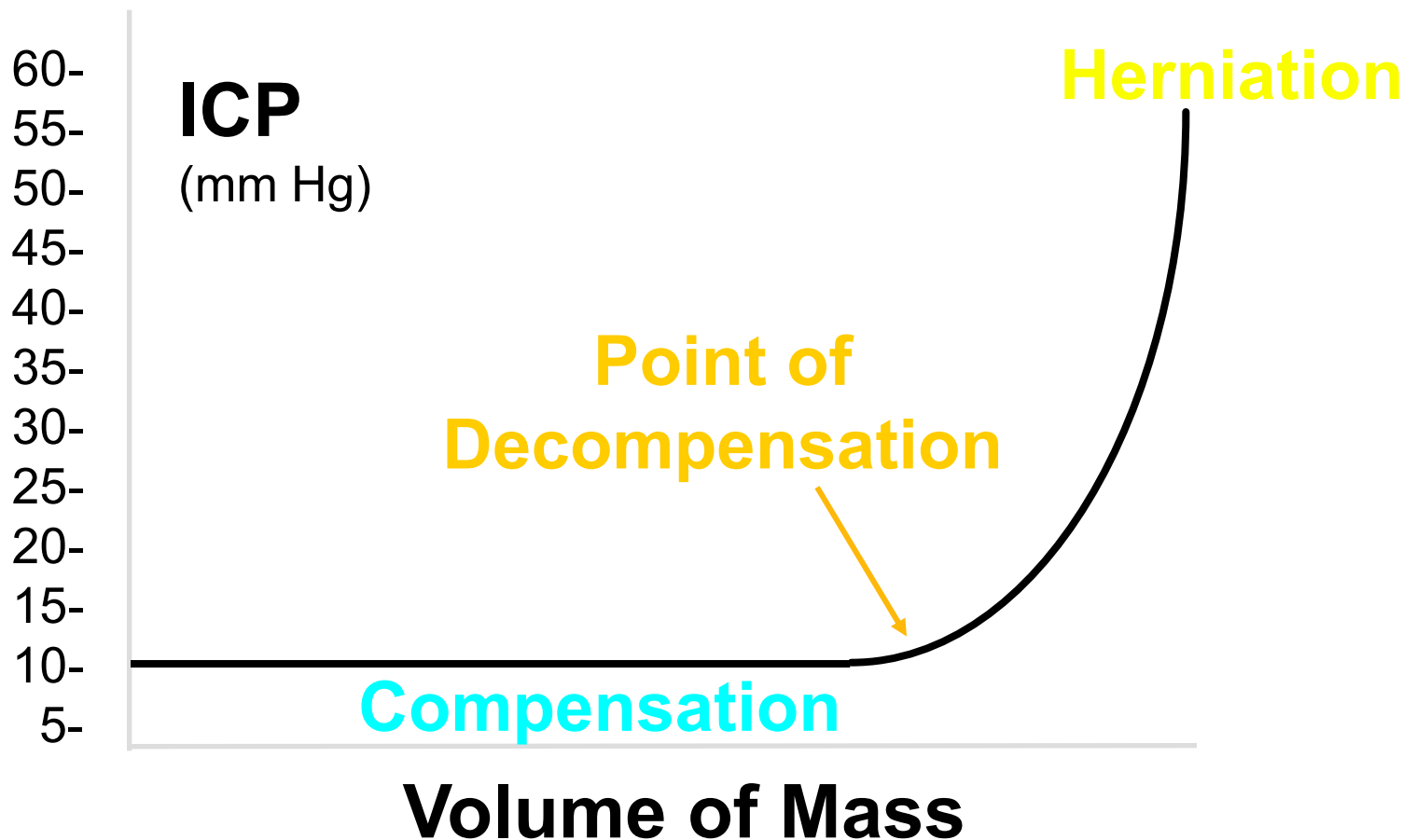
Anatomy and physiology

- **Rigid, nonexpansile skull filled with brain, CSF, and blood**
- **CBF autoregulation (55ml/min/100gm)**
 - **Autoregulatory compensation disrupted by brain injury**
- **Mass effect of intracranial hemorrhage**

Monro-Kellie Doctrine



Volume – Pressure Curve



Intracranial Pressure (ICP)

- **10 mm Hg = Normal**
- **> 20 mm Hg = Abnormal**
- **> 40 mm Hg = Severe**

- **Sustained $\uparrow$ ICP leads to $\downarrow$ brain function and outcome**

Cerebral Perfusion Pressure*

	MBP – ICP = CPP		
Normal	90	10	80
Cushing's Response	100	20	80
Hypotension	50	20	30

*** CPP ≠ Cerebral Blood Flow**

Autoregulation

- If autoregulation is intact, CBF is maintained with a mean BP of **50-160** mm Hg.
- Moderate or severe brain injury: Autoregulation often impaired
- Brain more vulnerable to episodes of hypotension → secondary brain injury

Classification of Injuries

By Mechanism

- **Blunt: High and low velocity**
- **Penetrating: GSW and other**



By Morphology: Skull Fractures

Vault

- **Depressed / nondepressed**
- **Open / closed**

Basilar

- **With / without CSF leak**
- **With / without cranial palsy**

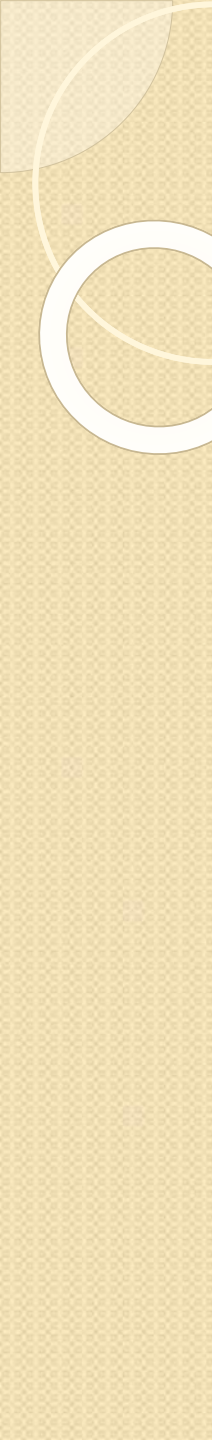
By Morphology: Brain

Focal

- **Epidural (extradural)**
- **Subdural**
- **Intracerebral**

Diffuse

- **Concussion**
- **Multiple contusions**
- **Hypoxic / ischemic injury**



Clinical classification

- **Mild: GCS 14-15**
- **Moderate: GCS 9-13**
- **Severe: GCS 3-8**

Scalp injuries

- Scalp wounds & lacerations
- Friction burns
- Degloving injuries

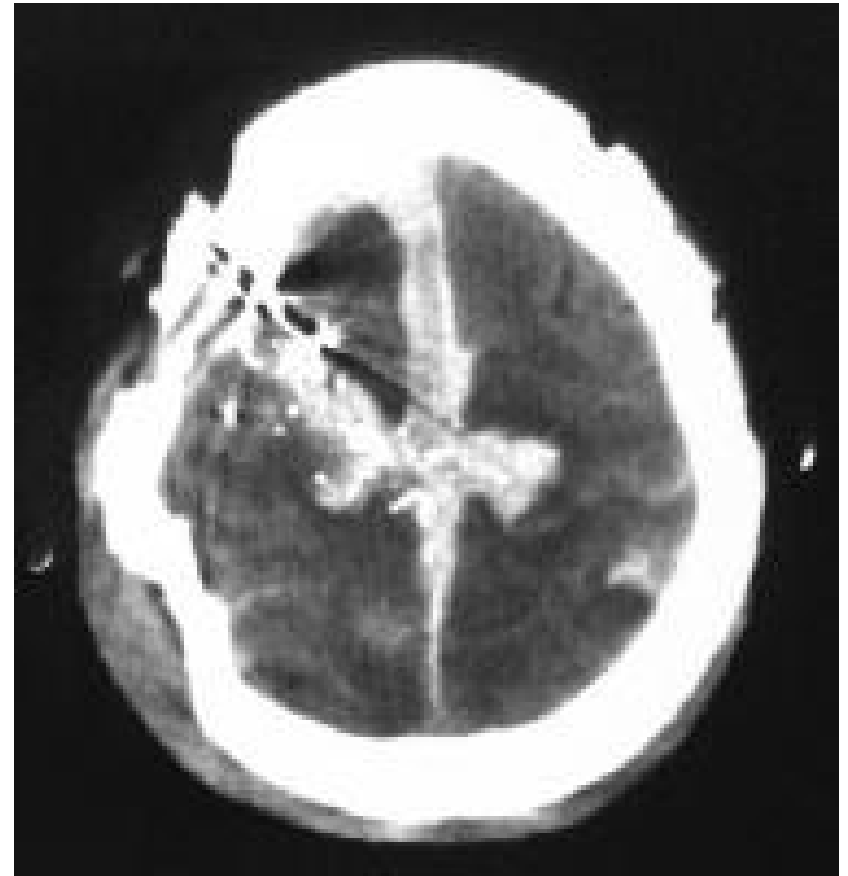
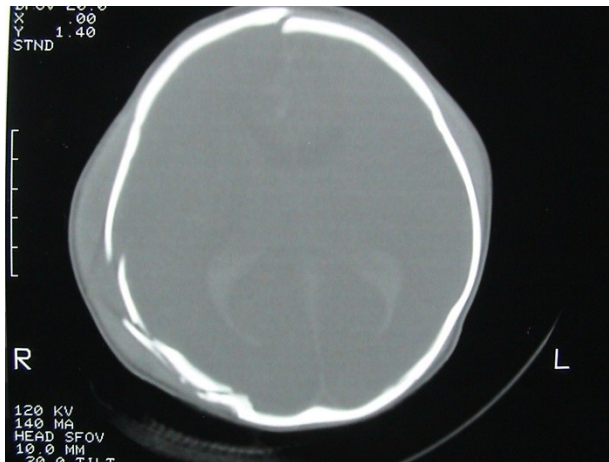
Bone injuries (skull fractures)

- Linear skull #

fissure #, Gapping , stellate

- Depressed skull #

simple depressed, compound, & comminuted depressed

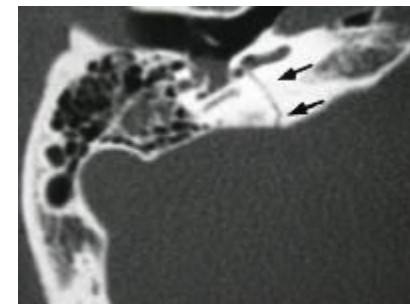


Skull base

- Longitudinal & transverse
- Simple & compound

Clinically

- **Ant. Cranial fossa #**
 - periorbital hematoma (Raccoon's eyes)
 - epistaxis
 - CSF rhinorrhoea,
 - subconjunctival hemorrhage
- **Middle fossa #**
 - bleeding per ear
 - CSF otorrh.
 - retromastoid hematoma (Battle's sign)

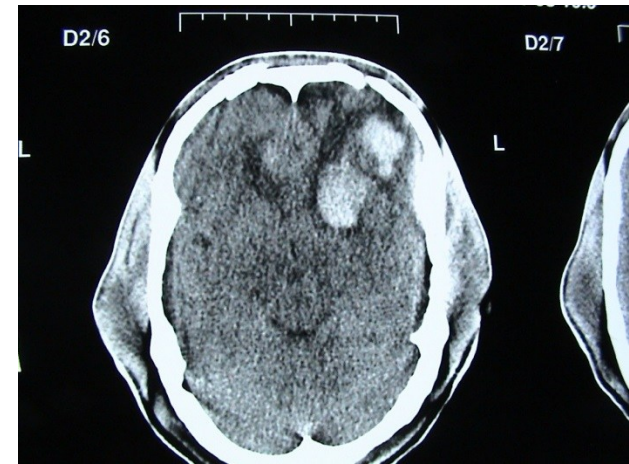




Brain injury

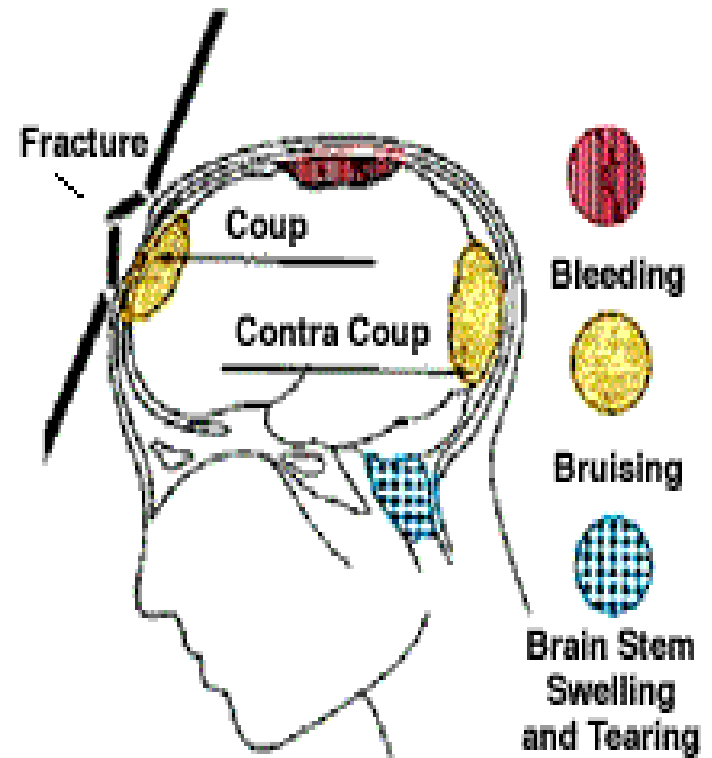
Primary brain injury

- Concussion
- Contusion (coup & Contra-coup)
- Brain Laceration
- Diffuse axonal injury (DAI).



Coup & Contra-coup contusion:-

- when the brain is accelerated there is +ve force generated immediately beneath the site of collision.
- Because of the physics of acceleration of gelatinous bodies there is at the same time –ve pressure in the opposite pole(s) of the brain.



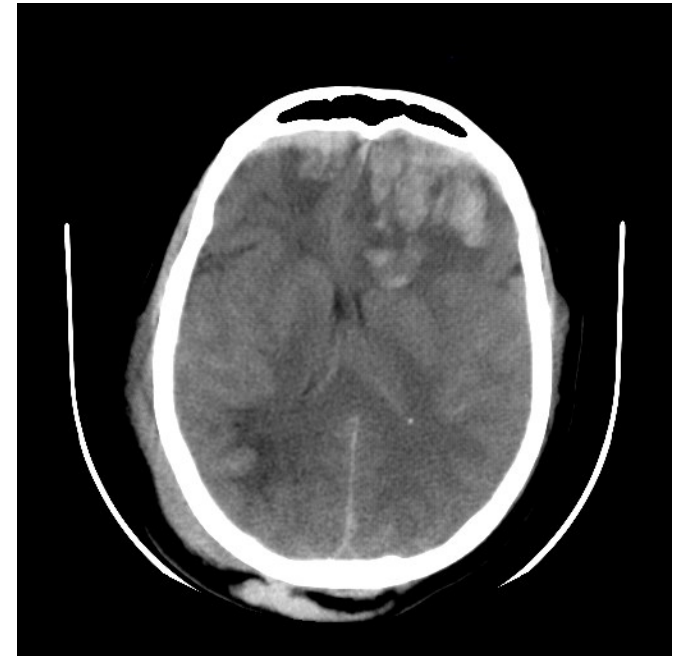
Diffuse axonal injury (DAI)

- ☐ ***Deceleration & Rotational forces.***
- ☐ ***Sheering white matter tracts.***
- ☐ ***CT & MRI ---- punctate hge.***
- ☐ ***prognosis is usually poor.***



Intracranial hematoma

- Occurs in four main sites:
 - extradural
 - subdural
 - subarachnoid
 - intraparenchymal
- Each has a characteristic cause, presentation and treatment.
- However, all cause a **rise in ICP**, which may compromise perfusion of the brain.



Initial evaluation & management

- ABCDE
- **History**

Bystanders often give valuable history:

- pre-injury state (fits, alcohol, chest pain)
- energy involved in the injury (speed of vehicles, height fallen)
- conscious state and haemodynamic stability
- length of time taken for extrication
- length of retro- and antegrade amnesia
- Any loss of consciousness, and its duration.
- medical & medication history, esp. MI, anticoagulants

Examination: primary survey

- Ensure adequate oxygenation and circulation
- Check pupil size and response and Glasgow Coma Score as soon as possible
- Check for focal neurological deficits (eg paraplegia) before intubation if possible
- Check blood sugar for hypoglycaemia

Pupils

Record pupil **size** in mm, and **reactivity** as present, sluggish or absent.

- **Uncal herniation** (with compression of third nerve), first produces an enlarged and sluggish pupil, which later becomes fixed and dilated.
- **Direct ocular trauma** or nerve injury in association with a skull base fracture can cause mydriasis from the start.

Glasgow Coma Score

	Eyes opening	Verbal response	Motor response
6			Obeys commands
5		Normal oriented conversation	Localises to pain
4	Spontaneously	Confused	Withdrawal (pain)
3	To verbal command	Inappropriate words	Flexion (pain)
2	To painful stimulus	Sounds only	Extension (pain)
1	Do not open	No sounds	No motor response

Examination: secondary survey

- **Examination of the head**

- Look & feel over the **whole skull and face** for cuts, bruises & fractures
- Check for fractured **base** of skull by looking for blood in the ears, nose or mouth and Battle's sign
- Check the **cranial nerves** (7, 8)
- Check the **eyes** for movement and for damage to the orbit itself
 - Midbrain or brainstem dysfunction may produce **gaze paresis** (inability to look across the midline), or **dysconjugate gaze** (inability of the eyes to work together).
 - Inspect the conjunctiva, cornea and retina (ophthalmoscope) looking for **hyphaema** (blood in the anterior chamber), **papilloedema** or **retinal detachment**.
- The **GCS and pupil** status require re-evaluation.

- **Examination of the whole patient**

- Cervical spine injury is common with head injuries (assume as present)
- Even obtunded patients should move all four limbs
 - Check and record power, tone and sensation in the peripheral nerves
- Log roll to check the whole spine for steps and tenderness
- Perform a rectal exam to check for anal tone
- Check for priapism

Management of head injury

- An **observation** period of a few hours is advisable, in mild injury with H/o loss of consciousness.
- **Discharge criteria** in mild head injury;
 - GCS 15/15 with no focal deficits
 - Normal CT brain (if performed)
 - Pt not under the influence of alcohol or drugs
 - Pt accompanied by a responsible adult
 - Verbal and written advice to seek medical attention if:
 - Persistent/worsening headache despite analgesia
 - Persistent vomiting
 - Drowsiness
 - Visual disturbance
 - Limb weakness or numbness

Guidelines for CT scan in head injury.

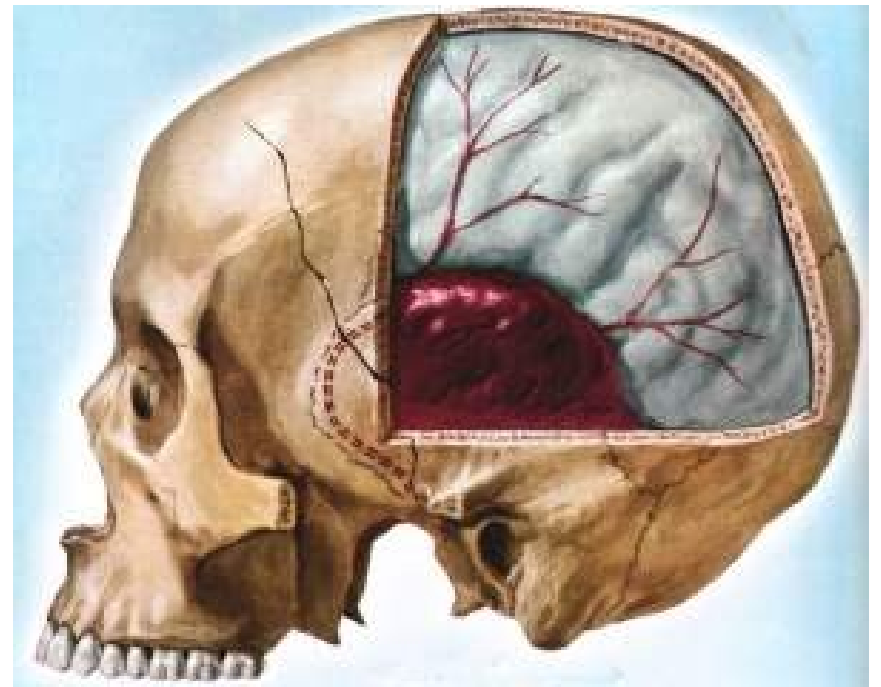
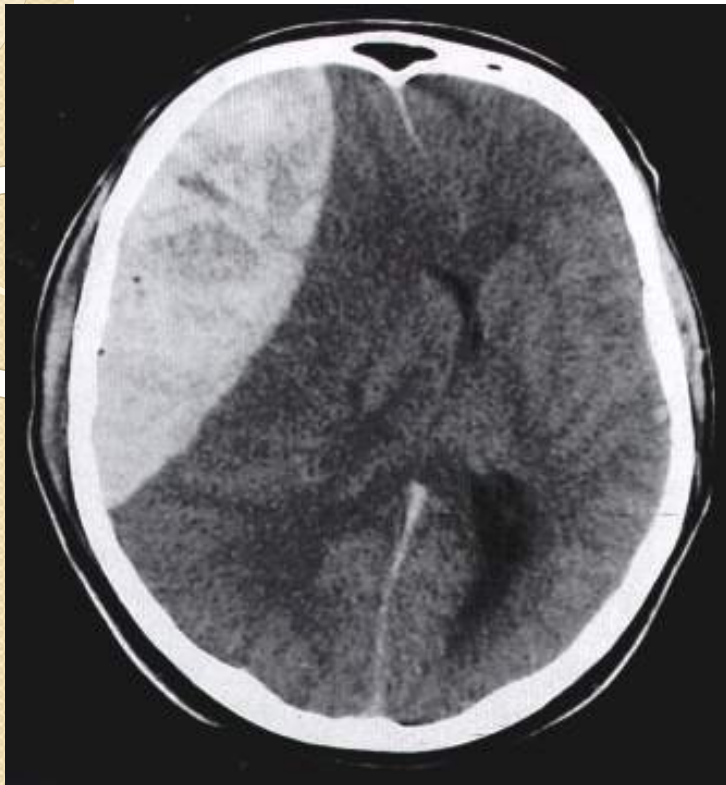
- GCS <13 at any point
- GCS 13 or 14 at 2 hours
- Focal neurological deficit
- Suspected open, depressed or basal skull fracture
- More than one episode of vomiting
- Any patient over the age of 65 years or with a coagulopathy
- Dangerous mechanism of injury or antegrade amnesia >30 minutes

Criteria for hospital admission

The presence of one or more of the following:-

- 1. Confusion or any other depression of the level of consciousness at the time of examination**
- 2. Skull fracture**
- 3. Neurological signs or headache or vomiting**
- 4. Difficulty in assessing the patient e.g. alcohol , the young and epilepsy.**
- 5. Other medical condition e.g. hemophilia**
- 6. The patient social condition or lack of responsible adult or relative.**

- 
- Scalp wounds need closure
 - Significant depressed fractures need elevating, antibiotics and antiepileptics
 - Skull base fractures may be associated with CSF leak (usually resolve spontaneously).
 - Pneumococcus vaccination is valuable, but prophylactic antibiotics are not usually indicated



Epidural (Extradural) Hematoma

- Can occur in the context of apparently **minor trauma**, associated with skull fracture
- Due to **middle meningeal** artery or vein tear
- Isolated EDH may manifest as sudden deterioration following a **lucid interval**
- Signs of **lateralization** (initially contralateral hemiparesis & ipsilateral mydriasis; later ipsilateral hemiparesis)
- **Lentiform lesion on CT**
- Can be rapidly fatal
- **Early evacuation is essential**

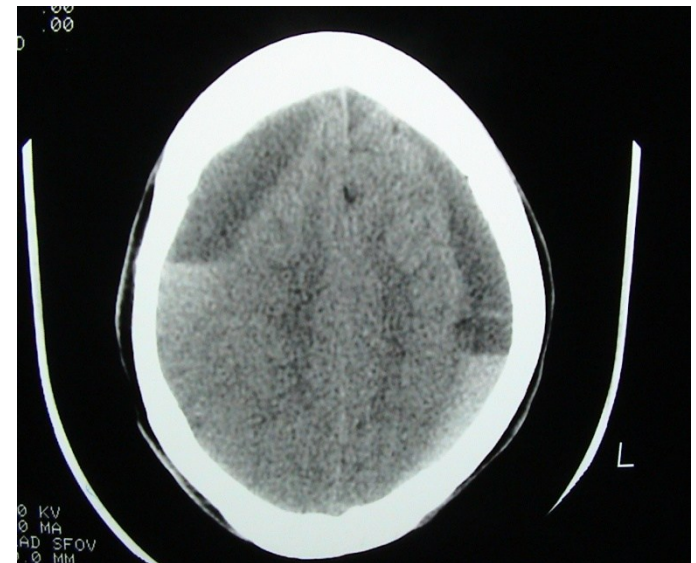


Acute Subdural hematomas

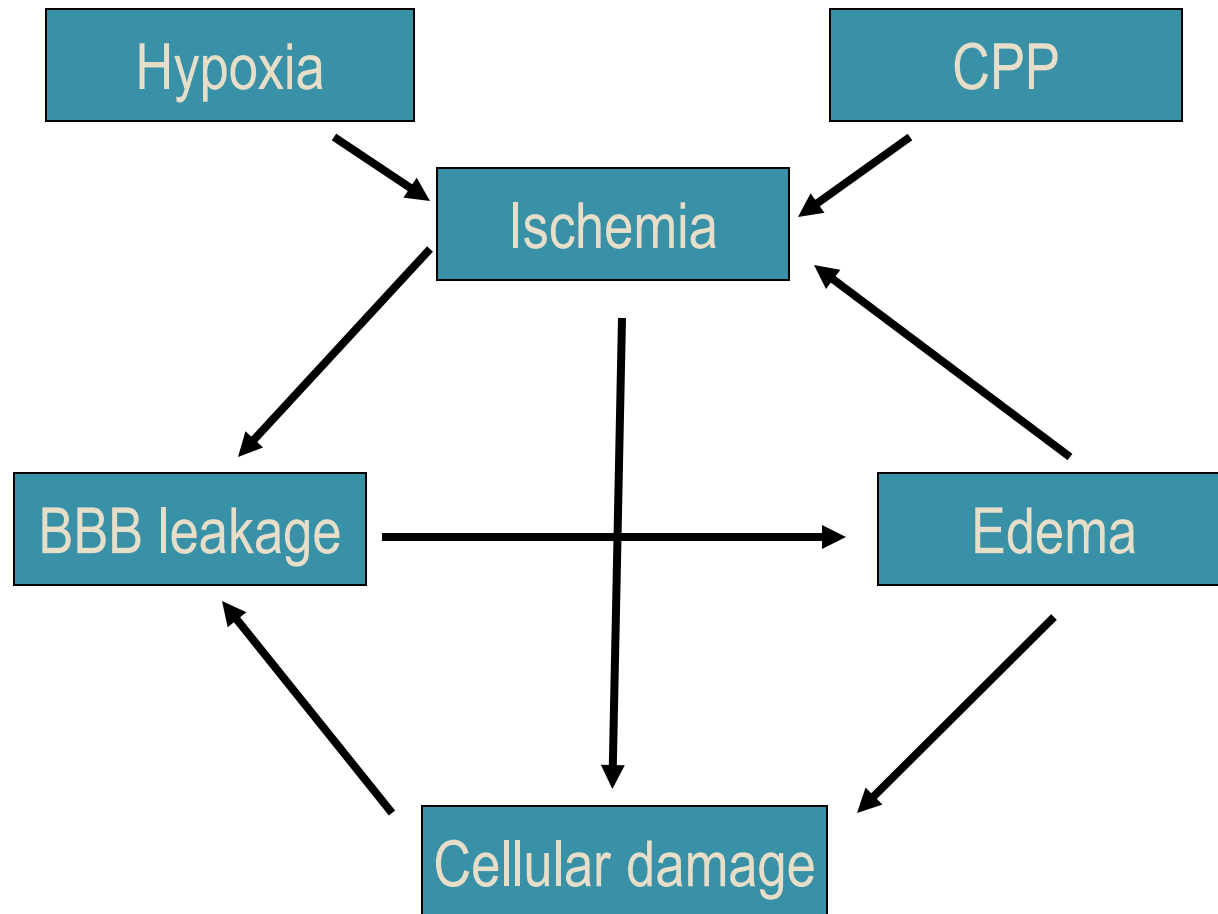
- Caused by relatively **severe trauma**, with rupture of cortical vessels or brain laceration
- **No lucid** interval
- Patient is often **unconscious** (GCS 3-7) throughout the course.
- Clinically signs of **uncal in herniation**.
- Diffuse **concave lesion** on CT
- **Rapid surgical evacuation recommended, especially if > 5 mm shift of midline**
- Poor prognosis (50% mortality).

Chronic SDH

- Occurs in the **elderly**, especially those on anticoagulants
- May take days or weeks to develop
- **Headache, confusion, hemiparesis**
- **Diffuse hypodense lesion** on computed tomography
- **Evacuation** may be delayed until clotting has been improved
- Usually good prognosis



Pathophysiology

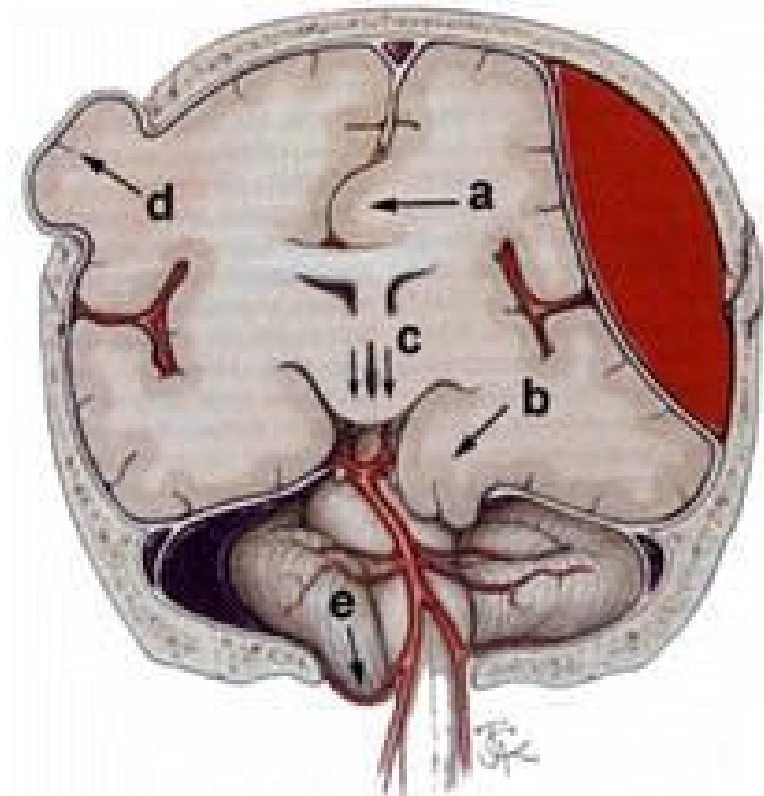


Secondary Brain injury

- Shock, Hypoxia, Hypo-/hyper-thermia, Metabolic (hypoglycemia, U/E disturbances).
- Hematoma
- Brain edema & Herniation
- CSF leak & Infection
- Hydrocephalus

Brain Herniation

- Subfalcial
- Transtentorial (uncal)
- Central (downward & upward)
- Tonsillar
- External



Ongoing management: prevention of secondary injury

- The patient should be **intubated and ventilated** with adequate sedation
- **Intracranial pressure monitoring** using a bolt ICP monitor, or an external ventricular drain inserted into the lateral ventricle which also allows drainage of CSF.
- Key parameters to maintain include;
 - $p\text{CO}_2 = 4.5\text{--}5.0$ kPa
 - $p\text{O}_2 > 11$ kPa
 - $\text{MAP} = 80\text{--}90$ mmHg
 - $\text{ICP} < 20$ mmHg
 - $\text{CPP} > 60$ mmHg
 - $\text{Na}^+ > 140$ mmol/L
 - $\text{K}^+ > 4$ mmol/L

Control of intracranial pressure

Initial measures

- positioning the head up 20–30°
- cervical collar should be loosened (to allow venous return)
- Ventilation to achieve normocapnia ($pO_2 > 11$, $pCO_2 \sim 4.5\text{kPa}$)
 - hypocapnia may be used to achieve transient ICP control, but the resultant cerebral vasoconstriction can produce hypoperfusion and further secondary brain injury.
- Sedation & seizure control using opiates and barbiturates
- Optimise electrolyte balance (hypertonic fluids if necessary),
- treat hyperglycaemia

Intermediate measures

- Where initial measures fail to control ICP, sedation needs to be supplemented with **paralysis**.
- **External ventricular CSF drainage**.
- **Mannitol/furosemide/hyperventilation** as temporising measures
 - Mannitol is helpful if there is evidence of herniation, eg dilated unresponsive pupil.
 - 100 mL of 20% mannitol given as bolus.
 - Repeated use is counterproductive as it produces hypovolaemia and hypotension.
 - Catheterising the patient to monitor fluid balance.
- **Pyrexia** should be avoided, as it increases brain oxygen requirements and cell damage.

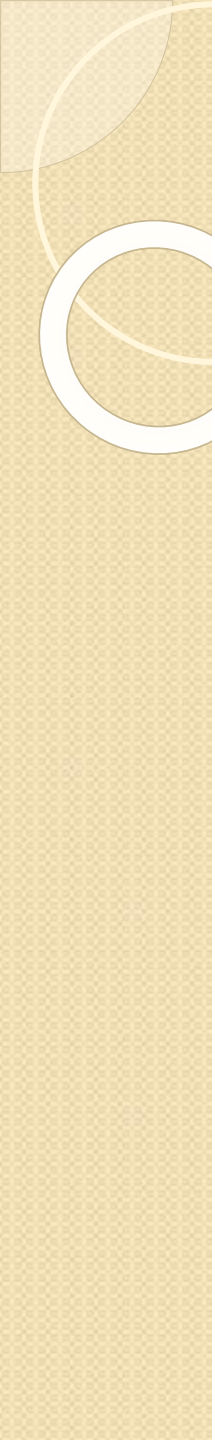
Final measures

- **Decompressive craniectomy**
 - involves removal of a portion of skull vault and opening of the underlying dura, so that brain swelling can occur without the pressure increases
 - unilateral or bifrontal decompressive craniectomy is usually performed, with the bone flap placed subcutaneously in the abdomen, then replaced (cranioplasty) weeks or months later.
- **Induction of thiopentone coma**
 - high risk of complications and
 - results in the loss of normal EEG activity and pupil responses, compromising ongoing evaluation of the patient.

Pituitary dysfunction: endocrine & metabolic management

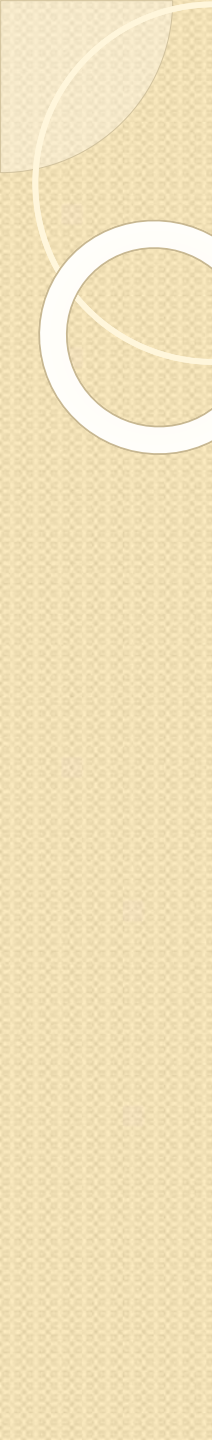
Electrolyte imbalance is common in TBI, and contributes to brain swelling and seizures.

- **Cerebral salt wasting**, with brain insult, leads to volume depletion and hyponatraemia.
- **SIADH** leads to water retention and hyponatraemia.
 - Hypotonic fluids are avoided in this setting.
- **ADH** secretion may be compromised, producing diabetes insipidus resulting in hypernatraemia.
 - This may be managed with boluses of desmopressin.
- All aspects of pituitary function may be compromised in the setting of TBI. **Routine screening of pituitary hormone** levels is important.
- Routine administration of **corticosteroids** in severe head injury is associated with increased mortality and is not recommended.



Seizures

- Seizures may occur early (within 7 days) or late.
- Risk factors include injury severity, esp. the presence of ICH, depressed skull fractures and tears of the dura.
- Antiepileptics, typically **phenytoin**, are given prophylactically to high risk patients.



Nutrition

- Enteral nutrition is preferred, and should be commenced **within 72 hours** of injury.
- Prokinetics (e.g. metaclopramide, erythromycin) can be given to promote absorption.

Indication of Surgery in HI

Urgent

- Raised ICP due to intracranial hematoma
- Comp. depressed skull fracture
- Compound wound +/- contamination

Late

- Persistent CSF leak > 24h after injury
- Hydrocephalus
- Chronic subdural hematoma with impaired mental state
- Infection / cosmetic

Early Complication

- ***Epilepsy***
- ***Post concussion syndrome (headache, dizziness, fatigue , and poor memory)***
- ***Behavior changes***
- ***Brain death***

Prognosis (GOS)

OUTCOME		DESCRIPTION
Good Recovery (GR)	5	Minor disabilities, but able to resume normal life.
Moderate Disability (MD)	4	More significant disabilities, but still able to live <u>independently</u> . Can use public transportation, work in an assisted situation, etc.
Severe Disability (SD)	3	Conscious, but <u>dependent</u> upon others for daily care. Often admitted.
Persistent Vegetative State (PVS)	2	Not conscious, though eyes may be open and may "track" movement.
Death (D)	1	Self-explanatory

Long-term complications

- Physical disabilities: headache, fatigue, facial pain, limb weakness (usually hemiparesis), poor hand function, impaired balance, visual or hearing impairment, and epilepsy.
- Mental disabilities: personality change, depression, memory loss (especially short-term), poor concentration, learning problems, communication problems (perceptive, expressive).
- Social/economic problems: family disruption, isolation, loss of job, alcohol/drug abuse, crime

Overall Outcome

- *Most patients with a mild head injury make a good recovery spontaneously.*
- *After severe head injury:*
 - *33% make good recovery with treatment,*
 - *33% are left with varying degrees of disability,*
 - *33% die.*
- *Recovery is assessed at least six months from injury, and can continue for much longer, especially in children.*

Summary: What should I do?

- **Maintain mean BP > 90 mm Hg**
- **Maintain Paco_2 near / at 35 mm Hg**
- **Use isotonic solution for euvolemia**
- **Frequent neurologic exams**
- **Liberal use of CT scans**
- **Early neurosurgical consult**

Summary: What should I not do?

- **Allow patient to become hypotensive**
- **Over-aggressively hyperventilate**
- **Use hypotonic IV fluids**
- **Use long-acting paralytics**
- **Paralyze before performing complete exam**
- **Depend on clinical exam alone**



The End!