Head Trauma

Epidemiology
Responsible for 50-75% mortality of major trauma (10% abdo)
5% have associated C spine #

Physiology
**Autoregulation** occurs at MAP 60-150 - incr ICP - decr CPP and autoregulation - massive cerebral vasodilation - congestive brain swelling and cerebral oedema
CPP = MAP – ICP
**Munroe-Kellie**: vol must remain constant; brain 1400g, CSF 75ml, blood 75ml
**Normal CSFp** = 5-15 (10-12; <8 in children <3/12)
**CSF formation** = 500ml/day (50% choroid plexus, 50% BV); absorption = linear until 7cm H20; K 2.9, Cl 113, CO2 50, pH 7.33, glu 3; low protein
Incr BP/incr pH/incr O2/decr CO2 - vasoC - lowers ICP by 25%, but vasoC only last 12-24hrs, DOA 10-20mins, so only useful as short term measure in periods of severe deterioration, prolonged use causes ischaemia
Decr BP/decr pH/decr O2/incr CO2 - vasoD - incr ICP

Paediatrics
85% mild
Less mass lesions and contusions - less surgically amenable lesions
Large head - more rotational force - prone to cerebral oedema and axonal shearing - Sx may subtle
Thin cranial cortex - scalp haematomas more important - if skull #, 75% chance of ICH
No frontal sinus until 8-10yrs - frontal bone strong
Less incr ICP if open fontanelle or distendable sutures
Incr mortality <1yr

High risk - Do CT:
decr LOC/LOC >1min/irritability
 basal/depressed skull fracture
  >5 vomits in 6hrs (vomiting more common >2yrs)
  seizure
  FND
 bulging fontanelle
any scalp haematoma <2yrs (incr risk of skull #/ICH), mod/large scalp haematoma >1-2yrs

Mod risk - observe 4-6hrs or do CT:
LOC <1min / resolved lethargy or irritability
 skull # >24hrs old
  3-4 voms
  significant MOI
large non-frontal scalp haematoma
 unwitnessed, vague history, parental concern

Low risk - no imaging:
low MOI, asymptomatic, >2hrs since inj, >1yr

Primary injury
Mechanical irreversible direct neuronal damage (permanent cellular disruption, microV injury) at time of impact; only prevention is helpful
**Concussion**
Transient alteration in cerebral function, usually assoc with LOC, with rapid complete recovery
LOC <30secs/GCS 13-15 following inj/any loss of memory of event/post-traumatic amnesia <24hrs/any altered mental state at time of inj
**Sx:** headache, blurred vision, dizziness, lethargy, mild nausea, poor concn, sexual dysfunction, mood; usually resolve <1/52

**Axonal shear injury**
Most common finding after severe HI, occurs in up to 50%
At grey-white matter interface; due to rotational forces;
Initial CT abnormal in 25% (small petechial haemorrhages) - diffuse cerebral oedema, disruption of blood flow, disruption of metabolism

**Cerebral contusion**
Diffuse bleeding on/in brain
At grey matter/subcortical white matter (most common frontal/temporal lobes – rough surface bone)
CT shows petechial haem and oedema; often no skull #
Morbidity related to size (large, secondary oedema, seizures) and site (frontal/temporal)

**Skull fracture**
**Symptoms:**
linear - diffuse brain inj or depressed - localised inj
7% have ICH (75% in paeds)

** Clinically significant if:**
intracranial air/open
depressed below inner table (needs OT)
overlying dural venous sinus or MMA
posterior fossa #

**Basal skull fractures**
Battle sign, subconjunctival haem without posterior limit, CSF rhinorrhea/otorrhoea (occurs in 20%, test for glu, halo test); can cause CN defect, dislocate auricular bones, disrupt cavernous sinus (ICA, III, IV, V)

**Complications**
Meningitis (usually in first few weeks; H influenza, strep pneumonia, staph aureus)

**Management**
Admit; elevation if depressed
Basal skull fracture: do not require ABx (only if meningitis occurs or compound; ceftriaxone+vanc)
If CSF rhinorrhea: inj of cribiform plate; avoid BVM/NGT; instruct pt not to blow nose; higher risk of meningitis, but do not require ABx; if ongoing leak >72hrs, insert lumbar drain to divert flow and allow closure of defect; direct dural repair if major leak/>6/52
If CSF otorrhoea: inj of petrous temporal bone; assoc with VII and VIII defect; usually closes spont

**Intracerebral haematoma (40%)**
Same distribution as cerebral contusion
Assoc with other intracranial injuries in 50%, extend into ventricles in 35%
Symptoms may develop as haematoma enlarges over time
**RF for deterioration:** SAH, SDH, size of haemorrhage
**Indications for OT:** incr size of >5cm³; decr basilar cistern/lateral V volume
**Indication for SSU/discharge:** <2cm diameter; GCS 15; normal coag
Epidural/extradural haematoma (0.5%)
90% assoc with skull # (usually temporal bone); due to post branch MMA, veins, dural venous sinuses, carotid (low anterior, poor prognosis); 20% assoc with other IC inj; uncommon in elderly
**Symptoms:** fast onset if arterial, slow onset if venous; can occur after minor HI; LOC absent/brief in 50%; 30% have lucid interval; mortality >50%
**Investigation:** hyperdense, biconvex, ovoid, lenticular; do not cross suture lines
**Trt:** OT if >30cm³ vol
**Prognosis:** mortality 20-30% (5-10% if not in coma at diagnosis)

SDH (30%)
More common, esp in elderly
Assoc with acceleration/deceleration inj usually with LOC
Usually over lat hemispheres; bilat in 10%
Due to veins that drain dural sinuses
In children ?NAI
More common than extradural in elderly
**Symptoms:** 50% have lucid interval
Acute: within 24hrs; mortality 75%; usually significant 1Y injury; usually present GCS <3; coma from time of injury in 50%
Subacute: within 2/52; <20% mortality
Chronic: progressive neurologic deficit >2/52 following inj; bilat in 20%; 45% rebleed; remains clotted for 2-3/52 then gradually liquefies - rebleed; <20% mortality
**Investigation:** biconcave; crosses suture lines; acute = hyperdense; in acute, blood may collect along tent/falx; 3-7/7-3/52 = isodense; 4-6/52 = hypodense; hyperdense on MRI
**Trt:**
Acute: early evacuation if >10mm thick/>5mm midline shift/symptoms
Subacute: most require OT

SAH (40%)
**Traumatic likely if:** unusual site for primary SAH; other assoc features of brain inj; localised

Secondary injury
Due to cellular effects of trauma:
- Haematoma, oedema, cerebral vasospasm, cerebral hypoxia, cellular dysfunction
- Occurs 2-24hrs after injury
- Partly preventable by maintaining cerebral perfusion and oxygenation
- Other systemic insults: hypotension (SBP <90 - 2x mortality); hyperthermia; hypoxia (pO2 <60); anaemia; incr CO2; coagulopathy; seizures

**Incr ICP**
**Causes:** haematoma, oedema
**Herniation:** transtentorial: median temporal lobe through tentorial notch; occurs late
**Symptoms:** altered LOC; incr BP; decr HR; papilloedema (after 6hrs); absent retinal venous pulsations; VI nerve palsy; pupillary dilatation (usually ipsilateral; occurs late; not affected by paralysis); anisocoria; posturing

Penetrating HI
**Tangential wound:** bullet low E but high velocity; travels around skull
**Perforating wound:** high velocity; entrance and exit
**Penetrating missile wound:** high velocity, close range; entrance only
**Prognosis:** incr mortality if cross midline, pass through V, rest in post fossa, high velocity, high fragmentation, large missile; high risk of infection if periorbital / perinasal
**Assessment**

**RF for severe HI**: duration of LOC (not predictive in penetrating trauma / localised blunt trauma); persistently altered LOC (≥1Y), deteriorating LOC (≥2Y); amnesia >24hrs; severe headache; persistent vomiting

**RF for deterioration of HI**: coagulopathy; intracranial device; >65yrs (1.5x risk)

**Decorticate** = injury above midbrain
arm/elbow flexion, wrist flexion, arm adduction, leg extension, int rotation, feet plantar flexion

**Decerebrate** = injury below midbrain
arm/elbow extension, wrist flexion, arm adduction and int rotation, leg extension, int rotation feet plantar flexion, neck extension; teeth clenched

**CT head**

**Indications**: altered mental state OE (can observe 1hr if ETOH on board); FND; skull #; major trauma and unstable vitals, CNS FB in situ (eg. VP shunt), coagulopathy, persistent vomiting, severe headache; symptoms ongoing after 4hrs observation

**Canadian CT head rules**
Applies to minor HI (GCS 13-15)

**High RF:**
- GCS <15 at 2hrs - >92% sens
- ?open/basal skull # - 100% sens for need for neurosurg intervention
- 2+ vomits - 65% spec for predicting neurosurgical intervention
- >65yrs

**Med RF:**
- Retrograde amnesia >30mins - 97% sens for clinically important brain inj
- Dangerous MOI - 50% spec for clinically significant brain inj

**NICE head rules**
Adults: GCS <15 at 2hrs/≤13 OE; Children: GCS <14 OE (≤15 if ≤1yr)

- ?open/depressed/basal skull #
- Any vomits adults/3+ vomits kids
- Retrograde amnesia >30mins adults/>5mins kids
- FND
- Post-traumatic seizure

Also in kids:
- Dangerous MOI/?NAI Bruise/swelling/lac >5cm on head <1yr
- Tense fontanelle
- Abnormal drowsiness

**CHALICE high risk criteria (paeds; 2006)**
High sens for significant head injury requiring neuro intervention;
All levels of HI and what patients need CT scan
98.6% sens for ICH

**NEURO:**
- Witnessed LOC >5mins/GCS <15 <1yr/GCS <14 >1yr/drowsiness
- 3+ vomiting
- Amnesia >5mins
- FND
- Traumatic seizure, tense fontanelle
INJURY:
Depressed/basal skull #
bruising/swelling/lac >5cm <1yr
MECHANISM:
?NAI
MVA >40kmph
Fall >3m
High velocity projectile/penetrating inj

CATCH high risk criteria (paeds)
High RF:
GCS <15 at 2hrs - 100% sens for predicting neurosurgical intervention
?open skull #
Worsening headache; irritability

Med RF:
?basal skull # - 98% sens for any brain injury
Dangerous MOI
Large, boggy scalp haematoma

PECARN low risk criteria (paeds; 2009)
Looking for those who don’t need to be scanned
<2yrs:
Normal mental status/LOC <5secs/normal behaviour
No palpable skull # Sens 100%; NPV 100%
Non-severe MOI
No scalp haematoma (except frontal)
>2yrs:
Normal mental status/no LOC
No signs of basal skull # Sens 97%; NPV 100%
No vomiting 60% spec for death/neurosurg/intubation
Non-severe MOI
No severe headache

Yield:
GCS 15 = 6% have abnormality; 2% have neurosurgically treatable lesion
GCS 14 + headache/N+V/ETOH/depressed # = 21% abnormality; 5% neurosurg treatable lesion
GCS 13 = 30% abnormality; 8-20% have neurosurgically treatable lesion

Other investigations
Skull XR: only if no CT available; 50% sens for #; shows fluid in sphenoid / maxillary sinuses, intracranial gas, displacement of pineal gland, FB
USS: shows ICH if bony defect / open fontanelle
MRI:
Hyperacute = dark T1, bright T2
Acute = within 24hrs = dark T1 and T2
Subacute = 2-10/7 = bright T1 and T2
Chronic = >10/7 = dark T1 and T2
More sens than CT: 3x for SDH and extradural; 5x for shearing; 1.5x for contusion; 1.5x for sinus involvement; for brainstem/post fossa; for ischaemic infarct
Less sens than CT: 3x for #
**ECG:** bizarre T waves in severe
**CXR:** NCPO; aspiration
**Blood:** DIC in 25% severe HI; SIADH; jugular venous sats = cerebral sats; incr LDH and CKB

**ICP monitoring**
Indications: severe HI requiring ventilation (GCS <8), encephalopathy, Reye’s syndrome, ICH, hydrocephalus
Can be ventricular (CSF may be removed, placement may be hard), subdural (may underestimate ICP), extradural
Complications = 1%/day infection rate (lower if extradural), intracranial haemorrhage, may underestimate; no improvement in outcome
A waves assoc with intracranial mass/neuro deterioration, B waves assoc with raised ICP

**Complications**
Post-traumatic epilepsy: RF = severe trauma, need for OT (30%); penetrating inj (50%); contusion; GCS <10; skull fracture; female
Meningitis, brain abscess, cranial osteomyelitis, DIC, NCPO, cardiac dysfunction

**Management**
Prevents secondary injury

A:
**ETT if:**
GCS <9 (within 15mins arrival if not improving)
seizure
combative
inadequate ventilation or gas exchange
loss of airway reflexes
need for transport and unstable
1. Blunt incr ICP: Lignocaine 1.5mg/kg (not proven benefit), fentanyl 0.5-1mcg/kg, vec 0.3mg/kg
2. Thio 2.5-5mg/kg (or 0.3mg/kg etomidate) - maintain sedation to prevent gagging
3. Sux 1-1.5mgkg - vec 4-8mg
Avoid unnecessary suctioning; head up 30deg; C spine

B:
**Oxygenation** (avoid hypoxaemia - aim paO2 100)
**Normocarbia** (pCO2 35-40)

C:
**CPP** (avoid hypo/hypertension; aim MAP 80-90, elevate head of bed 20-30deg, CVP 0-2)
If incr BP, give 20-100mg IV thio, morphine up to 30mg
If decr BP, given IVF if hypoV, metaraminol if not
Maintain euvolaemia
Fluid restriction/minimal vol resus not recommended - Crystalloid at 2/3 maintenance

Coagulation

D:
Seizure prophylaxis if: depressed skull #, paralysed and intubated, seizure, penetrating brain inj, GCS <8, acute SDH/extradural/ICH, PMH seizures
Phenytoin 15-18mg/kg IV over 30-60mins
Aim BSL <10
Incr ICP: >20mmHg, treat if >15mins; >40mmHg, treat urgently
Mannitol 0.5-1g/kg IV over 10mins if acute deterioration - temporising measure
Complications = fluid overload, hyperosmolality, hypoV, rebound cerebral oedema
Early CT and neurosurg review

**Surgery:** drain haematoma; craniectomy if severe oedema (doesn’t improve outcome); ICP monitor
**Emergency craniotomy indications:** decreasing LOC + inability to get neurosurg in 2hrs + abnormal pupil
Do temporal - frontal - parietal

**Observation:** Q30minly obs until GCS 15 - Q30minly for 2hrs - Q1hrly for 4hrs - Q2hrly
Deterioration = altered behaviour/sustained decr GCS 1pt/any decr GCS 2pt/worsening headache/persisting vomiting/worsening neuro Sx
Indications for prolonged observation: unreliable social situation; ETOH; NAI; on aspirin/coagulopathy; ICH; skull #; altered LOC OE

**Indications for ABx:** penetrating HI / open skull # / complicated scalp lacs

**Not useful:** steroids (CRASH study, incr death or severe disability with steroids); mannitol (0.5-1g/kg over 30mins; little evidence to support, DOA 4-6hrs; may incr size of haematoma); albumin (worsens prognosis); ICP monitoring

**Discharge criteria**
4hr observation (6hrs if being discharge alone); normal exam; no vomiting; no ETOH; social circumstances OK

**Discharge advice**
Avoid aspirin/NSAIDs; avoid contact sports 1/52; instructions for carers; advice Re: post-concussive symptoms (eg. Short-term memory, info processing); provide written material; report immediately: >2 vomits, persistent drowsiness, confusion/disorientation/slurred speech, incr headache not relieved by paracetamol, localised weakness/altered sensation/incoordination, blurred/double vision, seizures, neck stiffness

**Prognosis**

**Prognostic indicators:** M score, pupils, age (children better prognosis; elderly worst), premorbid condition, 2Y systemic insult during acute period, duration of coma, presence of brainstem reflexes, CT findings (bad = focal findings, haem in brainstem/corpus callosum/BG/infratentorial/bilateral ICH/intra and extraC bleed/delayed bleed); ICP (>25 bad); pre-hospital time; time to definitive surgery

GCS correlates poorly with morbidity outcome
GCS <8 = 30-40% mortality; 15-20% survival with severe disability
GCS 3 with OK pupils = 95% mortality if penetrating, 60% mortality if blunt
GCS 3 with fixed dilated pupils = mortality >99%

**Limitations of ED prognosis:** length of coma not known; reversible factors present (eg. Hypoxia, decr BP, electrolytes); sedation on board; early neuro abnormalities are not reliable prognostic factors