Head trauma

Common causes of head trauma
- Falls
- Assault
- Road traffic collisions (RTCs)

Pathophysiology of head trauma
- Coverings and spaces:
  - The coverings of the brain, or meninges, can be divided into three layers from superficial to deep:
    - Dura mater
    - Arachnoid mater
    - Pia mater
  - The dura is a tough fibrous layer that adheres to the internal surface of the skull; it forms the falx cerebri and tentorium cerebelli, and encloses large venous sinuses
  - Between the skull and the dura lies the extradural space; laceration of the middle meningeal artery can cause an extradural haematoma
  - The arachnoid is thin and transparent; it is not attached to the dura
  - Between the dura and the arachnoid lies the subdural space; laceration of bridging veins that travel from the brain surface to the venous sinuses can cause a subdural haematoma
  - The pia is firmly attached to the surface of the brain
  - Between the arachnoid and the pia lies the subarachnoid space, which is filled with cerebrospinal fluid (CSF) that drains from the ventricles; brain contusions can cause a subarachnoid haemorrhage
- Intracranial pressure (ICP):
  - The skull is a rigid box with incompressible contents
  - ICP depends on the volume of intracranial contents: blood, CSF and brain tissue
  - Normal ICP = 5-12 mmHg
  - Elevated ICP can reduce cerebral perfusion and cause or exacerbate ischaemia
- The Monro-Kellie doctrine:
  - Because the volume of the skull is fixed, any increase in volume of one of its components, such as an expanding extradural haematoma, has to be compensated for by a corresponding reduction in volume of another component
  - Initially CSF and blood are shunted out, providing a degree of buffering and preventing a rise in ICP (compensated state)
  - Once displacement of CSF and blood has been exhausted, a critical point is reached and a sharp rise in ICP occurs (decompensated state)
- Cerebral blood flow (CBF):
  - CBF is proportional to cerebral perfusion pressure (CPP)
  - CPP = mean arterial pressure (MAP) – ICP
  - As ICP rises, MAP rises to maintain CPP; excessively high MAP leads to a reflex bradycardia and this is the basis of Cushing’s reflex
  - CPP is autoregulated at MAP = 50-150 mmHg
  - If MAP <50 mmHg, CPP falls and ischaemia and infarction may occur
  - If MAP >150 mmHg, CPP rises and cerebral oedema may occur
  - CPP also varies with changes in $P_{O_2}$ and $P_{CO_2}$; hypoxia and hypercapnia lead to cerebral vasodilatation whereas hypocapnia causes cerebral vasoconstriction
- CPP should be maintained ≥70-80 mmHg and most clinicians aim for ≥90 mmHg; the critical level for ischaemia is thought to be 30-40 mmHg

- Uncal herniation and false localising signs:
  - An expanding intracranial haematoma may cause a region of the temporal lobe known as the uncus to herniate through the tentorial notch
  - This can cause compression of the ipsilateral oculomotor nerve which runs along the edge of the tentorium
  - Compression of its parasympathetic fibres which lie on the surface of the nerve, cause pupillary dilatation due to unopposed sympathetic activity; this may be accompanied by a down and out gaze
  - In addition, compression of the corticospinal tract which decussates caudally in the medulla causes contralateral hemiparesis
  - Therefore ipsilateral pupillary dilatation and contralateral hemiparesis are the classical signs of uncal herniation from an expanding intracranial haematoma

### Worrying clinical features in head trauma

- Headache
- Vomiting
- Confusion
- Seizures
- Reduced Glasgow coma scale (GCS)
- Amnesia
- Focal neurology
- Visual disturbance
- Dilated/’blown’ pupil and contralateral hemiparesis
- Scalp lacerations
- Open or depressed skull fractures
- Signs of basal skull fracture
  - Periorbital ecchymoses (panda eyes)
  - Postauricular ecchymoses (Battle’s sign)
  - CSF otorhinorrhea
  - Haemotympanum
- Cushing’s triad (very late sign)
  - Hypertension
  - Bradycardia
  - Irregular respirations
- N.B. there is inadequate space within the cranial cavity for haemorrhage to cause shock; if the patient has sustained head trauma and is shocked, look elsewhere for the source of haemorrhage and/or consider alternative causes of shock other than haemorrhage

### Assessment of consciousness in head trauma: Glasgow coma score (GCS)

- Adult GCS:
  - Eye opening
    - E4 = spontaneously
    - E3 = to voice
    - E2 = to pain
    - E1 = none
  - Verbal response
    - V5 = conversation
- V4 = confused
  - V3 = words
  - V2 = sounds
  - V1 = none
  - Motor response
    - M6 = obeys commands
    - M5 = localises
    - M4 = withdraws
    - M3 = flexes
    - M2 = extends
    - M1 = none

- Paediatric GCS
  - Eye opening
    - E4 = spontaneously
    - E3 = to voice
    - E2 = to pain
    - E1 = none
  - Verbal response
    - V5 = normal words/sounds
    - V4 = fewer words/sounds, spontaneous cry
    - V3 = cries to pain
    - V2 = moans to pain
    - V1 = none
  - Motor response
    - M6 = obeys commands
    - M5 = localises
    - M4 = withdraws
    - M3 = flexes
    - M2 = extends
    - M1 = none

- Imaging in head trauma
  - Adult NICE indications for CT scan:
    - GCS <13 initially
    - GCS <15 at 2 hours post-injury
    - Suspected open or depressed skull fracture
    - Signs of basal skull fracture
      - Periorbital ecchymoses (panda eyes)
      - Postauricular ecchymoses (Battle’s sign)
      - CSF otorhinorrhoea
      - Haemotympanum
    - Post-traumatic seizure
    - >1 episode of vomiting
    - Focal neurological deficit
    - Loss of consciousness/amnesia + one of the following
      - Age >65
      - Dangerous mechanism (pedestrian or cyclist struck by a motor vehicle; occupant ejected from motor vehicle; fall from >1 m or five stairs)
      - >30 min retrograde amnesia
  - Although not officially one of the NICE indications, many Emergency Departments consider anticoagulation an absolute indication for CT scan in the context of head trauma
• Paediatric NICE indications for CT head:
  o GCS <14 initially for children >1 year old
  o GCS <15 initially for children <1 year old
  o GCS <15 after 2 hours post-injury
  o Suspected open or depressed skull fracture, or tense fontanelle
  o Signs of basal skull fracture
    ▪ Periorbital ecchymoses (panda eyes)
    ▪ Postauricular ecchymoses (Battle’s sign)
    ▪ CSF otorhinorrhoea
    ▪ Haemotympanum
  o Post-traumatic seizure
  o ≥3 episodes of vomiting
  o Focal neurological deficit
  o Suspicion of non-accidental injury (NAI)
  o Children <1 year old + bruising/swelling/laceration >5 cm
  o >1 of
    ▪ Witnessed loss of consciousness > 5 min
    ▪ Abnormal drowsiness
    ▪ Dangerous mechanism (pedestrian or cyclist struck by a motor vehicle; occupant ejected from motor vehicle; fall from >1 m or five stairs)
    ▪ Amnesia >5 min

Initial management of head trauma: General points
• The severity of head injury can be graded as mild (GCS 13-15), moderate (GCS 9-12) or severe (GCS 3-8)
• Manage patients with moderate or severe head trauma, or a dangerous mechanism of injury, from an ABCDE perspective
• Request a CT head in any patient with one or more NICE indication
• Discuss any clinically significant CT head findings with neurosurgery
• Have a low threshold for requesting a CT head in elderly patients with dementia and/or delirium who have fallen and sustained a head injury: It is unlikely they will be able to provide a reliable history or comply with examination and if the fall was unwitnessed there will be no collateral history about the event either
• Consider whether imaging is required to exclude a cervical spine injury; NICE guidelines advise that if patients require a CT head and imaging is required to exclude a cervical spine injury, then CT neck is the recommended imaging modality
• Consider what led to the head injury; if it was a fall, what was the cause and are there any other injuries?

Initial management of head trauma: Prevention of secondary brain injury
• Primary brain injury occurs during the initial trauma; secondary brain injury occurs after the initial insult and is potentially preventable or treatable
• Intubate patients with a low GCS in order to maintain and protect their airway
• Avoid hypoxia and maintain $P_{O_2} > 13$ kPa
• Aim for $P_{CO_2}$ in normal range (4.5-5 kPa) – therapeutic hypocapnoea is no longer used
• Intubate and ventilate as required to achieve these aims
• Tape endotracheal tube in place as opposed to tying them so as not to obstruct venous drainage
• Avoid excessive intra-thoracic pressures
• Avoid hypotension and maintain MAP ≥90 mmHg using vasopressors as necessary
- Avoid hypoglycaemia and replace glucose as necessary
- Treat seizures; paralyse if necessary
- Nurse with 30° head-up tilt, neck inline to improve venous drainage and reduce ICP without compromising CPP
- Avoid cervical collars if possible
- Consider mannitol 20% 500 ml IV to reduce ICP
- Ensure adequate analgesia to avoid rises in ICP
- Aim for normothermia

**Initial management of head trauma: Wound management**
- The scalp is highly vascular and wounds may need compression to achieve haemostasis
- Explore and clean any wounds; remove any foreign bodies identified with the naked eye and request a soft tissue radiograph if glass was involved and/or further foreign bodies are suspected
- Most scalp lacerations can be closed with glue and/or steristrips but deeper wounds will require sutures
- Consider the need for tetanus and antibiotic prophylaxis

**Further management of head trauma**
- Admission criteria:
  - CT head with clinically significant abnormalities
  - GCS not returned to normal
  - Awaiting CT head
  - Continued clinical concern e.g. vomiting
  - Other ongoing concern e.g. intoxication
- Recommended frequency of neurological observations (neuro obs):
  - Half-hourly until GCS = 15
  - Then half-hourly for 2 hours
  - Then hourly for 4 hours
  - Then 2-hourly
- Discharge advice:
  - Written and verbal advice should be given to all patients discharged following a head injury
  - Advise patients to return if any of the following develop
    - Unconsciousness
    - Confusion
    - Inappropriate drowsiness
    - Problems understanding or speaking
    - Problems with balance
    - Weakness
    - Blurred vision
    - Painful headaches that won’t go away
    - Vomiting
    - Seizures
    - Clear straw-coloured fluid coming from their nose and/or ears
    - Bleeding from one/both ears
**Common questions concerning head trauma**

- List three causes of head trauma
  - Falls
  - Assault
  - RTCs

- List the three meninges from superficial to deep
  - Dura mater
  - Arachnoid mater
  - Pia mater

- List the three potential spaces from superficial to deep
  - Extradural space
  - Subdural space
  - Subarachnoid space

- Summarise the Monroe-Kellie doctrine
  - Because the volume of the skull is fixed, any increase in volume of one of its components, such as an expanding extradural haematoma, has to be compensated for by a corresponding reduction in volume of another component

- Give an equation for CPP
  - CPP = MAP – ICP

- Between what pressures is CPP is autoregulated?
  - CPP is autoregulated at MAP = 50-150 mmHg

- List the three features of Cushing’s triad and explain its mechanism
  - Hypertension
  - Bradycardia
  - Irregular respirations
  - As ICP rises, MAP rises to maintain CPP; excessive MAP may cause a reflex bradycardia

- A 79 year old lady presents with a reduced level of consciousness after sustaining a head injury during a fall; she does not open her eyes but moans and flexes her limbs when given a jaw thrust; give a breakdown of her GCS including the total score
  - GCS = E1 V2 M3 = 6

- On opening her eyes, you see that one of her pupils is fixed and dilated; what is the likely mechanism of this?
  - Third nerve palsy from uncal herniation secondary to an expanding intracranial haematoma

- Give six of the NICE indications for CT head; any six of
  - GCS <13 initially
  - GCS <15 at 2 hours post-injury
  - Suspected open or depressed skull fracture
  - Signs of basal skull fracture
    - Periorbital ecchymoses (panda eyes)
    - Postauricular ecchymoses (Battle’s sign)
    - CSF otorhinorrhoea
    - Haemotympanum
  - Post-traumatic seizure
  - >1 episode of vomiting
  - Focal neurological deficit
  - Loss of consciousness/amnesia + one of the following
    - Age >65
    - Dangerous mechanism (pedestrian or cyclist struck by a motor vehicle; occupant ejected from motor vehicle; fall from >1 m or five stairs)
    - >30 min retrograde amnesia

- Explain the difference between primary and secondary brain injury
- Primary brain injury occurs during the initial trauma; secondary brain injury occurs after the initial insult and is potentially preventable or treatable.