

## 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)
  - $CPP = \text{mean arterial pressure (MAP)} - \text{ICP}$
  - 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  $\text{MAP} = 50\text{-}150$  mmHg
  - If  $\text{MAP} < 50$  mmHg, CPP falls and ischaemia and infarction may occur
  - If  $\text{MAP} > 150$  mmHg, CPP rises and cerebral oedema may occur
  - CPP also varies with changes in  $P_aO_2$  and  $P_aCO_2$ ; hypoxia and hypercapnia lead to cerebral vasodilatation whereas hypocapnia causes cerebral vasoconstriction

- CPP should be maintain  $\geq 70$ -80 mmHg and most clinicians aim for  $\geq 90$  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 otorrhoea
  - 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 otorrhoea
    - 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:
  - GCS <14 initially for children >1 year old
  - GCS <15 initially for children <1 year old
  - GCS <15 after 2 hours post-injury
  - Suspected open or depressed skull fracture, or tense fontanelle
  - Signs of basal skull fracture
    - Periorbital ecchymoses (panda eyes)
    - Postauricular ecchymoses (Battle's sign)
    - CSF otorrhoea
    - Haemotympanum
  - Post-traumatic seizure
  - ≥3 episodes of vomiting
  - Focal neurological deficit
  - Suspicion of non-accidental injury (NAI)
  - Children <1 year old + bruising/swelling/laceration >5 cm
  - >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  $P_aO_2 >13$  kPa
- Aim for  $P_aCO_2$  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 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 otorrhoea
    - 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