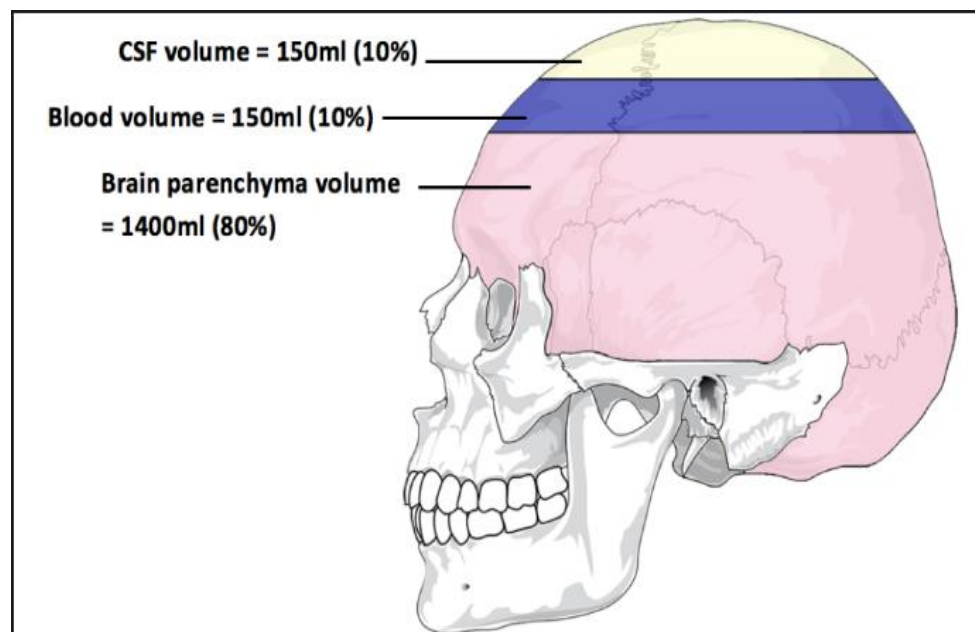




## Background of ICP

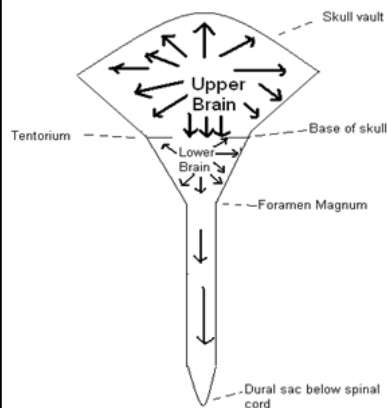
The basis for treatment of an intracranial pressure rise is the Monro-Kellie doctrine: The skull is a closed box containing blood (~150ml, 10%), cerebrospinal fluid (CSF) (~150ml, 10%) and brain tissue (~1400ml, 80%). These 3 components usually exist in equilibrium to each other, if the volume of one increases; the volume of one of the others must decrease (autoregulation). To achieve equilibrium, the main compensatory mechanisms are increased drainage of blood or CSF from the cranial cavity. Autoregulation will compensate for a long time for slow growing tumours for example, but will quickly fail due to a sudden brain injury or subarachnoid haemorrhage (SAH). When autoregulation is exhausted, there is no further drainage of blood/CSF and consequently a rise in ICP. This rise can present itself through the Cushing's triad: **a RISE in BP with a simultaneous DROP in HR and respirations**. If this is not treated, the brain tissue itself can become displaced (herniation). The most dangerous are uncal and tonsillar herniation: In these cases, the rise in pressure is so great that the brainstem itself can be forced into/through the foramen magnum at the base of the skull. This results in the brain taking the shape of an upside down cone (the patient is 'coning') and a cut off of blood flow and oxygenation, thus being fatal to the patient.

### Monro-Kellie doctrine:





## Coning



- Huge pressure in the upper brain
- Less pressure in the lower brain
- Almost no pressure at the base of the spinal cord
- Creates a “pressure cone” in which the upper brain forces itself through the tentorium, crushing the brain stem

## Cushing's Triad

INCREASED  
INTRACRANIAL PRESSURE (ICP)

**"CUSHING'S TRIAD"**

*(Symptoms of ICP are OPPOSITE of Shock)*

**ICP**

- ↑ Systolic B/P
- ↓ Pulse
- ↓ Respirations



**Shock**

- ↓ B/P
- ↑ Pulse
- ↑ Respirations





## General Treatment of Traumatic Brain Injury Patients (TBI)

### Bedside preparation:

- 2 drip stands: 1 for transducer plate, 1 for ICP monitor
- 3 transducer cables (arterial line, CVP, ICP monitor), temperature probe attachment for monitor
- Transferable ventilator with 2 full oxygen cylinders and 120 minutes of battery time (i.e. SERVO U); **DO NOT** change ventilators to transfer patients to CT, this creates unnecessary ICP instability
- LiDCO monitor
- Propofol, Fentanyl/Alfentanil, Metaraminol, Glycopyrrolate (in vial) and 2x Noradrenaline ready

### On patient arrival:

- Check pupils (patient is most likely paralysed, these will be the only indication of a problem)
- Change ventilator over and use a volume controlled mode of ventilation (VC or PRVC)
- Transfer patient to bed (if spine not cleared, log roll patient)
- Transfer/attach sedative infusions
- Attach monitoring and take 12 lead ECG
- Check ABG, aim adequate oxygenation and  $\text{paCO}_2$  ( **$\text{paO}_2 > 10\text{kPa}$  and  $\text{paCO}_2 4.5\text{-}5.0\text{kPa}$** ) + take full set of ICU bloods including  $\text{MgSO}_4$  and G+S
- Level arterial transducer to tragus of ear (to measure BP at level of 3<sup>rd</sup> ventricle), maintain MAP  $>90\text{mmHg}$ , starting Metaraminol (peripheral) or Noradrenaline (central) if necessary and line cleared
- Zero ICP on Camino monitor and sync to bedside monitor (ask/ring NICU for tips on how to find ICP/ CPP on monitors)
- Initial ICP target between **0-25mmHg**, **CPP  $> 60\text{mmHg}$**
- Nurse head up 30-45 degrees (ensure spinal clearance completed and documented)





### During the first 24 hours:

- Neurological:
  - As these patients are usually deeply sedated, **RASS** and **GCS** should only be checked + recorded 4 hourly and need to be **-5 and 3/15** respectively
  - Check + record pupils **HOURLY**
  - If required, get spinal clearance OR maintain neutral alignment of spine and attach Miami J collar
- Respiratory:
  - Maintain tight paCO<sub>2</sub> control, checking ABG 2-4 hourly (**4.5-5.0kPa**)
  - Use closed suction system to reduce break of ventilation, remove secretions as required and ensure HME is clear
- Cardiovascular:
  - Maintain CPP >60mmHg and ensure monitoring targets are agreed by neuro consultant/registrar
  - Calibrate LiDCO and give targeted fluid boluses to aid with CPP control
  - Maintain serum Na<sup>+</sup> >140mmol/l, MgSO<sub>4</sub><sup>-</sup> >1mmol/dl, PO<sub>4</sub><sup>-</sup> >1mmol/l and K<sup>+</sup> >4.0mmol/l
- GI:
  - Insert NGT/OGT and oesophageal temperature probe (ensure **NO skull fractures** prior to insertion of NG probes!!) + start as per ICU feeding protocol
  - Start PPI as per unit guidelines
  - If patient has reduced GI motility (aspirates > 300mls) start Metoclopramide 10mg IV TDS and/or Erythromycin 250 mg NG QDS
  - Maintain BSL < 10mmol/l and **AVOID** hypoglycaemia
  - **DO NOT GIVE DEXTROSE AT ANY POINT** – encourages brain swelling
- Elimination:
  - Maintain euvolaemia, hourly fluid balance
  - Report UOP >300ml/hr to neuro registrar/consultant
  - Bowel care: Senna and Sodium Docusate +/- Laxido as required; if spinal injury, follow spinal bowel care guideline
- Miscellaneous and Integumentary system:
  - Check temperature 2-4 hourly and aim for normothermia < 37.5 degrees
  - Mechanical VTE prophylaxis initially, review daily if pharmacological thromboprophylaxis feasible
  - Regular eye and mouth care
  - Turn as per PUP guidance – if patient does not tolerate side-lying, turn/logroll every 4 – 6 hours, then bring back and maintain in supine position





## Treatment of Raised ICPs

### First tier treatment for high ICP

- Ensure **CPP > 60mmHg** - give boluses of sedation & increase Noradrenaline rate to achieve this
- Ensure adequate oxygenation and check  $\text{paCO}_2$  (aim  **$\text{paO}_2 > 10\text{kPa}$  and  $\text{paCO}_2 4.5\text{-}5.0\text{kPa}$** ) – patients should be on PRVC mode ventilation to allow tight  $\text{CO}_2$  control (titrate ventilation slowly!)
- Check for secretions on chest – give 5% sodium chloride nebs if thick secretions
- Due to sedation, patients will not cough – if secretions can be auscultated, but not cleared, **DO NOT** deliver manual assisted cough (this increases ICP)
- Check positioning – **sit patient up to 45 degrees**, head straight with knees **unbent** (use towels to keep head and neck straight to allow good venous drainage)
- If ICP rises when bent at the hips, put patient flat and reverse trendelenburg up to 45 degrees head up (use pillows to prevent patient from slipping to bed end)
- Check temperature – if  $> 37.5$  degrees consider Arctic Sun to target normothermia
- Seizures - use BIS monitoring if available. If ICP  $> 25\text{mmHg}$  and BIS  $> 50$  then consider loading with Levetiracetam (Keppra) (60mg/kg in 250ml NaCl over 10mins) then BD maintenance doses (500-1500mg in 100ml NaCl) +/- starting Midazolam infusion
- If EVD in situ – ensure adequately draining, check for blockage/tap turned off or if positioned too high (**level at tragus of ear when lying supine or bridge of nose if on side**)





### Second tier treatment for high ICP

- If requiring multiple boluses of sedation, consider increasing Propofol (max: 5mg/kg/hr) + Fentanyl/Alfentanil rates and consider Midazolam infusion
- Lower  $\text{paCO}_2$  to **4.0-4.5kPa**, after discussion with Neuro consultant
- Can give bolus of 5% sodium chloride IV, but **MUST** be discussed with Neuro consultant/senior registrar first (1-2ml/kg bolus) 4-6hrly. Max 8ml/kg in 24hrs. Only give if  $\text{Na}^+ < 160\text{mmol/l}$ . Consider checking serum  $\text{Na}^+$  and osmolality levels BD
- If consistently high ICPs, check pupils on pupillometer ( **$\text{NPI} > 3 = \text{brisk}$ ,  $0.1-3 = \text{sluggish}$ ,  $0 = \text{unreactive}$** ) and report if new sluggish/unreactive pupils seen
- Inform Neurosurgical SpR – may require urgent (within 30 mins) CT head and possible surgery (either EVD insertion or decompressive craniectomy = removal of a piece of skull to allow for pressure reduction)

### Third tier treatment for high ICP

- Therapeutic hypothermia down to 35 degrees
- Barbiturate (Thiopentone) coma:
  - made by a senior experienced doctor (consultant only)
  - only considered for salvageable patients (i.e. those with a potentially good outcome)
  - only considered on haemodynamically stable patients
  - only considered after maximal medical therapies have been exhausted and surgical therapies are not an option

**Second and third tier treatments are potentially hazardous and should only be authorised by someone experienced in managing head injuries – consultant level**

