Management of traumatic brain injury (TBI) in adults

General Recommendations

- **Sedation –** aim RASS -5. Risk of Propofol infusion syndrome (PRIS) with high rates of infusion.
- **Aim for normothermia (core temperature <38°C).** Treat pyrexia with regular paracetamol. Control of fever remains controversial. Active temperature control may be appropriate.
- **Review indications for cervical collar** placement and remove early if appropriate.
- **Consider repeat CT brain** to rule out progression of, or development of an intracranial lesion.
- **Surgical management of TBI** should be consistent with Brain Trauma Foundation Guidelines.

Goals of therapy
- GCS≤8 intubate

Initial Management

A. Airway Management

- Patients with a GCS ≤ 8 should be intubated for airway protection.
- Tape the tracheal tube or use an Anchor fast type device. Consider using a SACETT Tube.

B. Oxygenation/Ventilation

Goals of therapy
- SpO_2 ≥ 95%
  PaO_2 ≈ 13kPa
- $PaCO_2$ 4.5-5 kPa

- Avoid hypoxia: SpO_2 ≥ 95%, PaO_2 approximately 13kPa.
- Continuous monitoring of $EtCO_2$.
- Avoid hyperventilation: target $PaCO_2$ 4.5-5 kPa.

  Although prophylactic hyperventilation ($PaCO_2$ <4kPa) is contraindicated, therapeutic hyperventilation may be necessary for brief periods when there is acute neurological deterioration that coincides with a cerebral herniation syndrome or for refractory elevations in ICP (See management of ICP).

C. Circulation

Goals of therapy
- MAP> 90mmHg
- H^+ 35-40nmol/l
- $[Na^+]$ 135-145mmol/L
- core temp 36.0-38.3°C

- Hb ≥ 90 g/l
- platelets ≥ $75x10^9$
- glucose 4.5-10 mmol/l

- INR ≤ 1.5

- Blood Pressure avoid hypotension. Target MAP> 90mmHg. Invasive monitoring is mandatory.
- Volume Resuscitation - Initial resuscitation fluid should be Plasmalyte 148. FICE Echo may add to the clinical assessment if available.
- Anaemia - the target haemoglobin concentration is 90 g/l or above.
- Vasoactive drugs noradrenaline should be used to achieve target MAP.
- Coagulation –target INR & APTT ratio ≤1.5 and maintain platelets >=75 x $10^9/mm^3$.

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Invasive Monitoring

Significant brain injuries will require invasive monitoring. The default is to use an intraparenchymal Licox® brain tissue oxygen ($P_{bt}O_2$) and intracranial pressure monitoring (ICP) set. The aim of management is to maintain $P_{bt}O_2$ =>20mmHg. A guideline protocol for this is available on the Licox® monitor and on the Intranet.

Goals of therapy
$P_{bt}O_2$ ≥ 20mmHg
ICP < 20 mmHg
CPP ≥ 70mmHg

$P_{bt}O_2$ monitoring supplements and does not replace ICP monitoring. The achievement of the target $P_{bt}O_2$ requires optimization of ICP, CPP, Hb, P_aCO_2 and cardiac output

When PbtO2 monitoring is not available, the use of intraparenchymal ICP only will suffice. Consideration should be given to revising to the Licox system, when available.

- Increased ICP is defined as ≥ 20mmHg
- Cerebral perfusion pressure (CPP = MAP-ICP) should be maintained at ≥70mmHg.

Non-emergency surgery that requires general anaesthesia, such as orthopaedic procedures and plastic surgery, should be avoided in both moderate and severe TBI patients until it is clear that the brain injury has stabilised or resolved. In the case of emergency surgery priority should be given to maintaining target physiological parameters such as MAP> 90 mmHg (or control of CPP/ICP if available), and oxygenation.

Adjunctive medications and prevention of complications

1. **Seizure prophylaxis –**Evidence does not support routine seizure prophylaxis**.**
2. **Glucocorticoids -** glucocorticoids for brain injury are not effective at improving outcome or reducing intracranial hypertension.
3. **Stress ulcer prophylaxis –** as per unit policy
4. **Venous thromboembolism (VTE) prophylaxis –**all patients with a TBI requiring mechanical ventilation and sedation should receive VTE prophylaxis by intermittent pneumatic compression devices (flowtrons®) until chemoprophylaxis has been agreed with the Neurosurgical team.
5. **Propofol-** daily ECG, serum lipids and CK.

Metabolic monitoring

1. **Sodium and osmolality -** maintain within normal range [Na^+] 135-145mmol/L
2. Patients with diabetes insipidus or SIADH should have 12 hourly monitoring of plasma osmolality and sodium and see stage 2 management of raised ICP
3. **Glucose monitoring -** hyperglycaemia and hypoglycaemia are both detrimental to the outcome of patients with TBI. **Target glucose range 6.0-10mmol/l.**

Nutritional support

1. Nutritional support should be established via enteral route as soon as possible (oro-gastric tube if base of skull fracture confirmed or suspected)**.**
2. TPN should be used with caution in patients with TBI due to the high glucose concentrations and lipid load (Risk PRIS).
3. Patients not on neuromuscular blockers should receive 140% and those on NMBs 100% of basal energy expenditure. 15% of calories should be provided as protein.

Treatment of raised intracranial pressure in adults

Treatment of intracranial hypertension should be initiated when the ICP ≥ 20 mmHg.

- NB Brain Trauma Foundation guidelines recommend a CPP of > 60mmHg. This is calculated when both the MAP and ICP are zeroed at the external auditory meatus. However, in our practice the arterial line is zeroed at the left atrium and so when 30° head up tilt is used, the target CPP should be >70mmHg. The use of $P_{bt}O_2$ monitoring often guides optimal CPP.

- If ICP resistant to therapy, consider repeat brain CT scan.

- Ventricular catheters - prophylactic antibiotic use and routine surveillance cultures are not recommended.

STAGE 1

- **Head of patient's bed** to be placed at ≥ 30 degrees with head in neutral position.

- **Sedation and analgesia**. Titrate sedation and analgesia to RASS -5. Use Propofol 4mg/kg/hr and alfentanil. Add Midazolam if Propofol does limit is reached.

- **Hypertonic therapy –** first line **sodium chloride 5%** 125ml iv over 15 mins.
  second line **mannitol 20%** 200ml with Plasmalyte-148 250ml iv over 15 mins.

- **If ventriculostomy in place – set at**10 cmH_2O if ICP ≥ 20 mmHg sustained for ≥ 5min. The preferred method for ICP monitoring and drainage is to monitor the ICP continuously with a parenchymal monitor and to drain only for elevations above the threshold (20 mmHg).

(if ICP remains ≥ 20 mmHg proceed to Stage 2)

STAGE 2

- **Neuromuscular blockade (NMB)**: pharmacologic NMB with a continuous infusion should be employed if the above measures fail to adequately lower the ICP. Adequate sedation must be utilized if NMB is employed & EEG monitoring applied to look for seizure activity.

- **Hypertonic therapy -** euvolemia should be maintained. The serum sodium and osmolality must be measured every 12 hr. Alternatives to osmotherapy should be used if the plasma osmolality exceeds 320mOsm/L or the serum sodium exceeds 160 mmol/l.

- **Review Imaging**- If no change on repeat CT, treatment threshold may be increased above ICP 20mmHg, if $P_{bt}O_2$ >20mmHg.

- **Consider Seizures:** - request EEG and consider loading Phenytoin 20mg/kg IV and then 100mg IV tid.

- **Revise $PaCO_2$ goal** 4-4.5 kPa, if brain $PbtO_2$>20mmHg

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(if ICP remains ≥ 20 mmHg proceed to stage 3)

Treatment of raised intracranial pressure in adults Continued

STAGE 3 (rescue therapies – all reduce ICP but positive effect on outcome remain unproven).

All stage three measures should be discussed with ICU Consultant before application.

- **Active control of core temperature to normothermia:** The control of fever is widely advocated but of unproven value.
- **Decompressive hemi-craniectomy or bifrontal craniectomy:** Whilst these therapies may prevent death, an increase in good outcome has not been shown. Survival may be at the cost of significant long-term disability.
- **Thiopental coma** is an option for those patients who have failed to respond to stage 1 & 2 measures to control raised ICP (link to thiopental monograph).
  - Bolus Propofol 1mg/kg IV as a test. Maintain CPP.
  - If ICP and CPP improve, start Thiopental.
  - Hypotension is a frequent side effect.

    Life-threatening hyperkalemia may occur for up to 24hours after stopping thiopental infusion.

    Target $[K^+]$3mmol/l during infusion.

    Measure K^+ 2-3 hourly for 24 hours after stopping (ABG samples are adequate).
- **Hypothermia** (32 - 36 °C). Prophylactic and early use of cooling is either ineffective or harmful and should not be used. Its place in refractory ICP management is uncertain.
  - If used, avoid shivering, hypotension and metabolic side effects (limit propofol dose to 3mg/kg/hr, may need to add midazolam.)