Management of traumatic brain injury (TBI) in adults

General Recommendations

- **Sedation –** titrate sedation to aid synchrony with mechanical ventilation.
- **Consider if the patient is having seizures** and treat them (link to seizure management)
- **Normothermia (core temperature <38°C)** treat pyrexia with regular paracetamol and cooling if necessary.
- **Review indications for cervical collar** placement and remove if appropriate.
- **Consider repeat CT brain** to rule out development of an unexpected intracranial lesion.
- **Surgical management of TBI** should be consistent with Brain Trauma Foundation Guidelines - www.braintrauma.org/coma-guidelines/

Goals of therapy
- GCS≤8 intubated

A. Airway Management- patients with a GCS ≤ 8 should be intubated for airway protection tape tracheal tube

B. Oxygenation/Ventilation

- Avoid hypoxia SpO_2 ≥ 95%, PaO_2 ≥ 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)
- Brain tissue oxygen monitoring eg. LICOX® should be employed when prolonged hyperventilation is utilised

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

C. Blood Pressure, Volume Resuscitation, Anaemia, and Coagulopathy

1. **Blood Pressure** avoid hypotension, target MAP> 90mmHg
2. **Volume Resuscitation -** invasive monitoring is recommended. Initial resuscitation fluid should be Plasmalyte 148; target volume resuscitation to achieve euvolaemia and should not be withheld to prevent cerebral oedema. Fluid overload should be **avoided** as it is associated with increased incidence of ARDS
3. **Anaemia -** the **target** haemoglobin concentration is **90 g/l or above**
4. **Vasoactive drugs** noradrenaline should be used to achieve target MAP
5. **Coagulation** –target INR & APTT ratio ≤1.5 and maintain platelets > 75 x 10^9/mm^3

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

D. Intracranial pressure monitoring (page 2)

Title: Management of traumatic brain injury in adults	
ID: Management of traumatic brain injury in adults 220414	**Lead Author:**P Andrews **Co Authors:**B Hogg, L Weir, B Harris, J Rhodes, G Nimmo
Category: 1	**Document Version;** 1
Status Draft/Final: Draft	**Review Date:** April 2016
Authoriser; e.g. QIT	**Date Authorisation:** April 2014

D. Intracranial pressure monitoring
Use intraparenchymal ICP monitor with $PbtO_2$ monitoring.

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

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

Indication	signs and symptoms of increased intracranial pressure (ICP)
	and/or GCS ≤ 8 following initial resuscitation if the admission CT scan of the brain is abnormal
contraindication	Coagulopathy (this should be corrected prior to inserting ICP monitor)
Consideration (two or more of)	age >40 years
	unilateral or bilateral motor posturing
	SBP < 100 mmHg
or	all patients undergoing urgent surgical procedures (orthopaedic repair, etc) in whom a moderate to severe brain injury is suspected (GCS 3-12) to guide appropriate intra-operative CPP management.

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 systolic blood pressure > 100 mmHg (or higher if ICP is elevated), and oxygenation.

Adjunctive medications and prevention of complications
1. **Seizure prophylaxis – refer to phenytoin** monograph **Stop after 7 days if no seizure activity.**
2. **Glucocorticoids -** glucocorticoids are not effective at improving outcome or reducing intracranial hypertension, and *should **not** be* administered.
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 graduated compression stockings from admission and intermittent pneumatic compression devices (flowtrons®) until chemoprophylaxis started as per unit VTE policy.

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 4.5-10mmol/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.
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.

- If ICP resistant to therapy consider repeat brain CT scan.
- 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^{o} head up tilt is used, the target CPP should be 70mmHg.
- 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 optimise synchrony with mechanical ventilation in order to achieve target blood gases.
- **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 -** drain to 10 cmH_2O for ICP ≥ 20 mmHg sustained for ≥ 5min. The preferred method for ICP monitoring and drainage is to monitor the ICP continuously and to drain only for elevations above the threshold (20 mmHg).

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

STAGE 2

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

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 utilised if NMB is employed & EEG monitoring applied to look for seizure activity.

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

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

- **Decompressive hemi-craniectomy or bifrontal craniectomy** should only be performed if stages 1 and 2 are not effective.
- **Thiopental coma** induced 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). Hypotension is a frequent side effect.
- NB life-threatening hyperkalaemia 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) avoid shivering, hypotension and metabolic side effects (limit propofol dose to 3mg/kg/hr)