MANAGEMENT OF SEVERE TRAUMATIC BRAIN INJURY (GCS≤8)

Assessment of GCS

Most, if not all, of the predictive power of the GCS comes from the motor score and in particular the motor response with the arms. Make sure that:

i) Pain is applied appropriately, i.e. in the cranial nerve distribution.
ii) The total GCS and the individual components (e.g. GCS 7=M5E1V1) are recorded.
iii) In shocked patients the GCS is reassessed once shock has been corrected.

Initial management

Many of these will be happening concurrently:

1. Trauma evaluation
2. Oxygenation
3. Endotracheal intubation
4. Ventilation to a PaCO$_2$ around 4.7-5.3 kPa
5. Fluid resuscitation. Hypotension is rarely due to head injury. Always look for concealed blood loss
6. Sedation: Morphine, diazepam
7. Muscle relaxants. To facilitate instrumentation and CT scanning initially.
8. Signs of herniation or progressive neurological deterioration? (worsening motor score, dilated pupil[s], developing focal signs, extensor posturing, Cushing’s reflex [hypertension, bradycardia]). If present, treated with hyperventilation and mannitol (1g/kg=5ml/kg 20% mannitol).
9. CT scan. If surgical lesion is present taken directly to OR for evacuation and placement of ICP monitor. If no surgical lesion, ICP monitor can be placed either in OR or in PICU.
10. If trauma evaluation and clinical course suggest the need for other emergency diagnostic or therapeutic procedures (e.g. surgery for ruptured liver or spleen), then this may be indicated at any stage in the pathway. If this is required, placement of an ICP monitor while in OR is desirable.
11. Cervical spine. Collar placed in all patients and lateral cervical spine Xray as part of initial trauma films. CT cervical spine in all patients with severe TBI. If CT and lateral cervical spine X-ray are normal, the collar can be removed in PICU and replaced with sandbags.

Standard Treatment

1. Monitoring. Placement of arterial, central venous and intracranial catheters. Arterial and intracranial transducers will be zeroed at the level of the external auditory meatus, central venous catheters at mid-axillary line. Monitor EtCO$_2$.
3. **Cervical Spine.** If there is no evidence of C-spine injury on CT scan the hard collar can be removed. The neck should still be protected with sandbags on each side and the child log rolled for cares.

4. **Analgesia/sedation.** As per Sedation and Analgesia Protocol, Phenobarbitone (10mg/kg boluses, maximum 30-40mg/kg) may also be a useful adjunct for sedation and ICP control.

5. **Ventilation.** Maintain adequate oxygenation (saturations > 94%) and low-normal CO\textsubscript{2}. Use volume control ventilation. Note correlation of PaCO\textsubscript{2} to monitored EtCO\textsubscript{2}.
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\begin{align*}
\text{PaCO}_2 & = 4.7 - 5.3 \text{ kPa} \\
\text{PaO}_2 & > 10.7 \text{ kPa}
\end{align*}
\]

6. **Circulation.** *Hypotension should be considered an emergency as it compromises cerebral blood flow and doubles mortality and morbidity.* Hypotension is rarely due to head injury and so should always prompt review and search for concealed bleeding and other causes. Assess by usual CVS principles: heart rate, BP, CVP, perfusion and urine output. Manipulate MAP to achieve target cerebral perfusion pressure for age. Generally this will mean a MAP:
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\begin{align*}
< 2 \text{ years} & > 55 \text{ mm Hg} \\
2 - 6 \text{ years} & > 60 \text{ mm Hg} \\
> 6 \text{ years} & > 70 \text{ mm Hg}
\end{align*}
\]
These goals are for avoiding hypotension prior to insertion of an ICP monitor or if there is no ICP monitor. Once the ICP monitor has been inserted, MAP will follow from the ICP/CPP goals.

7. If no blood products are required give crystalloid IV fluids (0.9% saline, plasmalyte) to maintain CVP 5-12mmHg. Do not use albumin without PICU Consultant authorisation. Manage hypotension initially with intravenous fluids and then noradrenaline. Hypotension requiring more than moderate dose noradrenaline (0.05 -0.3 mcg/kg/min) should be guided by echocardiography ± cardiac output measurement.

8. **Fluid/glucose management.** Give 75% of normal maintenance as isotonic saline with sufficient potassium to maintain normokalaemia. Dextrose should not be added in the first 48 hours unless the blood glucose is
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\begin{align*}
< 2 \text{ years} & < 4.4 \text{ mmol/L} \\
> 2 \text{ years} & < 3.9 \text{ mmol/L}
\end{align*}
\]
After 48 hours dextrose may be added as per IV fluid protocol, but may not be necessary if feeding has started. If the blood glucose is >11mmol/L on two occasions, insulin should be used to control the blood glucose. Do not use frusemide during the first 5 days unless clinically significant fluid overload (i.e. pulmonary oedema) occurs.

9. **Sodium & Osmolality.** Maintain serum sodium > 140mmol and serum osmolality > 280mOsm/kg. If sodium drops below 140mmol/l restrict fluids to 30-50% maintenance and give hypertonic saline (3mls/kg of 3% saline over 1 hour via central venous access).
10. **Routine bloods.** While ICP is being monitored:
   - 6 hourly: ABG
   - 12 hourly: magnesium, phosphate, osmolality
   - Daily: FBC, coagulation (coags only if abnormal the previous day)

11. **Paralysis.** Muscle relaxants are used for initial instrumentation and imaging. Thereafter patients are only paralysed when they are being actively cooled, are hypothermic or if there are difficulties controlling ICP.

12. **Anticonvulsants.** Phenytoin: 20mg/kg loading dose followed by maintenance IV dose is given to all children for 7 days to prevent early post traumatic seizures. Maintain levels in the normal therapeutic range (40-80 μmol/l)

13. **Nutrition.** Commence enteral feeding within 24 hours unless contraindicated and aim for full enteral feeding by 7 days. If gastric feeding is not tolerated, jejunal feeding should be used. If enteral feeding is contraindicated or not established within 72 hours parenteral nutrition will be prescribed. Commence PICU bowel protocol as soon as feeding established.

14. **Imaging.**
   - CT: repeat as clinically indicated. MRI as indicated to assess brain injury. Consider MRI of neck to exclude ligamentous injury in the comatose child.

15. **Intracranial pressure monitoring.** Indicated for all patients with a GCS ≤ 8 and an abnormal CT scan. If the CT scan is completely normal, ICP monitoring is still indicated if the motor score is 3 or less. If the motor score is 4 or 5, a short period of observation may be appropriate, in which case a repeat CT scan at 24 hours is mandatory. If there is no improvement or the CT scan becomes abnormal, ICP monitoring should be undertaken. Decisions about ICP monitoring are made in consultation with the neurosurgeon. An external ventricular catheter is strongly preferred because (i) ventricular pressure monitoring is reported as the reference standard for ICP monitoring and (ii) use of a ventricular catheter allows drainage of CSF as a first tier treatment for raised ICP.

   The EVD is positioned 20 cmH₂O (15 mmHg) above the tragus unless otherwise requested by the neurosurgeon. The 3 way tap is open to monitoring and closed to drainage. Prophylactic antibiotics are not required. CSF is sent every 3 days for microsocopy and culture. This should be done with full sterile precautions and the CSF must always be allowed to drip passively from the three-way tap and must never be aspirated (refer to RBP). If placement of a ventricular catheter is contraindicated or not possible a Codman intra-parenchymal monitor will be placed.

16. **ICP/CPP goals.**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>ICP (mmHg)</th>
<th>CPP (mmHg)</th>
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<tbody>
<tr>
<td>&lt; 6</td>
<td>&lt; 18</td>
<td>&gt;45 - 55</td>
</tr>
<tr>
<td>≥ 6</td>
<td>&lt; 20</td>
<td>&gt;50 - 60</td>
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A CPP of >40 mmHg may be acceptable for children ≤ 2 years old. An ICP ≤ 25 mm Hg with a preserved CPP despite first tier treatments may be tolerated for longer periods (eg 5-15 minutes) especially after the first 2-3 days.

17. **Standard temperature management.** All children will have their temperature maintained at 36 - 37ºC until the ICP is stable (commonly 3-5 days). Early “prophylactic” hypothermia is not indicated for TBI. Core temperature should be monitored continuously with a probe positioned in the distal ⅓ of the oesophagus (the position should be confirmed on CXR) or bladder temperature. Maintenance of normothermia requires active management using the cooling blanket. Give paracetamol regularly.

**Hypothermia for raised ICP.** Cool to the temperature that controls ICP not to some fixed temperature. Generally this will not need to be below 35ºC and is to never be lower than 32.0ºC.

**Rewarming.** Children who require hypothermia for raised ICP or who present hypothermic will be allowed to rewarm no faster than 1ºC every 12 hours.

18. **Jugular venous bulb catheter.** Consider in any child who requires hyperventilation. Infuse heparinised saline at 2mls per hour. Never give drugs through this line.

19. **Somatosensory evoked potentials (SEPs).** Perform on all within the first 24 hours after admission and repeat after 24-48 hours. These are only definitively prognostic if they are bilaterally absent. Several studies have shown this to predict very poor outcome (death, severely disabled or vegetative). Provided absent SEPs fit with the clinical picture, withdrawal of treatment is indicated. Abnormal but present SEPs have very limited prognostic significance.