EVALUATION AND MANAGEMENT OF A CHILD WITH MAJOR HEAD TRAUMA

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- The acute care clinical management of children with TBI incorporates principles from emergency medicine, surgery, anesthesiology, and intensive care.

Initial assessment

- The initial approach to the traumatized child involves going through primary and secondary surveys and definitive care of all injuries.
- GCS score (modified for children) remains the most commonly used neurological assessment.
- The principles of intensive care management for children with severe TBI should reflect the principles outlined in the 2003 national consensus document.
  - Carney NA, Chesnut R, Kochanek PM, et al. Guidelines for the acute medical management of severe traumatic brain injury in infants, children, and adolescents. Pediatr Crit Care Med 2003; 4 (3 Suppl):S72–S75.

Recommendations for The Management Of Severe Pediatric TBI

Physiologic parameter	Recommendations
Blood glucose	Avoid dextrose containing solutions Keep blood glucose $<200-250$ mg/dl
Temperature	Avoid hyperthermia, cool patients to $36-37^{\circ}C$ Hypothermia ($32-34^{\circ}C$) may be considered for refractory ICP
CBF and $PaCO_2$	Avoid mild/prophylactic hyperventilation ($PaCO_2$ <35 mmHg) Mild hyperventilation if acute brain stem herniation exist Mild hyperventilation may be considered for refractory ICP
SBP	Hypovolemia should be corrected as soon as possible SBP should be maintained at least 5th percentile for age May be beneficial to maintain SBP in normal range ($\geq$50th percentile)
CPP	Keep CPP >40 mmHg CPP 40–65 mmHg may represent an age-related continuum for best treatment
ICP	Monitor if Glasgow Coma Scale score <9 Treat ICP ≥ 20 mmHg Ventriculostomy or intraparenchymal catheter
Hypertonic solutions	3% Hypertonic saline 0.1–1.0 ml/kg/h Mannitol 0.25–1.0 g/kg

Cervical Spine Immobilization

- Head and neck should be maintained in neutral position to prevent further injury.
- Infants < 6 months of age, head and cervical spine is immobilized using a spine board with tape across the forehead and blankets or towels around the neck.
- Older children should receive an age-appropriate rigid collar (medium size for children>8 years of age).

Cervical Spine Immobilization

- **Manual inline stabilization** can be used in infants >6 months of age.

- Children <7 years of age have a prominent occiput, therefore, to maintain the neutral alignment of the cervical spine, a pad is placed under the thoracic spine to avoids excessive flexion that may occur in the supine position.

Airway Management

- Fully conscious, hemodynamically stable child can be managed conservatively.

- Airway must be protected in a child with altered mental status by:
    - Suctioning the pharynx.
    - Chin lift and jaw thrust maneuvers.
    - insertion of an oral airway.

Airway Management

- Endo-tracheal intubation is indicated in children with a GCS score <9 for:
  - Airway protection.
  - Management of increased ICP.

- End-tracheal intubation is performed by direct laryngoscopy and oral intubation with cricoid pressure under manual in-line stabilization, without traction

Airway Management

- Nasotracheal intubation is contraindicated in patients with basilar skull fractures.
- Fiberoptic bronchoscopy may not be available and often have poor resolution and suctioning capabilities.
- Fiberoptic bronchoscopy cannot be used in the agitated awake child.

Anesthetic technique

- Most recommendations regarding the choice of anesthetic technique and monitoring in children with TBI are coming from adult data.

- Anesthesiologists should be aware of the hemodynamic and physiological recommendations in children with TBI.

Intravenous Anesthetic Agents

- All intravenous sedative hypnotic induction agents such as barbiturates, etomidate, and propofol, are potent cerebral vasoconstrictors that will cause reduction in CBF and CMRO2 coupling leading to ICP decrease.

Intravenous Anesthetic Agents

- Opioids and benzodiazepines can be safely used to facilitate tracheal intubation but should be used in small doses.

- Ketamine should be used with caution in patients with TBI.

Intravenous Anesthetic Agents

- Lidocaine is commonly used as an anesthetic adjunct to prevent increases in ICP induced by laryngoscopy and tracheal intubation.

- Dexmedetomidine (Precedex or Dexdor) may be desirable as a sedative agent because of its:
  - Potential neuroprotective effects by preservation of cerebral flow and metabolism coupling.
  - It may reduce opioid requirements.

Volatile agents

- All inhalational agents are cerebral vasodilators.
- Sevoflurane may better preserve cerebral autoregulation at low doses compared with other volatile agents.
- Sevoflurane may be epileptogenic.
- Nitrous oxide can increase ICP, even in children with a recent TBI history and the pneumocephalus and should be avoided.

Muscle relaxants

- Muscle relaxants have little effect on the cerebral circulation.
- Succinylcholine is much better choice particularly when there are concerns for a difficult airway.

Intravenous fluids

- Unlike adults, children can become hypovolemic from scalp injuries and isolated TBI.
- Isotonic crystalloid solutions are commonly used for cerebral resuscitation and during anesthesia.
- Hypotonic crystalloids should be avoided, and the role of colloids is controversial.

Intravenous fluids

- Hypertonic saline 0.1–1.0 ml/kg may be used to lower ICP and improve cerebral perfusion pressure (CPP).

- The use of hydroxyethyl starch is discouraged because of its role in exacerbating coagulopathy.

Hyperglycemia Control

- Hyperglycemia is a common stress response resulting from the interaction between the hypothalamic–pituitary–adrenal axis and the immune system.

- Hyperglycemia leads to inflammation, infection, and multiorgan dysfunction.

Hyperglycemia Control

- Numerous retrospective studies in pediatric TBI showed frequent hyperglycemia that is related to TBI severity and an association between hyperglycemia and poor outcome.

» Tuggle DW, Kuhn MA, Jones SK, et al. Hyperglycemia and infections in pediatric trauma patients. Am Surg 2008; 74:195–198.

» Hirshberg E, Larsen G, Van Duker H. Alterations in glucose homeostasis in the pediatric intensive care unit: hyperglycemia and glucose variability are associated with increased mortality and morbidity. Pediatr Crit care Med 2008; 9:361–366.

» Klein GW, Hojsak JM, Schmeidler J, et al. Hyperglycemia and outcome in the pediatric intensive care unit. J Pediatr 2008; 153:379–384.

Therapeutic Hypothermia

- Hypothermia reduces:
  - Global cerebral metabolism.
  - Cerebral oxygen demands.
  - Lactic acid accumulation.
  - Calcium influx in neurocytes.
  - Free radicals production.
  - Lipid peroxidation.
  - Posttraumatic level of excitatory neurotransmitter.
  - Inhibition of apoptosis.
  - Lowers the damage of cytoskeletal structure.

Therapeutic Hypothermia

- Complications associated with induced systemic hypothermia are:
  - Cardiac arrhythmias.
  - Myocardial infarction.
  - Impaired immune function.
  - Sepsis and pneumonia.
  - Electrolyte imbalance.
  - Intravascular volume changes.
  - Impaired coagulation cascade.

Therapeutic Hypothermia

- A Cochrane review by Sydenham suggests that there may be a benefit for induced hypothermia in TBI.
  - Sydenham E, Roberts I, Alderson P. Hypothermia for traumatic head injury. Cochrane Database Syst Rev 2009:CD001048.

- Several trials are investigating the benefits of induced hypothermia in pediatric TBI.

Methods for Induction and Maintenance of Therapeutic Hypothermia

Methods	Advantages	Disadvantages
Simple external cooling: ice bags, cold wet blankets, ice-cold water, alcohol, etc.	Simple, noninvasive, easy initial cooling, prehospital use	Long time to reach target temperature, workload, local wounds, body fat isolates
Advanced external cooling: cooling blankets, pads, dress or similar devices (mainly water-filled or other cooling elements), cooling tents (with cold air), cooling beds/mattresses (with cold water)	Stable, excellent for maintenance, easy to apply, combined with ice-cold fluids, very fast cooling with some devices, prehospital use	Varying effect, depending on contact area, circulating substance and system used, some devices not for prehospital use, cooling tent and beds/mattresses requires space
Infusion of cold fluids: 0.9% saline peripheral intravenously, 40 ml/kg	Fast, easy, and cheap induction of cooling, prehospital use	Cannot be used to maintain temperature within narrow range, requires infusion of large volumes
Endovascular cooling: a saline-filled catheter for thermoregulation	Stable, excellent for maintenance and controlled rewarming	Invasive procedure, risk of catheter-related thrombosis few data indicated prolong usage

Monitoring

- Standard American Society of Anesthesiologists (ASA) monitors and invasive arterial BP monitoring are recommended.
- Central venous pressure monitoring can be useful by inserting internal jugular line.
- Retrograde jugular venous saturation monitoring can be useful to guide the degree of hyperventilation in patients with TBI but is not the standard of care.

Monitoring

- ICP monitoring is useful during surgery involving extracranial injuries to calculate CPP.
- ICP monitoring should be used to guide BP management in children with TBI undergoing nonneurosurgical procedures.
- Brain temperature monitoring is not and microdialysis can be used. However,ther roles in improving the over all outcome need to be proven.

Monitoring

- Urine output must be monitored.
- Hourly arterial blood gas and tests of coagulation need to be examined.

Cerebral Hemodynamics (ICP & SBP)

- MAP should not be allowed to decrease below normal values for age by using vasopressors.
- The presence of Cushing's reflex and autonomic dysfunction might be the only indicators of increased ICP.
- In the absence of ICP monitoring and suspected increased ICP, supranormal SBP may be needed to maintain CPP.

Indications for surgery

- The major goal of surgery for TBI is to optimize the recovery of viable brain.

- Most operations deal with the removal of mass lesions for the purpose of preventing:
  - Herniation.
  - intracranial hypertension.
  - Alterations in CBF.

EVD Inseartion

- Indications include:
  - To measure ICP.
  - To facilitate CSF drainage.
  - To drain intraventricular hematomas.

Hematoma Evacuation

- Epidural hematomas should be evacuated in comatose patients unless small and deemed likely venous.

- Subdural hematomas that are associated with brain herniation, are greater than 10mm thick, or produce a midline shift of more than 5mm should be removed.

Intraparenchymal Mass Lesions

- Indications include:
  - Signs of mass effect on CT.
  - Progressive neurological deterioration referable to the lesion.
  - Refractory intracranial hypertension.

Penetrating Injury

- Indications include:
  - Local debridement.
  - Dura watertight closure if not extensive.
  - Intracranial mass effect.

Severe Brain Swelling

- Children are more prone to develop diffuse brain swelling.

- It is diagnosed as:
  - Diffuse cisternal compression or midline shift on brain CT scan.
  - Persistent intracranial hypertension by ICP monitor despite medical treatment.

Severe Brain Swelling

- It is treated by generous decompressive craniectomy and duroplasty.
  - Unilateral craniectomy for lateralized swelling.
  - Bifrontal decompression for diffuse disease.

Conclusion

- Pediatric TBI results in large Health costs.
- Therefore, efforts to improve outcome are extremely important.

THANK YOU