**ALGORITHM 1: Post-Resuscitation**

**Inclusion Criteria:**
- Patient with traumatic brain injury and Glasgow Coma Scale (GCS) less than or equal to 12

**Exclusion Criteria:**
- Patients found down without clear traumatic brain injury (TBI) (can be used in conjunction with Post Cardiac Arrest Pathway if considered beneficial)

**Emergency Department Management**

- Trauma and Neurosurgery Consult
- Head Computed Tomography (CT) scan or quick MRI as a viable (radiation-free) option
- 2 IVs with Normal Saline (NS) as maintenance
- Modified Rapid sequence intubation (RSI) if not already performed
- For patients with signs of elevated intracranial pressure (ICP) empirically treat:
  - 3% (0.5 mEq/mL Na+) Hypertonic saline (HTS) bolus 5mL/kg/dose via peripheral IV or central line
  - For patients with ongoing seizures use the status epilepticus clinical pathway (below).
  - For patients with severe TBI who have not received a dose of levetiracetam at another institution, give levetiracetam 20mg/kg IV (max 2 grams)
- If transporting to Operating Room: Consider mild hyperventilation to PCO$_2$ of 32-35 mmHg
- Standard Neuroprotective measures**
- Standard neuroprotective monitoring ***
- Anschutz: Neurocritical Care (NCC) Consult OR
- Colorado Springs: Neurology Consult

**Operating Room**

- Surgery Indicated?
  - Yes
    - Surgery as indicated
  - No
    - Post resuscitation
      - Monitor GCS. GCS decrease to less than or equal to 8?
        - Yes
          - Head CT (if not already obtained) or a quick MRI as a viable (radiation-free) option
          - 2 IVs with Normal Saline (NS) as maintenance
          - Trauma and Neurosurgery Consult
          - Consider comfort sedation and standard neuroprotective measures.
          - Complete frequent neurologic exams.
          - If external ventricular drain (EVD)/intracranial pressure (ICP) monitor placed per neurosurgery, follow Intracranial pressure (ICP) management algorithm (next page)
        - No
          - Standard Neuroprotective measures**
          - Standard neuroprotective monitoring ***
          - Anschutz: Neurocritical Care (NCC) Consult OR
          - Colorado Springs: Neurology Consult

**PICU**

- Improving or stable?
  - Yes
    - Continue clinical monitoring and consult Physical Medicine & Rehabilitation (PM&R)
  - No
    - If external ventricular drain (EVD)/intracranial pressure (ICP) monitor placed per neurosurgery, follow Intracranial pressure (ICP) management algorithm (Next page)

**Rehab Considerations for Severe TBI Patients**

- Consult Physical Medicine & Rehabilitation (PM&R) for patients that have stabilized or have been hospitalized greater than 5 days
- Consult PT/OT on PICU admission for early passive range of motion, bracing & splinting, and out of bed when appropriate
- Consult speech therapy when patient stabilized or have been hospitalized for greater than 5 days
- Anschutz: Consult rehab neuropsychology when PM&R is consulted

**Post Cardiac Arrest Clinical Pathway**

**Status Epilepticus Clinical Pathway**
Algorithm 2. Moderate/Severe Traumatic Brain Injury (TBI) Intracranial Pressure (ICP) Management

**Clinical Pathway**

**Moderate/Severe Traumatic Brain Injury (TBI) Intracranial Pressure (ICP) Management Algorithm:**

- **Neuroprotective Monitoring:**
  - End Tidal CO₂ (ETCO₂), core temperature
  - If needed, central access and arterial line
  - Intracranial pressure (ICP) monitor or external ventricular drain (EVD) placed if needed per neurosurgery in emergency department, operating room, or PICU
  - Continuous EEG (uEEG) when stabilized

- **Inclusion Criteria:**
  - Patients with Moderate/severe TBI with ICP monitor in place

- **Exclusion Criteria:**
  - Patient without an ICP monitor in place

**Hyperosmolar Therapy**

- Bolus hypertonic saline (HTS) if sodium less than 165 mmol/L.
- If fluid overloaded or not responsive to HTS, bolus mannitol 0.5 g/kg/dose IV if HTS not available or refractory to HTS.
- Mannitol 0.5-1g/kg/dose IV if HTS not available or refractory to HTS.
- Monitor sodium and osmolality (Osm) every 4 hours.
- Sodium less than 165 mmol/L and osmolality less than 340 MOSM/Kg.

**Fluid Goals and Vasoactives**

- Maintain cerebral perfusion pressure (CPP) and euvolemia.
- If euvolemic, use ionotropic/vasopressor support.

**Cerebral Spinal Fluid (CSF) Drainage**

- For patients with external ventricular drain (EVD) inform neurosurgery if ICP elevated greater than 20mmHg for more than 10 minutes.
- If clamped, unclamp and place at 15 mmHg, do not raise if already lower than 15 mmHg.
- Recheck ICP every 10 minutes.
- Additional adjustments per neurosurgery.

**Comfort Sedation**

- Richmond Agitation and Sedation Score (RASS) less than or equal to -1
- Comfort score 17-24
- With a goal of preserving a neurologic exam and safety for the patient

**Deep Sedation**

- Midazolam, fentanyl, or morphine
- Avoid hypotension
- Consider neuromuscular blockade if not ventilating or refractory ICP
- Consider ketamine

**Intracranial pressure (ICP) monitor placed at the discretion of neurosurgery:**

- Sedating for comfort
- Responsive to touch or name.
- See sedation section for guidance.

**Elevated ICP?**

- Yes
- Elevated pressure
- Consider Salvage Therapies via PICU and Neurosurgery attending to attending call:
  - Depressor/Analgesics
  - Hypothermia to 32-34°C
  - Barbiturate Coma
- Notify Neurosurgery (NSYG), Trauma and Neurology critical care (NCC) Neuromuscular Blockade Consider Repeat CT Scan
- Maximized external ventricular drain (EVD) drainage, Hyperosmolar therapy and Sedation?
- Discuss with Neurology if EEG remains reactive, if so could consider further sedation.
- Continue current ICP directed Therapies 24 hours. Then wean per pathway.

**ICP less than 20**

- No
- Elevated ICP?
- Yes
- External ventricular drain (EVD) in place?
- No
- Hyperosmolar Therapy
- Bolus hypertonic saline (HTS) if sodium less than 165 mmol/L.
- If fluid overloaded or not responsive to HTS, bolus mannitol 0.5-1g/kg/dose IV if HTS not available or refractory to HTS.
- Mannitol 0.5-1g/kg/dose IV if HTS not available or refractory to HTS.
- Monitor sodium and osmolality (Osm) every 4 hours.
- Sodium less than 165 mmol/L and osmolality less than 340 MOSM/Kg.
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  - Depressor/Analgesics
  - Hypothermia to 32-34°C
  - Barbiturate Coma
- Notify Neurosurgery (NSYG), Trauma and Neurology critical care (NCC) Neuromuscular Blockade Consider Repeat CT Scan
- Maximized external ventricular drain (EVD) drainage, Hyperosmolar therapy and Sedation?
- Discuss with Neurology if EEG remains reactive, if so could consider further sedation.
- Continue current ICP directed Therapies 24 hours. Then wean per pathway.

**Elevated intracranial pressure (ICP) Parameters**

- For patients that are calm, unstimulated and outside of cares:
  - Actively treat for an ICP of greater than 20 mmHg for more than 10 minutes
- For a patient that is in pain, agitated or receiving cares:
  - Ensure appropriate sedation/analgesia
  - Consider treating ICP greater than 30 mmHg for longer than 10 minutes after appropriate sedation or the end of cares

**Hyperosmolar Therapy**

- Bolus hypertonic saline (HTS) if sodium less than 165 mmol/L.
- If fluid overloaded or not responsive to HTS, bolus mannitol 0.5-1g/kg/dose IV if HTS not available or refractory to HTS.
- Mannitol 0.5-1g/kg/dose IV if HTS not available or refractory to HTS.
- Monitor sodium and osmolality (Osm) every 4 hours.
- Sodium less than 165 mmol/L and osmolality less than 340 MOSM/Kg.
- Can Repeat after 15 minutes if ICP is elevated.

**Fluid Goals and Vasoactives**

- Maintain cerebral perfusion pressure (CPP) and euvolemia.
- If euvolemic, use ionotropic/vasopressor support.

**Cerebral Spinal Fluid (CSF) Drainage**

- For patients with external ventricular drain (EVD) inform neurosurgery if ICP elevated greater than 20mmHg for more than 10 minutes.
- If clamped, unclamp and place at 15 mmHg, do not raise if already lower than 15 mmHg.
- Recheck ICP every 10 minutes.
- Additional adjustments per neurosurgery.

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**Deep Sedation**

- Midazolam, fentanyl, or morphine
- Avoid hypotension
- Consider neuromuscular blockade if not ventilating or refractory ICP
- Consider ketamine

**Intracranial pressure (ICP) monitor placed at the discretion of neurosurgery:**

- Sedating for comfort
- Responsive to touch or name.
- See sedation section for guidance.

**Elevated ICP?**

- Yes
- Elevated pressure
- Consider Salvage Therapies via PICU and Neurosurgery attending to attending call:
  - Depressor/Analgesics
  - Hypothermia to 32-34°C
  - Barbiturate Coma
- Notify Neurosurgery (NSYG), Trauma and Neurology critical care (NCC) Neuromuscular Blockade Consider Repeat CT Scan
- Maximized external ventricular drain (EVD) drainage, Hyperosmolar therapy and Sedation?
- Discuss with Neurology if EEG remains reactive, if so could consider further sedation.
- Continue current ICP directed Therapies 24 hours. Then wean per pathway.

**ICP less than 20**

- No
- Elevated ICP?
- Yes
- External ventricular drain (EVD) in place?
- No
- Hyperosmolar Therapy
- Bolus hypertonic saline (HTS) if sodium less than 165 mmol/L.
- If fluid overloaded or not responsive to HTS, bolus mannitol 0.5-1g/kg/dose IV if HTS not available or refractory to HTS.
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- Monitor sodium and osmolality (Osm) every 4 hours.
- Sodium less than 165 mmol/L and osmolality less than 340 MOSM/Kg.
- Can Repeat after 15 minutes if ICP is elevated.
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TARGET POPULATION

Inclusion Criteria
• All patients cared for at Children’s Hospital Colorado with known or suspected brain injury secondary to trauma with a post-resuscitation Glasgow Coma Score (GCS) of less than 8 (Severe Traumatic Brain Injury) or GCS 9-12 (Moderate Traumatic Brain Injury) with concern for potential decompensation. This includes patients less than 2 years of age with concern for abusive head trauma.

Exclusion Criteria
• Patient found down without clear trauma

BACKGROUND | DEFINITIONS

This protocol is based on “The Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents” and on the existing literature and is intended to provide standardization in the care of traumatic brain injury (TBI) patients at Children’s Hospital Colorado.

Scope: Children’s Hospital Colorado – Anschutz Medical Campus (CHCO-Anschutz)

Severe Traumatic Brain Injury: Glasgow Coma Score (GCS) of 3 – 8

Moderate TBI: GCS of 9-12

Mild TBI: GCS of 13-15
INITIAL EVALUATION & CLINICAL MANAGEMENT

Emergency Department Management:

- Obtaining the best neurologic exam safely is critical for neurosurgical decision-making and appropriate patient management. In all patients, Glasgow Coma Scale (GCS) is assessed. When possible, consider avoiding further sedatives and paralytics until neurosurgery resident or fellow examines patient. Call neurosurgery early when sedation or intubation may be necessary.

- When sedation or analgesia are necessary, use short acting intermittent agents, including fentanyl (1-2 mcg/kg) and/or ketamine 0.5-1 mg/kg IV. Note that Propofol is not appropriate for long-term sedation in children but is a reasonable option for the first hours. Midazolam may also be used but can alter the neurologic exam for hours.

Primary Survey

- Airway control
  - Intubate for GCS of eight (8) or less or if unable to maintain stable airway.
    - Use rapid sequence intubation (RSI) Trauma Guideline
    - Assess GCS prior to administering sedation.
  - Maintain head of patient in neutral position, use rigid cervical collar (e.g. Aspen collar).

- Breathing
  - Maintain oxygen saturations at 93-97%
  - Maintain PCO₂ 35-40 mmHg
  - Monitor end tidal CO₂ (ETCO₂) and obtain blood gases to correlate ETCO₂ to PCO₂ when indicated.

- Circulation
  - Consider early, transfusion first approach for circulation to minimize fluid overload from crystalloid
  - See Table 1 for minimum acceptable blood pressure by age group.
  - Avoid hypotension by ensuring adequate circulating blood volume using isotonic fluid (Normal Saline) or Trauma Packed red blood cell (PRBC) units as indicated.
  - Avoid hypotonic fluids as they exacerbate brain swelling.
  - May use pressor support once intravascular volume has been repleted.
  - Once euvoemia is attained, use Normal Saline (avoid hypotonic fluids) at age-appropriate maintenance intravenous (IV) rate.

Secondary Survey:

- Full neurologic exam including cranial nerve exam
- Trauma labs and x-rays per protocol, including electrolytes, glucose, ionized calcium, full CBC, and PT/PTT
- Obtain head computed tomography (CT) and other indicated imaging. STAT upload prior imaging if available
- If head of bed elevation is preferred, utilize reverse Trendelenburg (Revere T) positioning rather than just raising the head of the bed until thoracic spine cleared. Place Foley and orogastric tube (OG) unless contraindicated. Establish adequate IV access. Obtain CVL when indicated.

Neuroprotective Measures

Glucose Management
See Glycemic Guidelines: Critical Care for Patients 6 Months of Age and Older or Glycemic Guidelines: Critical Care for Patients Less than 6 Months of Age)

- Check serum glucose measurements on admission to PICU and minimum every 6 hours for first 48 hours
- Maintain serum blood glucose 80-180 mg/dL. Persistent hyperglycemia (greater than 180 mg/dL) and severe hypoglycemia (less than 40 mg/dL) are associated with increased mortality/worse neurological outcome.
- Avoid bolus insulin dose in trauma patients.

**Ventilation**

- Goal PCO₂ of 35-40 mmHg
- Monitor end-tidal CO₂ (ETCO₂).
- Obtain blood gases to correlate ETCO₂ with PCO₂ as indicated.
- Aggressive, rapid hyperventilation must be reserved for acute ICP crisis as adjunct with therapy escalation. Effect is temporary (less than 30 min), and rebound ICP elevation will occur with normalization of CO₂.

**Seizures**

- Seizure prophylaxis with levetiracetam 10 mg/kg BID x 7 days (max dose 1 g BID) should be administered to all severe TBI patients of all ages.
- Seizure monitoring:
  - Initiate EEG as early as feasible to evaluate for subclinical seizures, encephalopathy and reactivity. Seizures are common in patients with TBI.
  - For all patients with TBI admitted to the PICU, monitor with EEG for a minimum of 24 hours, or longer if clinically indicated.
    - Infants and patients with suspected abusive head trauma have a high risk for seizures and may benefit from prolonged monitoring of 48-72 hours. (See Special Considerations for Suspected Abusive Head Trauma)
    - GCS is an unreliable marker of the risk for seizures in children less than 2.5 years of age.
  - If the patient develops seizures, discuss treatment options with the Neurocritical Care Consult team at Anschutz or the Neurology team at Colorado Springs. Reference the Status Epilepticus Clinical Pathway as needed.

**Sedation/Analgesia**

- Provide analgesia and sedation to achieve a COMFORT Pain Score of 17-24 and a Richmond Agitation and Sedation Score (RASS) of -1, unless deep sedation is instituted for treatment of elevated ICP. If Deep sedation is needed to manage elevated ICP, then change administration instructions within analgesia and sedation order to reflect new COMFORT and RASS goals.
- Initial dosing of sedative continuous infusions:
  - Titrate sedative continuous infusions, including fentanyl, midazolam, and dexmedetomidine (be careful with dexmedetomidine in first 72 hours).

**Indications for ICP Monitoring**

The decision to monitor ICP is based on Glasgow Coma Score (GCS), CT scan findings, and clinical scenario at the discretion of the on-call neurosurgery attending.

- Strongly consider an ICP monitor in patients with GCS of eight (8) or less after initial resuscitation, especially if CT scan shows mass lesions (e.g. hematoma, edema), effaced basilar cisterns, or diffuse edema.
  - An ICP monitor may be placed in the setting of a borderline GCS when neurologic exam is unavailable for a prolonged period of time, e.g. emergent non-cranial surgery.
• For those going to operating room for removal of an intracranial mass (bleed), the need for monitoring will be assessed at surgery.

• The decision for or against the placement of an ICP monitoring device should be communicated by the neurosurgery attending to the trauma service and PICU attendings as well as their level of concern for anticipated ICP elevations and threshold for interventions (i.e. ICP, exam changes, EVD output).

• External ventricular drainage is preferred in cases when ventricles are deemed adequate without significant anatomical distortion, are enlarged or where CSF diversion is likely to be beneficial for ICP control.

• If GCS is marginal (9-13), and ICP monitor is not placed, follow exam with minimum necessary sedation/analgesia.

• GCS is assessed hourly by ICU nursing staff, with any decline in exam communicated to the PICU provider who will communicate with the neurosurgical services. Subacute development of elevated ICP with need for medical or surgical interventions is possible from ongoing brain swelling.

• If signs of herniation are present, consider giving hypertonic saline 3% (0.5 mEq/mL Na+) (5 mL/kg) or mannitol (1 gm/kg IV) or mild hyperventilation (ETCO₂ 32-35) while monitor is being placed.

**THERAPEUTICS**

**Treatment of Elevated ICP**

• Treatments are initiated for intracranial hypertension as defined by elevated ICP. Table 1 defines threshold values for treatment by age group. ICP units are mmHg (20 cm H₂O = 14.7 mmHg).

• Treat if ICP is above stated values. Treat Cerebral perfusion pressure (CPP) only when ICP cannot be controlled.

<table>
<thead>
<tr>
<th>Age</th>
<th>MAP (mmHg)</th>
<th>ICP (mmHg)</th>
<th>ICP Treatment Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-23 months</td>
<td>50-70</td>
<td>Less than or equal to 15</td>
<td>Greater than or equal to 20</td>
</tr>
<tr>
<td>2-5 years</td>
<td>45-65</td>
<td>Less than or equal to 15</td>
<td>Greater than or equal to 20</td>
</tr>
<tr>
<td>6-8 years</td>
<td>65-85</td>
<td>Less than or equal to 20</td>
<td>Greater than or equal to 20</td>
</tr>
<tr>
<td>Greater than or equal to 9 years</td>
<td>70-95</td>
<td>Less than or equal to 20</td>
<td>Greater than or equal to 20</td>
</tr>
</tbody>
</table>

Mean Arterial Pressure (MAP)

• Elevate head of bed to 30 degrees – This is done in moderate to severe TBI patients.

• Check that cervical collar is loose enough to allow jugular venous return (able to easily slip a finger between collar and neck).

• Comfort sedation – Sedate as needed to a Richmond Agitation and Sedation Score (RASS) of -1. Short-acting agents are preferred. All intubated patients should receive comfort sedation.

• Cerebral spinal fluid (CSF) diversion – open external ventricular drain (EVD) if clamped and notify the PICU provider who will notify neurosurgery.
  
  o Consider placing an EVD or replacement of ICP monitor with EVD if ICP becomes refractory unless ventricles are slit-like or casted with blood

**Hyperosmolar Therapy**

• Hypertonic Saline 3% (0.5 mEq/mL Na+) is the first-line osmotic in any patient who is not fluid overloaded.
  
  o Administer a bolus of 5 mL/kg IV over 15 minutes for acutely elevated ICP.
  
  o Infuse 0.1 - 1 mL/kg/hour continuously for maintenance of ICP control.
  
  o Monitor serum chloride levels and for AKI while on hypertonic therapy (caution if greater than 125 mEq/L)

• Check serum sodium and osmolality every 4 hours while actively administering hyperosmolar therapy.
  
  o If sodium is greater than 165, be cautious and carefully consider administration of hypertonic saline.
If limitation of total fluid volume is required (e.g., in a patient receiving large amounts of fluid from drips and antibiotics), 12% (2 mEq/mL Na+) or 23.4% (4 mEq/mL Na+) saline solution may be substituted for 3% (0.5 mEq/mL Na+).

<table>
<thead>
<tr>
<th>Hypertonic Saline %</th>
<th>Hypertonic Sodium Concentration</th>
<th>Recommended Dose</th>
<th>Max Dose Volume</th>
<th>Expected increase in serum sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>0.5 mEq/mL</td>
<td>5 mL/kg</td>
<td>234 mL</td>
<td>5 mEq/mL</td>
</tr>
<tr>
<td>12%</td>
<td>2 mEq/mL</td>
<td>1 mL/kg</td>
<td>60 mL</td>
<td>5 mEq/mL</td>
</tr>
<tr>
<td>23.4%</td>
<td>4 mEq/mL</td>
<td>0.5 mL/kg</td>
<td>30 mL</td>
<td>5 mEq/mL</td>
</tr>
</tbody>
</table>

Mannitol
- Consider mannitol if:
  - Hypertonic saline is not immediately available.
  - Patient is fluid overloaded.
  - ICP does not respond to initial hypertonic saline (HTS) bolus.
  - Mannitol should be used with caution if serum OSM is greater than 340.
- Dosing: Refer to Formulary
- Check serum osmolality (OSM) and calculated OSM prior to repeat bolus after infusion. If OSM gap is greater than 10 mmol, would not administer more mannitol since it is still circulating.
- Osmolality (OSM) = (2 × Na⁺) + (glucose ÷ 18) + (BUN ÷ 3); OSM gap = Serum OSM – Calculated OSM

Cerebral hypoperfusion
The below therapies are instituted in the following order when ICP cannot be controlled and CPP is low as defined by Table 1. They may also be considered when ICP is normal but mean arterial pressure (MAP) is low. Cerebral perfusion pressure (CPP) is calculated as follows: CPP=MAP-ICP.
- Bolus IV fluid – Normal saline, colloid, or blood.
- Repeat boluses to maintain euvolemia
- Norepinephrine – Titrate to goal cerebral perfusion pressure (CPP)
- Additional pressors as necessary – Titrate to goal cerebral perfusion pressure (CPP)

Sedation
Comfort sedation:
- Richmond Agitation and Sedation Score (RASS) less than or equal to –1 Comfort score 17-24
- With a goal of preserving a neurologic exam and safety for the patient
- Evaluate responsiveness to sedation boluses given for ICP as additional sedation may not be beneficial if there are no clinical signs of responsiveness to additional boluses

Deep Sedation:
- May be used concurrently with hyperosmolar therapy or prior to hyperosmolar therapy, according to provider discretion.
- Deep sedation for control of ICP refractory to osmotic therapy. Nursing maneuvers are minimized and neurologic exams should be minimized during deep sedation to minimize any stimulation to the patient.

Neuromuscular blockade
- Add neuromuscular blockade if ICP is refractory to sedation.
- Rocuronium /cisatracurium: Refer to formulary
• Titrate infusion to maintain ICP within goal range. Monitor paralysis with train of four with maximal therapy being reached when there is either ICP control or an absence of a train of four twitches. Other neuromuscular blockers may be used if indicated.

• Institute EEG monitoring when neuromuscular blockade is ongoing.

Sedation and neuromuscular blockade may acutely raise pCO₂ (and hence ICP) if patient has been over-breathing the ventilator prior to administration. End Tidal CO₂ (ETCO₂) monitoring diagnoses this and allows appropriate monitoring of ventilator changes.

Second-line ICP therapies

• Pentobarbital Coma
  o Consider in severe, non-lateralized, potentially salvageable cases.
  o Initial bolus of 10 mg/kg bolus over 30 min (can use a smaller bolus of 3-5mg/kg or slower infusion rate if hypotension develops).
    o Follow the initial bolus with 5 mg/kg/hr of pentobarbital for 3 hours
    o Continue pentobarbital infusion at 1 mg/kg/hr
  o Titrate to ICP effect and consider monitoring with continuous EEG monitoring with a target of 90% suppression (or a 1 second burst per 10 seconds of suppression) as a maximal therapy.
  o Close blood pressure monitoring will be needed. Order pressors to bedside prior to administration of pentobarbital bolus.
  o Monitor for pancreatitis (lipase every 3 days) and infection (daily blood cultures).

Decompressive Craniectomy

• PICU attending and neurosurgery attending discussion of indication for decompressive craniectomy:
  o Consider in lateralized cases or bifrontal craniectomy in non-lateralized cases with some likelihood of survival

Order of ICP Therapy weaning

• Normocapnia
• Barbiturate withdrawal as tolerated (ICP/ CPP)
• Paralytic withdrawal as tolerated (ICP/CPP)
• Sedation withdrawal as tolerated (Opiate/benzodiazepine as indicated to prevent withdrawal symptoms)
• Normalize serum sodium and osmolarity

Target Temperature

• Target temperature therapy is not recommended prophylactically but can be considered for ICP targeted therapy in refractory cases to moderate hypothermia (32-33° Celsius)

SYSTEMIC MANAGEMENT OF PATIENTS WITH MODERATE/SEVERE BRAIN INJURY

Nutrition

• Traumatic brain injury is associated with significant elevation in mean energy expenditure above predicted levels.
  o Institute nutrition (enteral preferred) within 72 hours of injury
    • Parenteral nutrition may be delayed up to one week in compromised patients

  Nutrition consult to assist in determining optimal volume and content of feeds/TPNPICU Nutrition Guidelines:
    • PICU Enteral Nutrition Guideline
Venous Thromboembolism (VTE) prophylaxis and Treatment:
Due to the complexity of the Moderate/Severe TBI population please use the following VTE prophylaxis recommendations. Do not use the standard VTE Prevention clinical pathway recommendations for these patients.

Prophylaxis:
For VTE prophylaxis in TBI there are special consideration please see the VTE prophylaxis algorithm

Treatment:
The risk: benefit ratio of pharmacologic treatment of a documented venous thromboses, regardless of location (superficial vs deep DVT), is poorly defined for TBI patients and management decisions should be multidisciplinary between the involved surgical, critical care, and hematology services.

Blood Products and Coagulopathy
- Monitor and correct coagulopathy, as clinically indicated, in the initial 48 hours following injury
- Consider thromboelastography (TEG) as an adjunct lab to inform decisions regarding transfusion
- Platelet transfusion if platelets are > 100K may not provide benefit
- If intracranial pressure monitoring is warranted, consider platelet transfusion if platelets are < 100K
- If intracranial pressure monitoring is warranted, fresh frozen plasma may not provide benefit if INR is < 1.6

Rehabilitation
- Consult Physical Medicine & Rehabilitation (PM&R) for patients that have stabilized or have been hospitalized for greater than 5 days
- Consult PT/OT upon admission for early passive range of motion, bracing & splinting, and out of bed when appropriate.
- Consult speech therapy when patient stabilized or have been hospitalized for greater than 5 days to assist with assessing swallow abilities and communication even while intubated.
- Consult rehab neuropsychology when PM&R is consulted to assist with TBI education, coping with rehab process and adjustment to cognitive changes.
  - Colorado Springs consideration: If the patient is assessed by the on staff rehabilitation psychiatrist and it is determined that a neuropsychologist is needed, consult the Anschutz team to discuss treatment and/or transfer options

SPECIAL CONSIDERATIONS FOR SUSPECTED ABUSIVE HEAD TRAUMA
For Children less than 2.5 years of age
In children less than 2.5 years of age with concerns for or suspected abusive head trauma who:

- Present with seizures, apnea, sleepiness or irritability
- AND Have intracranial hemorrhage (subdural, subarachnoid, intraventricular or intraparenchymal hemorrhage) on initial imaging

Due to 1) the difficulty assessing mental status in young children, 2) unreliability of GCS in stratifying the severity of injury and 3) an increased risk of seizures (including clinical and subclinical seizures that may require ICU care) children meeting the above criteria should be:

- Admitted to the PICU for 24-48 hours
- Placed on continuous EEG for 72 hours (including after transfer from the ICU if less than 72 hours). Cessation of cEEG between 48 - 72 hours at the discretion of the neurology/neurocritical care team.

**For all children with suspected abusive head trauma**

**EEG**

Consider prolonged EEG monitoring (48-72 hours), since the majority of patients with abusive head trauma will have subclinical seizures which may be present on admission or delayed 24-72 hours.

**MRI Imaging**

Cases of suspected abusive head trauma may be of unknown timing and mechanism. As a result, they warrant aggressive monitoring and oftentimes further imaging. Definitive MRI brain imaging should be performed no earlier than 48 hours after admission and preferably 72 hours after admission, but no later than 7 days following admission. The order should be for: “MRI brain with and without contrast, with venography”. Also request “MRI cervical spine without contrast.” Additional MRIs may be obtained outside the 72 hour-7 day window to assist with medical management, as needed.
## Appendix A: Overview of Richmond Agitation and Sedation Score (RASS)

<table>
<thead>
<tr>
<th>Score</th>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4</td>
<td>Combative</td>
<td>Overtly combative or violent; immediate danger to staff</td>
</tr>
<tr>
<td>+3</td>
<td>Very agitated</td>
<td>Pulls on or removes tube(s) or catheter(s) or has aggressive behavior toward staff</td>
</tr>
<tr>
<td>+2</td>
<td>Agitated</td>
<td>Frequent non-purposeful movement or patient-ventilator dyssynchrony</td>
</tr>
<tr>
<td>+1</td>
<td>Restless</td>
<td>Anxious or apprehensive bust movements not aggressive or vigorous</td>
</tr>
<tr>
<td>0</td>
<td>Alert and calm</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td>Drowsy</td>
<td>Not fully alert, but has sustained (more than 10 seconds) awakening, with eye contact, to voice</td>
</tr>
<tr>
<td>-2</td>
<td>Light sedation</td>
<td>Briefly (less than 10 seconds) awakens with eye contact to voice</td>
</tr>
<tr>
<td>-3</td>
<td>Moderate sedation</td>
<td>Any movement (but no eye contact) to voice</td>
</tr>
<tr>
<td>-4</td>
<td>Deep sedation</td>
<td>No response to voice, but any movement to physical stimulation</td>
</tr>
<tr>
<td>-5</td>
<td>Unarousable</td>
<td>No response to voice or physical stimulation</td>
</tr>
</tbody>
</table>
Appendix B: VTE Prophylaxis for TBI

TBI Patient in the PICU

Mechanical Prophylaxis

TBI Patient in the PICU

Mechanical Prophylaxis

Age less than 12 years

Age greater than or equal to 12 years

Patient Age?

Any of the following:
• Known clotting disorder?
• Personal history venous thromboembolism (VTE)? OR
• Strong family history VTE?

No

Mechanical Prophylaxis only

Yes

Assess Bleeding Risk

Risk Factors:
• Craniotomy
• EVD/ICP monitor in place
• Moderate/large (greater than 5 mm) subdural, epidural, or IVH
• Moderate/large (greater than 1 cm) contusion
• INR greater than 1.5
• Platelets less than 100K
• Other site of bleeding (liver, spleen, pelvis)

High Bleeding risk? (any risk factors present)

Yes

Reassess 24 hours after injury

Clinically stable?

No

Clinically stable?

Repeat imaging (if obtained) stable?

Yes

Complete CHCO VTE risk assessment

VTE Risk level?

High VTE Risk

Enoxaparin Prophylaxis

Moderate/Low VTE Risk

Mechanical Prophylaxis only

No

Reassess 72 hours after injury

Clinically stable?

Repeat imaging (if obtained) stable?

Yes

No

Notes:
• For TBI patients with known clotting disorders, personal history of venous thromboembolism (VTE), or strong family history of VTE, consult Hematology for discussion of VTE prophylaxis and/or treatment.
• Reassess for bleeding risk should occur at 24 and 72 hours after injury and/or instrumentation (including EVD/ICP monitor placement and craniotomies), whichever is most recent.
• For reassessment of patients at 24 and 72 hours, repeat brain imaging should be considered but is not required to start VTE prophylaxis.
• For patients with low bleeding risk and high VTE risk, start enoxaparin prophylaxis per CHCO VTE guideline.
REFERENCES


2. Reiter PD, Pietras M, Dobyns EL. Prolonged dexmedetomidine infusions in critically ill infants and children. Indian Pediatr. 2009 Sep;46(9):767-73


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APPROVED BY

Clinical Pathways and Measures Committee – November 27, 2023
Pharmacy & Therapeutics Committee – December 7, 2023
Anschutz Trauma Committee: January 30, 2024
Colorado Springs Trauma Committee: January 30, 2024

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REVIEW | REVISION SCHEDULE
Scheduled for full review on November 27, 2027

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