SEVERE TRAUMATIC BRAIN INJURY CLINICAL PATHWAY - QUEBEC

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AGENDA

Introduction

Review the severe TBI pathway

Comments/Questions Feedback

Updated Guidelines overview

SEVERE TRAUMATIC BRAIN INJURY

Traumatic Brain Injury (TBI) remains one of the **most common causes of death** from trauma in children

Children (compared to adults) have large heads and higher center of gravity, predisposing them to TBI.

The Goal of severe TBI management if to **prevent secondary injury**!!

Hypoxemia, Hypercarbia, Poor Perfusion, Seizures, Hyperglycemia, Edema, Increased ICP

Hyperthermia

Guidelines for the Management of Pediatric Severe Traumatic Brain Injury, Third Edition: Update of the Brain Trauma Foundation Guidelines

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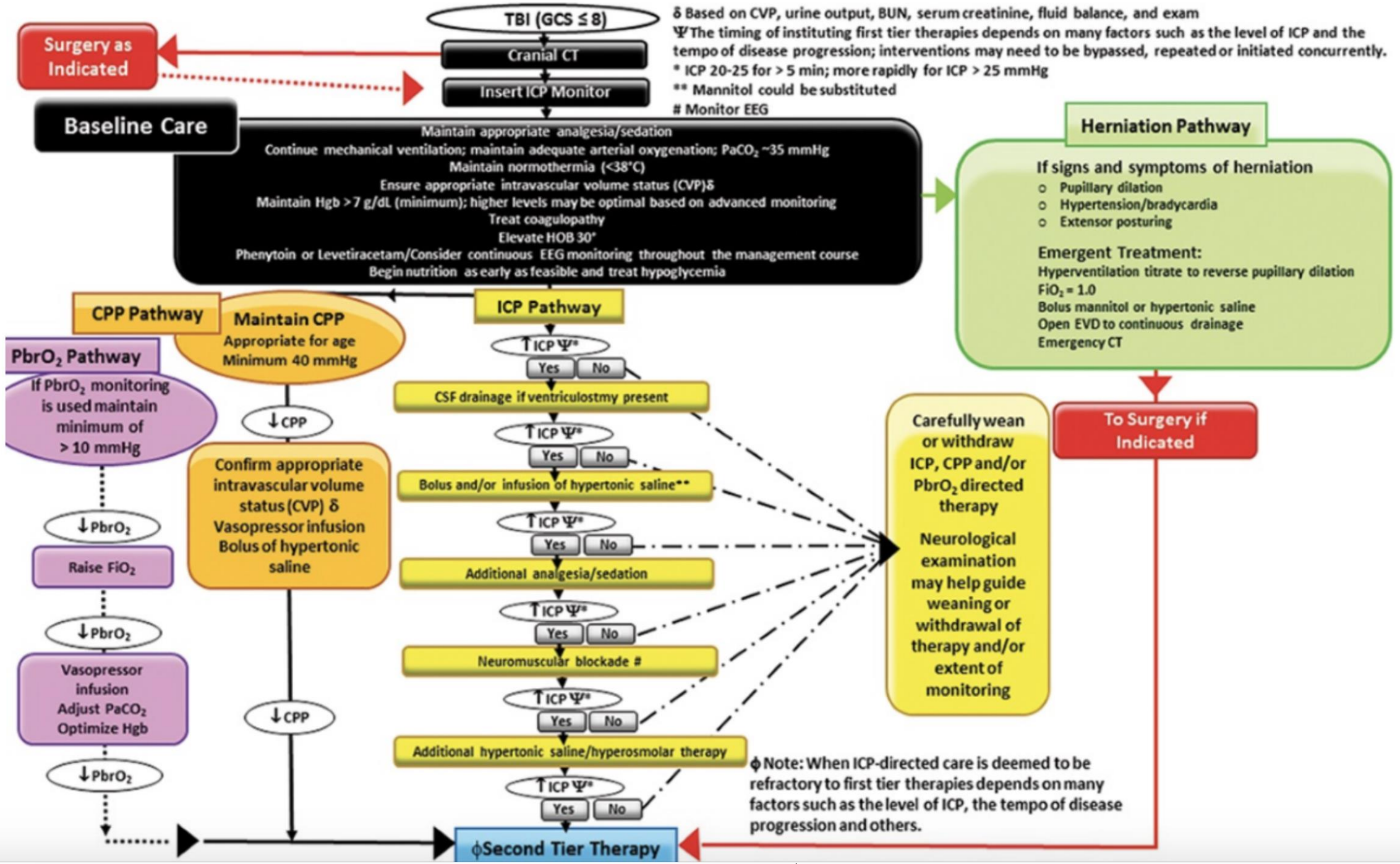
Pediatric Crit Care Med 2019


TBI (GCS ≤ 8)
Cranial CT
Insert ICP Monitor
Surgery as Indicated
δ Based on CVP, urine output, BUN, serum creatinine, fluid balance, and exam
Ψ The timing of instituting first tier therapies depends on many factors such as the level of ICP and the tempo of disease progression; interventions may need to be bypassed, repeated or initiated concurrently.
* ICP 20-25 for > 5 min; more rapidly for ICP > 25 mmHg
** Mannitol could be substituted
# Monitor EEG
Baseline Care
Maintain appropriate analgesia/sedation
Continue mechanical ventilation; maintain adequate arterial oxygenation; PaCO2 ~35 mmHg
Maintain normothermia (<38°C)
Ensure appropriate intravascular volume status (CVP)δ
Maintain Hgb >7 g/dL (minimum); higher levels may be optimal based on advanced monitoring
Treat coagulopathy
Elevate HOB 30°
Phenytoin or Levetiracetam/Consider continuous EEG monitoring throughout the management course
Begin nutrition as early as feasible and treat hypoglycemia
Herniation Pathway
If signs and symptoms of herniation
Pupillary dilation
Hypertension/bradycardia
Extensor posturing
Emergent Treatment:
Hyperventilation titrate to reverse pupillary dilation
FiO2 = 1.0
Bolus mannitol or hypertonic saline
Open EVD to continuous drainage
Emergency CT
To Surgery if Indicated
CPP Pathway
Maintain CPP
Appropriate for age
Minimum 40 mmHg
↓CPP
Confirm appropriate intravascular volume status (CVP) δ
Vasopressor infusion
Bolus of hypertonic saline
↓CPP
PbrO2 Pathway
If PbrO2 monitoring is used maintain minimum of > 10 mmHg
↓PbrO2
Raise FiO2
↓PbrO2
Vasopressor infusion
Adjust PaCO2
Optimize Hgb
↓PbrO2
ICP Pathway
↑ICP Ψ*
Yes
No
CSF drainage if ventriculostmy present
↑ICP Ψ*
Yes
No
Bolus and/or infusion of hypertonic saline**
↑ICP Ψ*
Yes
No
Additional analgesia/sedation
↑ICP Ψ*
Yes
No
Neuromuscular blockade #
↑ICP Ψ*
Yes
No
Additional hypertonic saline/hyperosmolar therapy
↑ICP Ψ*
Yes
No
ϕSecond Tier Therapy
Carefully wean or withdraw ICP, CPP and/or PbrO2 directed therapy
Neurological examination may help guide weaning or withdrawal of therapy and/or extent of monitoring
ϕ Note: When ICP-directed care is deemed to be refractory to first tier therapies depends on many factors such as the level of ICP, the tempo of disease progression and others.

PATHWAY FOR SEVERE TRAUMATIC BRAIN INJURY -QUEBEC

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WHO?

SEVERE TRAUMATION BRAIN INJURY

INCLUSION: Severe accidental or Abusive Traumatic Brain Injury with initial post-resuscitative GCS<=8

EXCLUSION: GCS>8

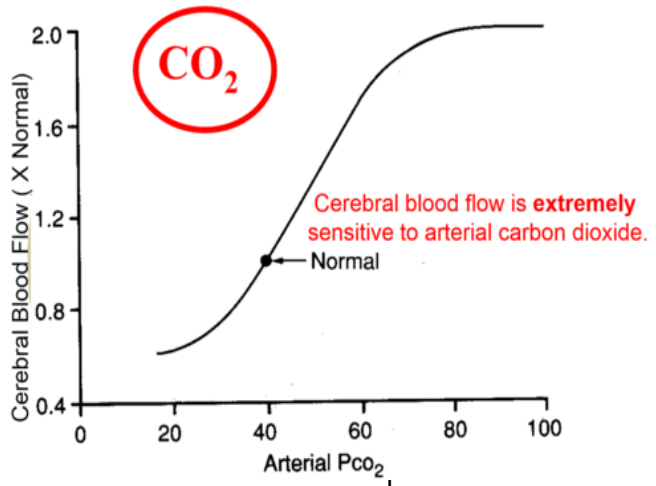
INITIAL MANAGEMENT

Time	Stage of management	Notes
0-30 min	**ACUTE EMERGENCY DEPARTMENT (ED) MANAGEMENT** **<u>ED management</u>** - Airway management - Avoid hypotension/hypoxemia - Evaluate/treat signs of elevated ICP - Expedite time for definitive care **Airway & Breathing** - Rapid Sequence Intubation recommendations: o Etomidate (0.3 mg/kg IV) & Rocuronium (1.2 mg/kg IV) OR o Ketamine (1-2 mg/kg IV) & Rocuronium (1.2 mg/kg IV) - Goals: o SpO2 >92% and ≤ 98% o EtCO2: 30-34 mmHg o CO2 (if available): 35-40	**Key Points:** ATLS protocol AVOID hypotension AVOID hypoxia (O2 for >92% and <98%) Normocarbia (CO2 35-39 or EtCO2 30-34) Avoid hyperthermia Signs of Elevated ICP: Bradycardia Hypertension Altered breathing

Neurologic
Head of Bed 30 degrees
Neutral Head Positioning
Signs of elevated ICP in the absence of an ICP monitor
Focal neurological exam deficit (e.g. unilateral dilated pupil)
AND/OR
Cushing's triad: hypertension, bradycardia, abnormal breathing

Consider the following interventions if concern for elevated ICP:
Hyperosmolar therapy with Hypertonic saline (3%) 2-5 ml/kg over 10-20 min (repeat PRN)
Hyperventilate to transiently lower EtCO2 to < 30 mmHg **if signs of herniation**

Secondary sedation post-RSI
Ensure adequate ongoing analgesia and sedation



Consider fentanyl 1-2 mcg/kg q20min or ketamine 1 mg/kg q30 min based on patient's clinical status
(administer minimal amount needed to avoid hypotension)
AVOID propofol

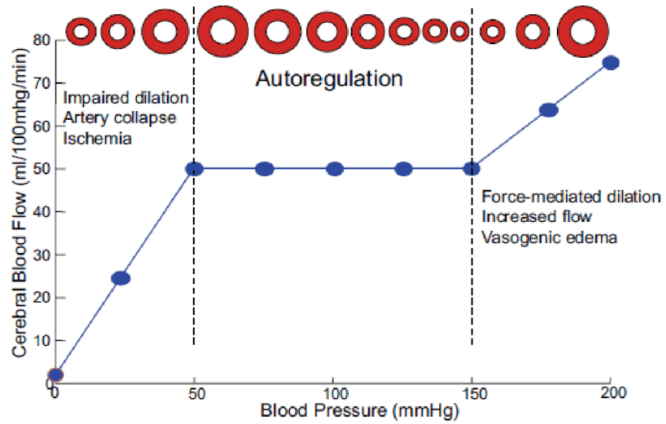
If seizures, antiepileptic medications: (TO BE DISCUSSED)

- Phenytoin (20 mg/kg IV) or Levetiracetam (50-60 mg/kg)
- Consider midazolam infusion (start 0.1mg/kg/h)

Consult neurosurgery regardless of CT results

Circulation
Maintain euvolemia
AVOID hypotension

Metabolic
AVOID hypoglycemia



	Acute radiology / Operating room management	
	STAT head/neck CT THEN OR for immediate intervention and /or ICP monitor OR If going to OR for other reasons, needs ICP monitoring. Admit to PICU	ICP Monitoring should be considered regardless of results of Head CT (based on persistent low GCS (8) in severe TBI) *other imaging depending on ATLS

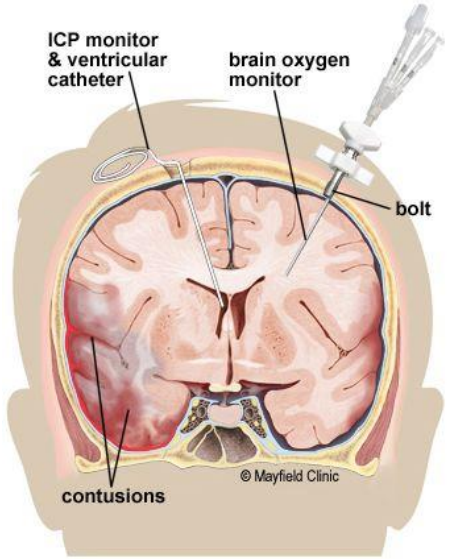
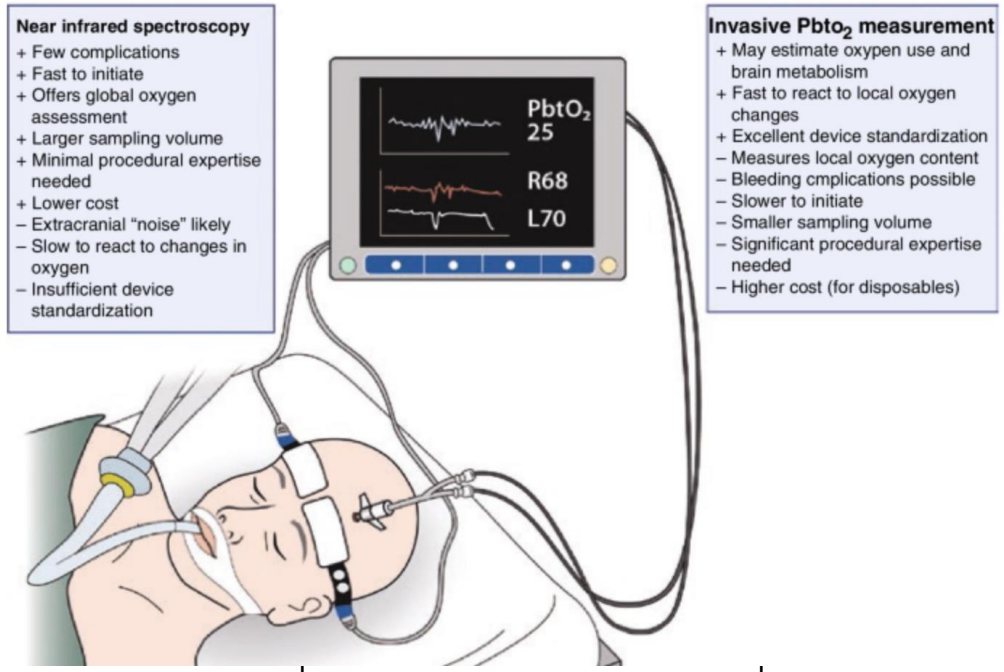


Fig. 1



	ACUTE PICU MONITORING	
Arrival	**MONITORS** Strongly Consider placing intracranial pressure (ICP) monitor Consider PbtO2 monitor Consider Extra ventricular Drain (EVD) Consider NIRS monitoring Continuous EEG monitoring if available (CT/MRI compatible if possible) Continuous temperature and Continuous arterial blood pressure monitoring	**Maintain**: ICP < 20 via normocarbia (arterial CO2 35-39; EtCO2 30-34) Cerebral perfusion pressure (CPP > 40 in young children, >50 in adolescents)

Cerebral Perfusion Pressure= Mean Art Pressure (MAP)-Intracranial Pressure (ICP)

	PHYSIOLOGIC GOALS - Sat > 92% and <= 98% - ICP < 20 mmHg - CO2 arterial: 35-40 (EtCO2 30-35 when reliable) - Avoid hypotension (Rx age dependent minimum MAP) - Adequate brain oxygenation **LABORATORY GOALS** (TO BE DISCUSSED) - Na: - ICP < 20 mmHg: 135-140 mEq - ICP >=20 mmHg: >140 <160 mEq - Glucose: 5-10 mmol/L - Hemoglobin: > 7 mg/dL - Coagulation: normal	Avoid hypotension Adequate brain oxygenation (PbtO2 ≥ 15 - ≤ 35 mmHg) Maintain normothermia, avoid hypoglycemia Call PICU resident/ attending if any value out of range for > 5 min Na sustained >160 associated with complications

PICU Management

Sedation/Analgesia

AVOID HYPOTENSION

- Use smallest doses and/or infusion and titrate to effect

AVOID continuous infusion of Propofol**

TREAT PAIN

Combination analgesia and sedation

Assess/titration

- Score : SBS vs RASS vs other
- Assess q4h + PRN
- Assess 30 min post PRN dose

If no intracranial hypertension:

SBS – 1 to – 2/ RASS -3 to -5

If intracranial hypertension:

SBS - 2 or – 3 / RASS - 4 to - 5

Suggested starting doses for analgesia and sedation:

Morphine start 0.05 mcg/kg/h or

Hydromorphone start 0.01 mcg/kg/h or

Fentanyl 1mcg/kg/h and

Midazolam start 0.03 mg/kg/h

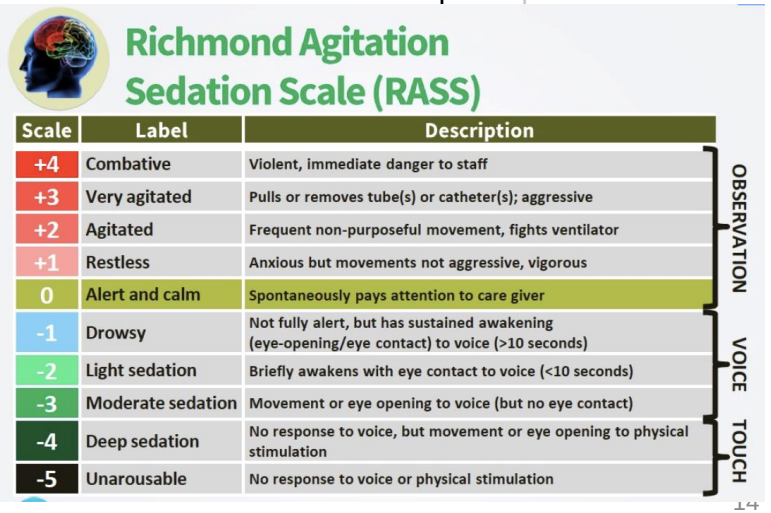
Maintain:

ICP < 20 via normocarbia (arterial CO2 35-39; EtCO2 30-34)

Cerebral perfusion pressure (CPP > 40 in young children, >50 in adolescents)

Avoid hypotension

Adequate brain oxygenation



Richmond Agitation Sedation Scale (RASS)

Scale	Label	Description	
+4	Combative	Violent, immediate danger to staff	OBSERVATION
+3	Very agitated	Pulls or removes tube(s) or catheter(s); aggressive	
+2	Agitated	Frequent non-purposeful movement, fights ventilator	
+1	Restless	Anxious but movements not aggressive, vigorous	
0	Alert and calm	Spontaneously pays attention to care giver	
-1	Drowsy	Not fully alert, but has sustained awakening (eye-opening/eye contact) to voice (>10 seconds)	VOICE
-2	Light sedation	Briefly awakens with eye contact to voice (<10 seconds)	
-3	Moderate sedation	Movement or eye opening to voice (but no eye contact)	
-4	Deep sedation	No response to voice, but movement or eye opening to physical stimulation	TOUCH
-5	Unarousable	No response to voice or physical stimulation	

If intracranial hypertension present, goal RASS -5 / SBS

Infusion (IV):

- fentanyl 1 mcg/kg/h
- Morphine 0.1 mg/kg/h OR
- hydromorphone 0.02 mg/kg/h
- midazolam 0.05 mg/kg/h

Incremental infusion change to target sedation goal:

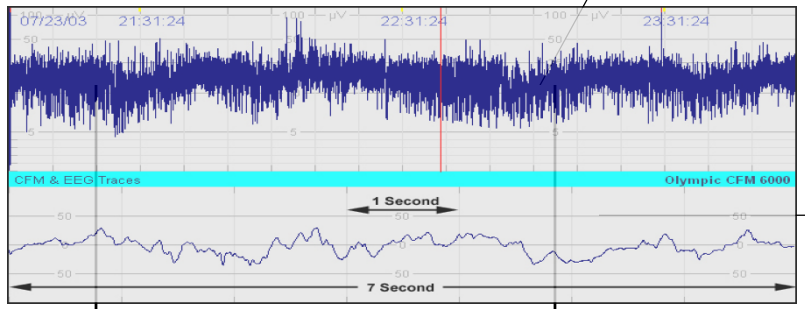
- fentanyl / hydromorphone / midazolam (dosing recs)

PRN doses

- match hourly infusion dose for fentanyl
- agitation present: midazolam (TO BE DISCUSSED)

Targeted Temperature Management

- Avoid hyperthermia (>= 38.0 C esophageal or rectal)
- Goal central temperature: 35.0 to 37.0 Celsius
- *Treatment options*:
  Acetaminophen (regular)
  Environmental adjustments
  Cooling blanket or cooling system (be prepared to manage shivering)* (shivering pathway via pharmacy)



Seizures

Consult neurology

Aggressively treat seizures

Order seizure action plan

Seizure prophylaxis to prevent early seizures

- Strongly consider during the 1st week and for infants and children with:
  < 4 years of age, or intraparenchymal hemorrhage, or depressed skull fracture or concern for abusive head trauma or if EEG positive
- Keppra (dose 25mg/kg BID?) or Phenytoin (dose ___)

Circulation

Ensure central assess (avoid jugular if possible)

Continuous arterial blood pressure monitoring

Initiate Vasopressor as needed to maintain CPP and avoid hypotension

Fluids & Nutrition

Total fluid intake prescribed to avoid excessive fluid administration

Initiate early enteral nutritional support within 72 hours from injury

- Progress slowly as tolerated to avoid discomfort

	OG tube if concern for basilar skull fracture **Physical/Occupational Therapy** - Consult PT/OT upon PICU admission **Skin Care** - Turn patients as per routine (q2h) - Protective mattress	

ELEVATED ICP TREATMENT ALGORITHM

For elevated ICP in the absence of noxious stimuli, regardless of the monitor that is in place, the following actions should be taken to achieve a goal of ICP < 20 mmHG.

ICP > 20 mmHg for > 5 minutes
Verify equipment (level of monitor to bed)
Call PICU resident / attending
Adjust head of bed
and/or
Loosen c-collar to promote venous drainage
Open EVD transiently, if present
Check pupils for signs herniation

↓

If NO resolution after 5 minutes
Adequate sedation and analgesia – consider bolus and increase infusion and additional pharmacotherapy
Avoid midazolam and /or Fentanyl bolus which can reduce cerebral perfusion
AVOID HYPOTENSION

↓

If NO resolution after 5 minutes
Consider hyperosmolar therapy
3% hypertonic saline: 2-5 ml/kg over 10-20 min?
20% Mannitol 0.25-0.5 g/kg
(monitor for osmotic diuresis and treat hypotension)
Monitor Osmolarity (Na 160)?

↓

If NO resolution after 5 minutes
Bolus analgesia/sedation and incremental increase infusion
Consider neuromuscular blockade
Consider cEEG monitoring (if not present)
Consider repeat head CT

Consider vasopressor in order to minimize impact of sedation on BP

Decompressive Craniectomy Criteria

Persistent ICP > 20 with/without PbtO2 < 15 / CPP < 40 that fails to respond to escalation of therapies, including:
Adjusting HOB
Loosening collar
Increased sedation &

↓ If NO resolution, after 5 min Consider Initiation of barbiturate coma for burst suppression on cEEG Bolus dose: 3-5 mg/kg IV (low dose recommended to avoid hypotension), repeat boluses q30min? to achieve burst suppression (will take multiple boluses) Continuous IV infusion: 1-4 mg/kg/hour Order/begin continuous *IV Phenylephrine or Norepinephrine* infusion when starting Pentobarbital continuous infusion AND/OR Consider moderate hypothermia, 32-34°C If signs of herniation: 1. Hyperventilated to lower arterial paCO2 to 28-34 mm Hg Discuss with neurosurgery to consider early decompressive craniectomy **Decompressive craniectomy** Consider with persistent elevated ICP with/without PbtO2 < 15 / CPP < 40 that fails to respond to escalation of medical management including: - Adjusting head of bead - Loosening c-spine collar - Increased sedation & analgesia - Failure to control seizures - Hypertonic saline (3%) bolus ~~+ infusion~~ - Neuromuscular blockade (bolus + infusion) - Pentobarbital (bolus + infusion) - Hypothermia (temp 32-34?)	Failure to control seizures 3% hypertonic saline bolus Neuromuscular blockade bolus + infusion Hyperventilation Pentobarbital bolus + infusion

PbtO2 (Licox) Monitoring

The Licox monitors ICP, brain tissue oxygenation (PbtO2) and brain temperature.

Cerebral Ischemia +/- Elevated ICP

If concern for cerebral ischemia (PbtO2 <= 15), perform the following actions:

Perform "O2 Challenge" test to rule out monitor malfunction

Increase FiO2 transiently to 100% to increase PaO2 and assess:

- Licox functioning: increase in brain PbtO2
- Possible Licox dysfunction: no PbtO2 improvement → decrease FiO2 to ____ and contact neurosurgery to discuss Licox and possible imaging (CT)

If O2 Challenge is Passed:

1. Decrease FiO2 to lowest level to maintain PbtO2 >= 15 (max FiO2 ___ to avoid O2 toxicity)
2. If lowest FiO2 = 55% and PbtO2 continues to decrease, consider the following: (see below)

Values in mmHg	ICP ≤ 22	ICP > 22
$PbtO_2 \geq 20$	**Type A** No interventions needed	**Type B** Interventions to lower ICP
$PbtO_2 < 20$	**Type C** Interventions to increase $PbtO_2$	**Type D** Interventions to lower ICP and increase $PbtO_2$

DE-ESCALATION OF INVASIVE MONITORING / INTERVENTIONS

Once ICP normal for 24-48 hours, can consider de-escalation of interventions but maintain monitoring

Wean (in this order):

- Pentobarbital infusion (stop infusion as slowly elimination)
- Neuromuscular blockade
- Hypertonic saline therapy
- Sedation infusions

Remove

- ICP monitor prior to extubation
- C-spine (c-collar) if cleared by Trauma

INTRACRANIAL HYPERTENSION

ICP > 20mmHg for > 5 minutes

Verify equipment (level of monitor to bed)

Call PICU resident/Fellow/MD
Look for signs and symptoms of herniation:
- Pupillary dilatation
- Hypertension/bradycardia
- Extensor positioning

STEP 1:
Adjust:
- HOB (≥ 30°)
- Neutral Head Positioning (unless contra-indication)
- Loosen c-collar to promote venous drainage

Consider CSF drainage if EVD in place

STEP 2: If NO resolution after 5 minutes
Provide adequate sedation and analgesia:
- consider bolus
- or increase infusion
- or additional pharmacotherapy

Avoid midazolam and /or Fentanyl bolus which can reduce cerebral perfusion
AVOID HYPOTENSION

STEP 3: If NO resolution after 5 minutes
Consider hyperosmolar therapy:
- 3% hypertonic saline 2-5 ml/kg over 10-20 min
- Or 20% Mannitol 0.25-0.5 g/kg over 20-30 min (monitor for osmotic diuresis and treat hypotension)

STEP 4: If NO resolution after 5 minutes
Consider:
- Continuous EEG
- Neuromuscular blockade
- Additional sedation / Hyperosmolar therapy
- Repeat Head CT

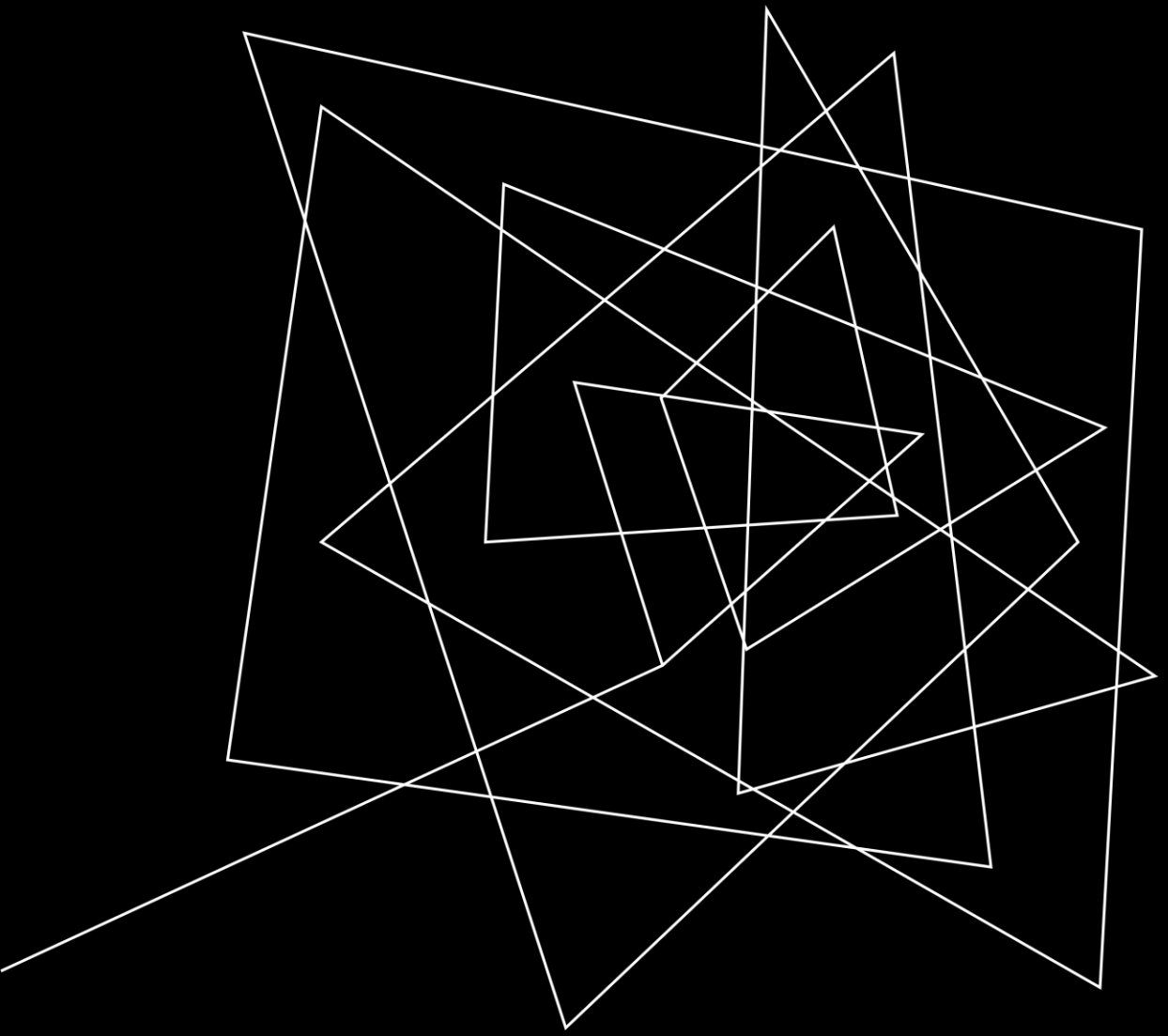
Call neurosurgery

STEP 5 : If NO resolution after 5 minutes
Consider
- Surgical intervention: remove mass lesion / or decompressive craniectomy
- Initiation of Barbiturate coma for burst suppression on cEEG (Avoid/anticipate hypotension)
- Moderate hypothermia 32-34°C
- Hyperventilation
- Higher level of osmolar therapy

If signs of herniation

Emergent treatment :
- Open EVD
- Hyperventilation (titrate)
- FiO2 100%
- Hypertonic saline or mannitol bolus

Emergency CT
Call Neurosurgery



GUIDELINE REVIEW 2019

GUIDELINE RECOMMENDATIONS

ICP Monitoring

Recommendations

Strength of Recommendations: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

To Improve Overall Outcomes. III.1. Use of ICP monitoring is suggested.

Changes From Prior Edition. There are no content changes from the Second Edition to the recommendations. Three new class 3 retrospective observational studies were added to the evidence base for this topic (17–19).

Regardless of initial
Head imaging results.
Normal CT Head is not indicative
of lack of raised ICP !!

ADVANCED NEUROMONITORING

Advanced Neuromonitoring

Recommendations

Strength of Recommendation: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

To Improve Overall Outcomes. III.1. If brain tissue oxygenation ($Pbro_2$) monitoring is used, maintaining a level greater than 10 mm Hg is suggested.

Note 1. There was insufficient evidence to support a recommendation for the use of a monitor of $Pbro_2$ to improve outcomes.

ICP THRESHOLD

Recommendations

Strength of Recommendation: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

To Improve Overall Outcomes

III.1. Treatment of ICP targeting a threshold of less than 20 mm Hg is suggested.

Changes From Prior Edition. There are no content changes from the Second Edition to the recommendations. Two new class 3 retrospective observational studies were added to the evidence base for this topic (73, 74), and one class 3 study from the Second Edition was removed (53).

CPP THRESHOLD

Thresholds for CPP Recommendations

Strength of Recommendations: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

To Improve Overall Outcomes. III.1. Treatment to maintain a CPP at a minimum of 40 mm Hg is suggested.

III.2. A CPP target between 40 and 50 mm Hg is suggested to ensure that the minimum value of 40 mm Hg is not breached. There may be age-specific thresholds with infants at the lower end and adolescents at or above the upper end of this range.

Changes From Prior Edition. There are no content changes from the Second Edition to the recommendations. Of the 15 included studies (30, 40, 44, 52, 60, 61, 73, 74, 79–85), four are new to this edition. One new class 2 (79) and three new class 3 retrospective observational studies were added to the evidence base for this topic (73, 74, 85).

SEDATION IN PICU

Analgesics, sedatives, and neuromuscular blockade

Level III

For ICP Control

III.1. With use of multiple ICP-related therapies, as well as appropriate use of analgesia and sedation in routine ICU care, avoiding bolus administration of midazolam and/or fentanyl during ICP crises is suggested due to risks of cerebral hypoperfusion.

Note 1: In the absence of outcome data, the specific indications, choice, and dosing of analgesics, sedatives, and neuromuscular blocking agents should be left to the treating physician.

Note 2: Based on guidance from the U.S. Food and Drug Administration, prolonged continuous infusion of propofol for either sedation or the management of refractory intracranial hypertension is not recommended.

HYPEROSMOLAR THERAPY

Hyperosmolar Therapy

Recommendations

Strength of Recommendations: Weak

Level I

There was insufficient evidence to support a level I recommendation for this topic.

Level II

For ICP Control. II.1. Bolus HTS (3%) is recommended in patients with intracranial hypertension. Recommended effective doses for acute use range between 2 and 5 mL/kg over 10–20 minutes.

Level III

For ICP Control. III.1. Continuous infusion HTS is suggested in patients with intracranial hypertension. Suggested effective doses as a continuous infusion of 3% saline range between 0.1 and 1.0 mL/kg of body weight per hour, administered on a sliding scale. The minimum dose needed to maintain ICP less than 20 mm Hg is suggested.

III.2. Bolus of 23.4% HTS is suggested for refractory ICP. The suggested dose is 0.5 mL/kg with a maximum of 30 mL.

Safety Recommendation (applies to all recommendations for this topic). In the context of multiple ICP-related therapies, avoiding sustained (> 72 hr) serum sodium greater than 170 mEq/L is suggested to avoid complications of thrombocytopenia and anemia, whereas avoiding a sustained serum sodium greater than 160 mEq/L is suggested to avoid the complication of deep vein thrombosis (DVT).

SEDATION

Analgesics, Sedatives, and NMB

Recommendations

Strength of Recommendations: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

For ICP Control. III.1. With use of multiple ICP-related therapies, as well as appropriate use of analgesia and sedation in routine ICU care, avoiding bolus administration of midazolam and/or fentanyl during ICP crises is suggested due to risks of cerebral hypoperfusion.

Note 1. In the absence of outcome data, the specific indications, choice, and dosing of analgesics, sedatives, and neuromuscular blocking agents should be left to the treating physician.

Note 2. Based on guidance from the U.S. Food and Drug Administration, prolonged continuous infusion of propofol for either sedation or the management of refractory intracranial hypertension is not recommended.

CSF DRAINAGE

CSF Drainage

Recommendations

Strength of Recommendation: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

For ICP Control. III.1. CSF drainage through an EVD is suggested to manage increased ICP.

Changes From Prior Edition. The recommendation from the Second Edition about use of lumbar drain (LD) was eliminated. One new class 3 treatment series was added to the evidence base for this topic (127).

SEIZURE PROPHYLAXIS

Seizure Prophylaxis

Recommendations

Strength of Recommendation: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

For Seizure Prevention (Clinical and Subclinical). III.1. Prophylactic treatment is suggested to reduce the occurrence of early (within 7 d) PTSs.

Note. At the present time, there is insufficient evidence to recommend levetiracetam over phenytoin based on either efficacy in preventing early PTS (EPTS) or toxicity.

Changes From Prior Edition. Recommendation III.1. is modified from the Second Edition of these guidelines, with phenytoin removed. The note regarding levetiracetam is new to this Third Edition. Three new class 3 studies—one prospective observational (131), one retrospective observational (132), and one treatment series (133)—have been added to the evidence base for this topic.

PCO2 CONTROL

Ventilation Therapies

Recommendations

Strength of Recommendations: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

To Improve Overall Outcomes. III.1. Prophylactic severe hyperventilation to a $Paco_2$ less than 30 mm Hg in the initial 48 hours after injury is not suggested.

III.2. If hyperventilation is used in the management of refractory intracranial hypertension, advanced neuromonitoring for evaluation of cerebral ischemia is suggested.

Changes From Prior Edition. There are no content changes from the Second Edition to the recommendations. The title was

TEMPERATURE CONTROL & HYPOTHERMIA

Temperature Control/Hypothermia

Recommendations

Strength of Recommendation: Moderate

Level I

There was insufficient evidence to support a level I recommendation for this topic.

Level II

To Improve Overall Outcomes. II.1. Prophylactic moderate (32–33°C) hypothermia is not recommended over normothermia to improve overall outcomes.

Level III

For ICP Control. III.1. Moderate (32–33°C) hypothermia is suggested for ICP control.

Safety Recommendation 1. If hypothermia is used and rewarming is initiated, it should be carried out at a rate of 0.5–1.0°C every 12–24 hours or slower to avoid complications.

Safety Recommendation 2. If phenytoin is used during hypothermia, monitoring and dosing adjusted to minimize toxicity, especially during the rewarming period, are suggested.

REFRACTOROY ICP

BARBITURATES

Recommendations

Strength of Recommendations: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

For ICP Control. III.1. High-dose barbiturate therapy is suggested in hemodynamically stable patients with refractory intracranial hypertension despite maximal medical and surgical management.

Safety Recommendation. When high-dose barbiturate therapy is used to treat refractory intracranial hypertension, continuous arterial blood pressure monitoring and cardiovascular support to maintain adequate CPP are required because cardiorespiratory instability is common among patients treated with barbiturate coma.

THIOPENTAL and PENTOBARBITAL
Are no longer available.
Phenobarbital must be used

REFRACTORY ICP

Decompressive Craniectomy

Recommendations

Strength of Recommendation: Weak

Levels I and II

There was insufficient evidence to support a level I or II recommendation for this topic.

Level III

For ICP Control. III.1. Decompressive craniectomy (DC) is suggested to treat neurologic deterioration, herniation, or intracranial hypertension refractory to MM.

Changes From Prior Edition. The specification in the recommendation from the Second Edition, ". . . with duraplasty, leaving the bone flap out . . ." has been removed, and for this edition, the recommendation is made specifically for ICP control. One class 3 RCT from the First Edition which was removed from the Second Edition was returned to this edition (176). Fourteen new class 3 studies—five retrospective comparisons (176–180) and nine treatment series (181–189)—were added to the evidence base for this topic.

NUTRITION

Nutrition

Recommendations

Strength of Recommendations: Weak

Level I
There was insufficient evidence to support a level I recommendation for this topic.

Level II
To Improve Overall Outcomes. II.1. Use of an immune-modulating diet is not recommended.

Level III
To Improve Overall Outcomes. III.1. Initiation of early enteral nutritional support (within 72 hr from injury) is suggested to decrease mortality and improve outcomes.

Changes From Prior Edition. The level III recommendation from the Second Edition has been removed. Recommendation III.1. is new to this Third Edition. One new class 3 retrospective observational study was added to the evidence base for this topic (209).

THANK YOU

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REFERENCES