SIBICC SEVERE TBI ALGORITHM
FOR PATIENTS WITH ICP MONITORING

A comprehensive protocol designed to assist clinicians managing sTBI patients undergoing ICP monitoring. These recommendations are based on combined expert option and reflect neither a standard-of-care nor a substitute for thoughtful individualized management.

PRINCIPLES FOR USING TIERS:

- When possible, use lowest tier treatment
- There is no rank order within a tier
- It is not necessary to use all modalities in a lower tier before moving to the next tier
- If considered advantageous, tier can be skipped when advancing treatment

TIER 0

Basic Severe TBI Care – Not ICP Dependent

Expected Interventions:

- Admission to ICU
- Endotracheal intubation and mechanical ventilation
- Serial evaluations of neurological status and pupillary reactivity
- Elevate HOB 30–45°
- Analgesia to manage signs of pain (not ICP directed)
- Sedation to prevent agitation, ventilator asynchrony, etc. (not ICP directed)
- Temperature management to prevent fever
  - –Measure core temperature
  - –Treat core temperature above 38°C
- Consider anti-seizure medications for 1 week only (in the absence of an indication to continue)
- Maintain CPP initially ≥ 60mmHg
- Maintain Hb > 7g/dL
- Avoid hyponatremia
- Optimize venous return from head (e.g. head midline, ensure cervical collars are not too tight)
- Arterial line for continuous blood pressure monitoring
- Maintain SpO_2 ≥ 94%

Recommended Interventions:

- Insertion of a central line
- End-tidal CO_2 monitoring

TIER 1

- Maintain CPP 60–70 mmHg
- Increase analgesia to lower ICP
- Increase sedation to lower ICP
- Maintain P_aCO_2 at low end of normal (35–38 mmHg/4.7–5.1 kP_a)
- Mannitol by intermittent bolus (0.25–1.0 g/kg)
- Hypertonic saline by intermittent bolus[1]
- CSF drainage if EVD *in situ*
- Consider placement of EVD to drain CSF if parenchymal probe used initially
- Consider anti-seizure prophylaxis for one week only (unless indication to continue)
- Consider EEG monitoring

TIER 2

- Mild hypocapnia range 32–35 mmHg/4.3–4.6 kP_a
- Neuromuscular paralysis in adequately sedated patients if efficacious[2]
- Perform MAP Challenge to assess cerebral autoregulation and guide MAP and CPP goals in individual patients[3]
  - – Should be performed under direct supervision of a physician who can assess response and ensure safety
  - – No other therapeutic adjustments (i.e. sedation) should be performed during the MAP Challenge
  - – Initiate or titrate a vasopressor or inotrope to increase MAP by 10 mmHg for not more than 20 minutes
  - – Monitor and record key parameters (MAP, CPP, ICP and $P_{bt}O_2$) before during and after the challenge
  - – Adjust vasopressor/inotrope dose based on study findings
- Raise CPP with fluid boluses, vasopressors and/or inotropes to lower ICP when autoregulation is intact

TIER 3

- Pentobarbital or Thiopentone coma titrated to ICP control if efficacious[4]
- Secondary decompressive craniectomy
- Mild hypothermia (35–36°C) using active cooling measures

- Re-examine the patient and consider repeat CT to re-evaluate intracranial pathology
- Reconsider surgical options for potentially surgical lesions
- Review that basic physiologic parameters are in desired range (e.g. CPP, blood gas values)
- Consider consultation with higher level of care if applicable for your health care system

[1] We recommend using sodium and osmolality limits of 155mEq/L and 320mEq respectively as administration limits for both mannitol and hypertonic saline.

[2] We recommend a trial dose of neuromuscular paralysis and only proceeding to a continuous infusion when efficacy is demonstrated.

[3] Rosenthal G, Sanchez-Mejia RO, Phan N, Hemphill JC 3rd, Martin C, Manley GT. Incorporating a parenchymal thermal diffusion cerebral blood flow probe in bedside assessment of cerebral autoregulation and vasoreactivity in patients with severe traumatic brain injury. J Neurosurg. 2011;114(1):62–70. doi:10.3171/2010.6. JNS091360

[4] Barbiturate administration should only be continued when a beneficial effect on ICP is demonstrated.
–Titrate barbiturate to achieve ICP control but do not exceed the dose which achieves burst suppression.
–Hypotension must be avoided when barbiturates are administered.

AUTOREGULATION

MAP Challenge

Record baseline parameters at the beginning of the challenge (ICP, MAP, CPP).

Initiate or titrate a vasopressor to increase the MAP by 10 mmHg for up to 20 minutes.

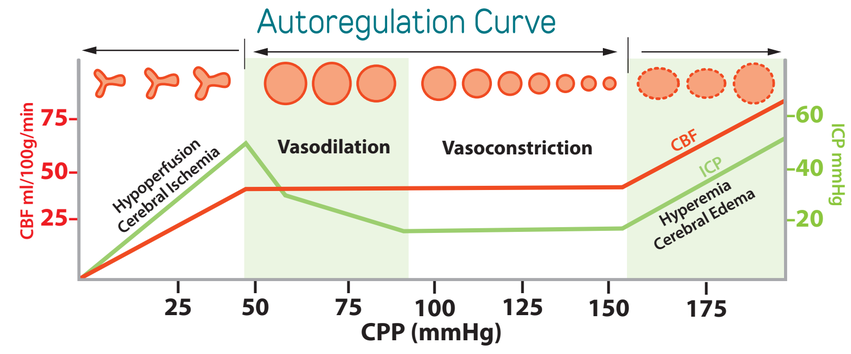
Observe the interaction between the MAP, ICP, and CPP during the challenge.

Record monitor parameters at the end of the challenge.

Evaluate the observed responses and recorded values for evidence of static pressure autoregulation status (sPAR). Disrupted sPAR will present as a sustained increase in ICP with MAP elevation.

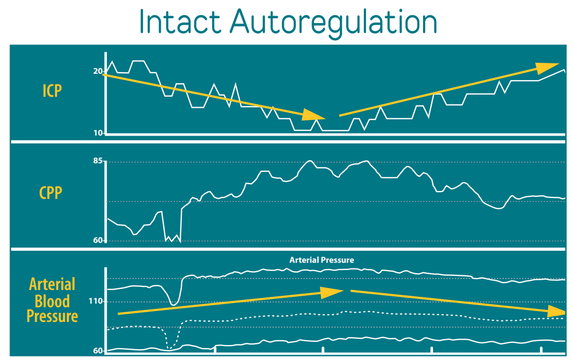
Adjust the target MAP back to baseline (disrupted sPAR) or to the chosen new, elevated target (intact sPAR).

Autoregulation Curve

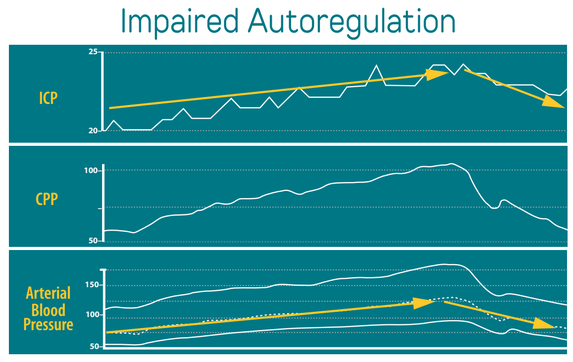


Lassen NA (1959). Cerebral blood flow and oxygen consumption in man. Physiol Rev. 39, 183–238.

Intact Autoregulation



Impaired Autoregulation



GCS SCORING

Indicator of level of consciousness	Term used: 1974	Term used: 2014
Eye Opening	Spontaneous	Spontaneous
	To speech	To sound
	To pain	To pressure
	None	None
Verbal Response	Orientation	Orientated
	Confused conversation	Confused
	Inappropriate speech	Words
	Incomprehensible speech	Sounds
	None	None
Motor response	Obey commands	Obey commands
	Localizing	Localizing
	Normal flexion	Normal flexion
	Abnormal flexion	Abnormal flexion
	Extension	Extension
	None	None

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CRITICAL NEUROWORSENING

A serious deterioration in clinical neurologic status which requires an immediate physician response such as:

- Spontaneous decrease in the GCS motor score of ≥ 1 points (compared with the previous examination)
- New decrease in pupillary reactivity
- New pupillary asymmetry or bilateral mydriasis
- New focal motor deficit
- Herniation syndrome or Cushing's Triad

RESPONSE TO CRITICAL NEUROWORSENING

Emergent evaluation to identify possible cause of neuroworsening. If herniation is suspected:

- Empiric treatment
  - –Hyperventilation[5]
  - –Bolus of hypertonic solution
- Consider emergent imaging or other testing
- Rapid escalation of treatment

[5] The hyperventilation P_aCO_2 limit 30 mmHg/ 4.0 kPa does not apply here

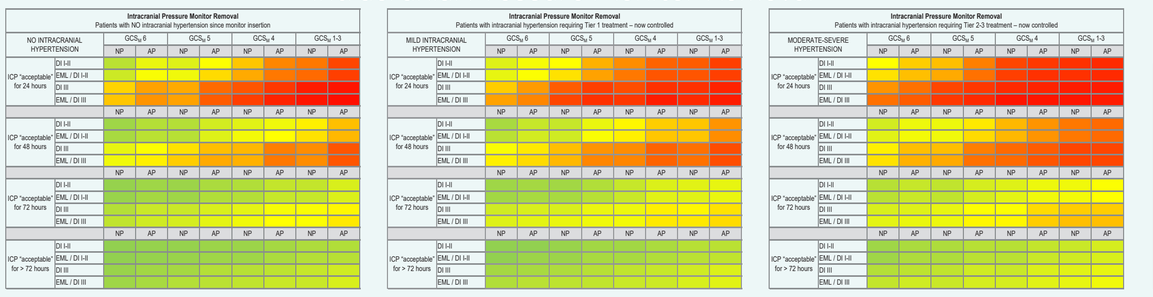
POSSIBLE CAUSES OF NEUROWORSENING

- Expanding intracranial mass lesion
- Cerebral edema
- Elevated ICP
- Stroke
- Electrolyte or other metabolic disturbance
- Medical comorbidity
- Medication effect
- Impaired renal or hepatic function
- Systemic hypotension
- Seizure or post-ictal state
- Hypoxemia/tissue hypoxia
- CNS infection
- Infection or sepsis
- Substance withdrawal
- Dehydration
- Hyper or hypothermia

HEATMAPS INFORMING THE SAFETY OF A SEDATION HOLIDAY AND ICP MONITOR REMOVAL

AP=Abnormal pupils; CT=Computed tomography; DI=Diffuse injury as defined in the Marshall CT Head Score; EML=Evacuated mass lesion as defined in the Marshall CT Head Score; GCS=Glasgow Coma Scale; ICP=Intracranial pressure; NP=Normal pupils

Intracranial Pressure Monitor Removal



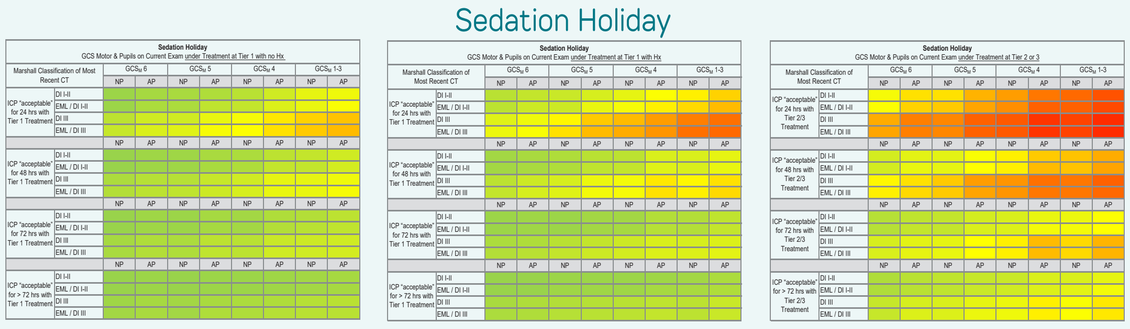
Color reflects composite panel opinion for the given conditions

DO NOT PROCEED

PROCEED WITH CAUTION

PROCEED

Sedation Holiday



TREATMENT **NOT** RECOMMENDED

Mannitol by non-bolus continuous intravenous infusion
Scheduled infusion of hyperosmolar therapy (e.g., every 4–6 h)
Lumbar CSF drainage

Furosemide
Routine use of steroids
Routine use of therapeutic hypothermia to temperatures below 35 °C due to systemic complications

High-dose propofol to attempt burst suppression
Routinely decreasing PaCO2 below 30 mmHg/4.0 kPa
Routinely raising CPP above 90 mmHg

Look for additional information on

1. A management algorithm for patients with intracranial pressure monitoring: The Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC)
2. Glasgow coma scale
3. Guidelines for the management of severe TBI 4th edition
4. Marshall CT Score Paper
5. Randall Chesnut's 2019 CNS presentation

Meeting Participants and Authors: Gregory W. J. Hawryluk, Sergio Aguilera, Andras Buki, Eileen Bulger, Giuseppe Citerio, D. Jamie Cooper, Ramon Diaz Arrastia, Michael Diringer, Anthony Figaji, Guoyi Gao, Romergryko Geocadin, Jamshid Ghajar, Odette Harris, Alan Hoffer, Peter Hutchinson, Mathew Joseph, Ryan Kitagawa, Geoffrey Manley, Stephan Mayer, David K. Menon, Geert Meyfroidt, Daniel B. Michael, Mauro Oddo, David Okonkwo, Mayur Patel, Claudia Robertson, Jeffrey V. Rosenfeld, Andres M. Rubiano, Juan Sahuquillo, Franco Servadei, Lori Shutter, Deborah Stein, Nino Stocchetti, Fabio Silvio Taccone, Shelly Timmons, Eve Tsai, Jamie S. Ullman, Paul Vespa, Walter Videtta, David W. Wright, Christopher Zammit and Randall Chesnut; Poster Creation: Randall Chesnut, Gregory Hawryluk, Karen March, Linda Littlejohns, Tyler Harmon, Global Neuro

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