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DEPARTMENT (DIVISION): Trauma  
TITLE: Guidelines for the Management of Head Injury

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## Purpose

To assist Associates and Medical Staff Members in the evaluation and management of patients with head injury. With reference to severe traumatic brain injury, these guidelines have been informed by and are intended to align with the “Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents – Second Edition” and the “Best Practices in the Management of Traumatic Brain Injury” published by the American College of Surgeons Trauma Quality Improvement Program.<sup>3,4</sup> Interested readers may wish to consult these sources for detailed recommendations and supporting evidence.

## Guidelines

- 1) Minor Head Injury
  - a) Definition – Glasgow Coma Scale [GCS] score 13 – 15. Typically a patient with GCS 15 is neurologically normal: awake with sustained eye opening, oriented to person, place, and time, and able to follow spoken commands. A patient with GCS 14 may be disoriented but otherwise normal. In addition to disorientation a patient with GCS 13 may exhibit a tendency to eye closure in the absence of stimulation. An infant with a minor head injury may be behaviorally normal. Or the infant may have open eyes but exhibit less spontaneous activity than normal. Or the infant may have a tendency to close eyes in the absence of verbal or tactile stimulation. A crying infant with a minor head injury can be consoled. In the absence of another painful injury, inconsolable crying is not consistent with minor head injury.
  - b) Evaluation
    - i) The initial clinical evaluation is performed by the staff of the Emergency Department [ED].
    - ii) Low-dose CT scanning of the head is performed, if indicated according to Pediatric Emergency Care Applied Research Network [PECARN] guidelines.<sup>5</sup>

- iii) Radiography or CT scanning of the cervical spine is performed, if indicated according to the NEXUS criteria – see N/AIDHC Clinical Management Guideline No. 5.05 and Appendix 2.<sup>8</sup>
- c) Management
  - i) Isotonic intravenous fluids are administered if there is a history of vomiting or if the patient must be kept NPO for a protracted period for imaging or surgical consultation.
  - ii) Non-narcotic analgesics are administered for painful injuries.
- d) Consultation
  - i) The ED requests Trauma Service consultation if admission is anticipated [see 1-e] or for other indications in accordance with N/AIDHC Policy and Procedure No. 3.04.
  - ii) The Trauma Service consults the CARE Team in accordance with hospital policy – see N/AIDHC Policy and Procedure No. 60.82.
  - iii) The Trauma Service requests consultation by the Neurosurgery Service if admission is anticipated. This consultation is completed within 24 hours.
  - iv) The Trauma Service requests consultation by the Rehabilitation service if admission is anticipated.
    - (1) The consulting physiatrist arranges rehabilitation or outpatient follow-up in Concussion Clinic as clinically indicated.
- e) ED Disposition
  - i) The patient is admitted to a general in-patient nursing unit on the Trauma service.
    - (1) Inability to tolerate normal feedings is an indication for admission
    - (2) Suspicion of abusive head injury is an indication for admission.
    - (3) Intracranial hemorrhage on CT scan is an indication for admission. If the presence of hemorrhage is questionable, or if the injury is older than 24 hours, the decision for admission is made at the discretion of the Trauma Service in consultation with the neurosurgeon.
  - ii) If none of the above-mentioned indications for admission are present, the patient is discharged from the ED.
    - (1) Referral is made to the patient's primary physician for follow-up within 2 days and for referral to the Concussion Clinic at the primary physician's discretion.
  - iii) Direct referral to Concussion Clinic from the ED is appropriate for patients with histories of multiple previous concussions.
- f) Inpatient disposition:
  - i) The patient is discharged from the inpatient Trauma Service when the following criteria are met
    - (1) The patient is tolerating an age-appropriate diet
    - (2) The patient has returned to neurologic and behavioral baseline
    - (3) All necessary diagnostic investigations and evaluations have been completed.

- (4) If CARE Team consultation has been required, the discharge destination has been determined to be appropriate by the CARE Team or by the relevant state agency.
  - ii) The patient is referred to Concussion Clinic for follow-up.
  
- 2) Moderate Traumatic Brain Injury [TBI]
  - a) Definition – GCS 9 – 12. A patient with a moderate TBI falls on the continuum of responsiveness between minor head injury, as defined above, and traumatic coma or severe TBI, as defined below. [If a patient with a moderate TBI has been intubated, Section 4) applies.] A patient with GCS 13 – 15 who requires a neurosurgical procedure – typically elevation of a depressed skull fracture or evacuation of an epidural hematoma – is considered to have moderate TBI as well.
  - b) Evaluation
    - i) The initial clinical evaluation is performed by Emergency Medicine and/or the Trauma Service, unless evaluation at a referring hospital has demonstrated a condition requiring admission directly to the Operating Room [OR] for immediate surgical intervention.
    - ii) Low-dose CT scanning of the head is performed.
    - iii) Radiography or CT scanning of the cervical spine is performed, if indicated according to the NEXUS criteria – see N/AIDHC Clinical Management Guideline No. 5.05 and Appendix 2.<sup>8</sup>
    - iv) Laboratory studies
      - (1) additional studies as indicated by the CT scan or by injuries of other organ systems.
  - c) Consultation
    - i) The ED initiates a Trauma Activation in accordance with N/AIDHC Policy and Procedure No. 3.01.
    - ii) The Trauma Service requests consultation by the Neurosurgery Service. The neurosurgeon will review imaging studies at the time of the consultation and will complete the consultation within 24 hours.
    - iii) The Trauma Service consults the CARE Team if indicated in accordance with N/AIDHC Policy and Procedure No. 60.82.
    - iv) The Trauma Service requests consultation by the Physical Medicine & Rehabilitation Service.
      - (1) The consulting physiatrist arranges rehabilitation or outpatient follow-up in Concussion Clinic as clinically indicated.
  - d) Management
    - i) The patient is admitted to the hospital under the Trauma Service. Whether to the OR, to the Pediatric Intensive Care Unit [PICU], or to a general in-patient nursing unit is determined by the trauma surgeon conferring with the neurosurgeon.
    - ii) Neurosurgical procedures are performed as indicated. Post-neurosurgical care is provided in the PICU. [If the patient is not extubated after of the procedure, Section 4) applies.]

- iii) O2 saturation is monitored continuously.
  - iv) Vital signs and neurological checks are performed at intervals according to the policy of the nursing unit to which the patient is admitted.
  - v) The patient is kept NPO. Restrictions on oral intake are liberalized at the discretion of the trauma surgeon conferring with the neurosurgeon.
  - vi) Isotonic fluids are continued by vein until a regular diet is tolerated.
  - vii) Serum Na is measured every 12 hours until a regular diet is tolerated.
  - viii) Non-narcotic analgesics are administered as needed.
  - ix) The neurosurgeon on call is contacted immediately for any perceived deterioration in responsiveness or neurological status.
- 3) Severe Traumatic Brain Injury
- a) Definition – GCS 3 – 8. Typically a patient with GCS 8 groans [if not already intubated], opens eyes briefly, and withdraws to painful stimulation. GCS 3 implies unresponsiveness to painful stimulation in all dimensions. In the severe TBI range, the GCS scores can be determined equally well for infants as for older children.
  - b) Evaluation
    - i) The initial evaluation is performed in the ED, unless evaluation of a transfer patient at the referring hospital has demonstrated a condition requiring admission directly to the Operating Room [OR] for immediate surgical intervention.
    - ii) Low-dose CT scanning of the head is performed.
    - iii) Radiography or CT scanning of the cervical spine is performed in accordance with N/AIDHC Clinical Management Guideline No. 5.05 and Appendix 2.
    - iv) Laboratory studies
      - (1) electrolytes
      - (2) complete blood count
      - (3) screening coagulation tests
      - (4) type and screen
  - c) Consultation
    - i) The ED initiates a Trauma Code, if one has not already been initiated through the Transport Program, in accordance with N/AIDHC Policy and Procedure No. 3.01.
    - ii) The Neurosurgery Service is included in Trauma Code notification. The neurosurgeon confers immediately in person or by telephone with the trauma surgeon.
    - iii) The Trauma Service consults the CARE Team if indicated in accordance with N/AIDHC Policy and Procedure No. 60.82.
    - iv) The Trauma Service requests consultation by the Physical Medicine & Rehabilitation Service.
  - d) Management
    - i) See Appendices 3 and 4.

- ii) The expectation is that patients with severe TBI are intubated in the ED and that subsequent management takes place in the PICU or the OR. Patients are admitted to the Trauma Service. Rapid clinical deterioration in the ED or in the course of imaging investigation may necessitate urgent treatment. Examples of rapid deterioration are sudden appearance of bradycardia or hypertension, decline in GCS motor score, and dilatation of a previously reactive pupil. In the event of rapid deterioration, the following therapies may be implemented in coordination with Neurosurgery.
  - (1) Hyperventilation
  - (2) Mannitol 0.25 gm / kg bolus
  - (3) 3% NaCL 10 mL / kg bolus
  
- 4) Head injury with Obscured Clinical Examination
  - a) Definition – obscuration of the clinical neurological examination by intubation, sedation, or neuromuscular blockade. Typically intubation and sedation have been performed after an initial clinical assessment for purposes of diagnostic imaging or transportation.
  - b) Evaluation
    - i) The initial evaluation is performed in the ED, unless an urgent surgical indication has been identified in a transfer patient at the referring institution, in which case, at the discretion of the trauma surgeon or the neurosurgeon, the patient may be evaluated in the Operating Room.
    - ii) Low-dose CT scanning of the head is performed.
    - iii) Radiography or CT scanning of the cervical spine is performed in accordance with N/AIDHC Clinical Management Guideline No. 5.05 and Appendix 2.
    - iv) Laboratory
      - (1) electrolytes
      - (2) additional studies as indicated by the CT scan or by injuries of other organ systems.
  - c) Consultation
    - i) The ED initiates a Trauma Code, if one has not already been initiated through the Transport Program, in accordance with N/AIDHC Policy and Procedure No. 3.01.
    - ii) The Neurosurgery Service is included in Trauma Code notification. The neurosurgeon confers immediately in person or by telephone with the trauma surgeon.
    - iii) The Trauma Service consults the CARE Team if indicated in accordance with N/AIDHC Policy and Procedure No. 60.82.
    - iv) The Trauma Service requests consultation by the Physical Medicine & Rehabilitation Service.
  - d) Management
    - i) The patient is admitted to the PICU on the Trauma Service.

- ii) Based on the mechanism of injury, on what is known about the patient's clinical status before intubation, on the patient's current physical examination, and on the CT scan, the neurosurgeon, conferring with the trauma surgeon and the PICU attending, commits within 24 hours to one of the following courses of action:
  - (1) withdrawal of sedation and attempted extubation.
    - (a) If after withdrawal of sedation, the patient opens eyes and exhibits purposeful movements, no escalation of monitoring is required. The patient may be extubated according to the judgment of the PICU attending.
    - (b) If after withdrawal of sedation, the patient does not open eyes and exhibit purposeful movements, the patient will be managed according to guidelines for severe TBI – see Appendices 3 and 4.
  - (2) management according to guidelines for severe TBI – see Appendices 3 and 4.
- 5) Special considerations for specific injuries
  - a) Skull fractures involving the orbit – see N/AIDHC Clinical Management Guideline No. 5.04
  - b) Skull fractures involving the labyrinth or the mastoid sinus
    - i) Consult Otolaryngology.
  - c) CSF rhinorrhea or otorrhea
    - i) elevation of head of bed
    - ii) lumbar CSF drainage if no spontaneous resolution in 72 hours
    - iii) maximal age-appropriate immunization against pneumococcus.<sup>6</sup>
  - d) Cerebrovascular injury
    - i) Screening according to guidelines of the Eastern Association for the Surgery of Trauma<sup>2</sup>
      - (1) arterial hemorrhage from cervicocephalic wound or orifice or expanding cervical hematoma
      - (2) cervical bruit
      - (3) neurological deficit not explained by CT scan
      - (4) cerebral infarct on secondary CT scan
      - (5) LeFort II or III facial fracture
      - (6) basilar skull fracture involving the carotid canal
      - (7) cervical spine fracture involving the foramina transversaria
      - (8) diffuse axonal injury with GCS  $\leq$  6
      - (9) near-hanging with anoxic brain injury
    - ii) CT angiography if screening positive.

## Appendix 1 - The Glasgow Coma Scale<sup>7</sup>

### Motor

- 6 pts - compliance with spoken commands
- 5 pts - purposeful movement, including localization of painful stimuli
- 4 pts - normal withdrawal to painful stimuli
- 3 pts - abnormal flexion to painful stimuli
- 2 pts - abnormal extension to painful stimuli
- 1 pt - unresponsiveness to painful stimuli

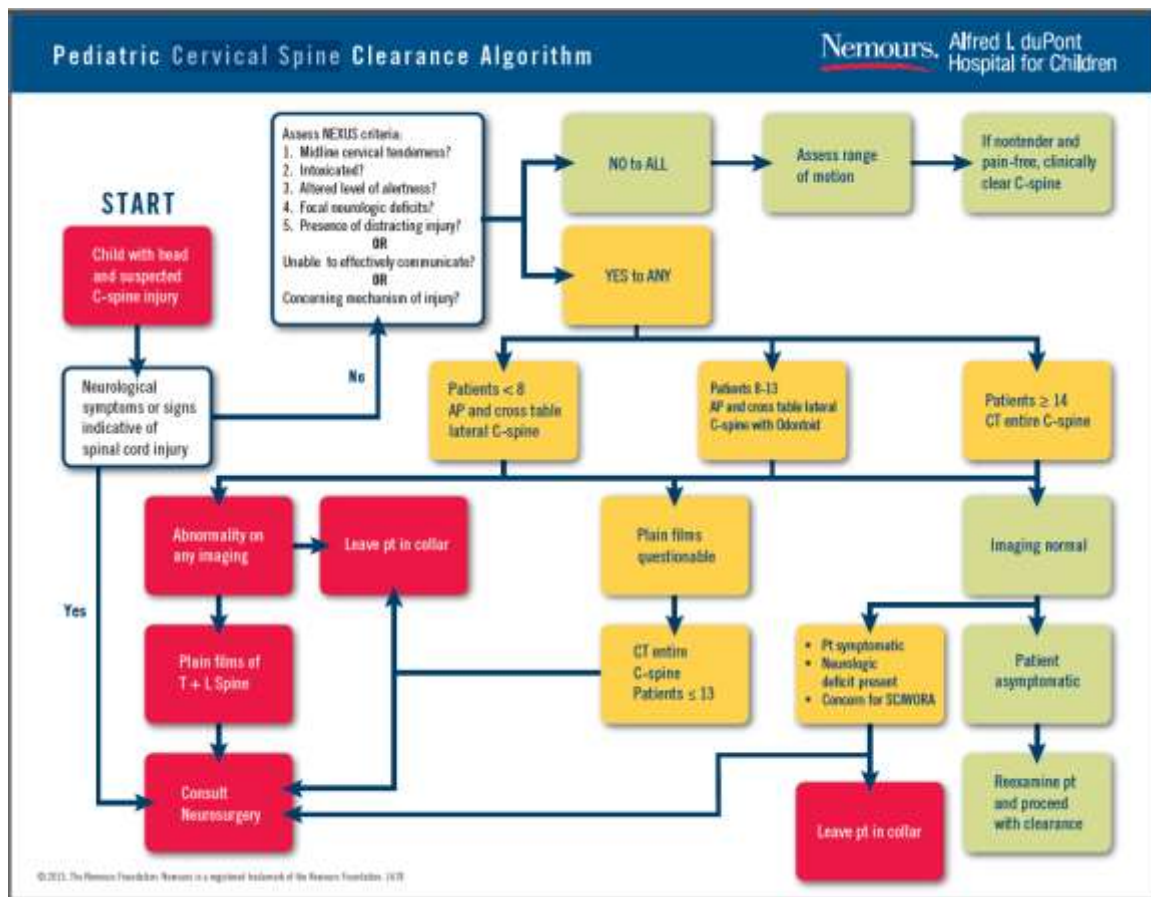
### Eye opening

- 4 pts - spontaneous
- 3 pts - responsive to verbal stimulation
- 2 pts - responsive to painful stimulation
- 1 pt - unresponsive to painful stimuli

### Verbal

- 5 pts - orientation to person, place, and time
- 4 pts - disorientation, but appropriate speech
- 3 pts - inappropriate but intelligible speech
- 2 pts - unintelligible vocalization
- 1 pt - no vocalization to painful stimuli

Appendix 2 - N/AIDHC Pediatric Cervical Spine Clearance Algorithm





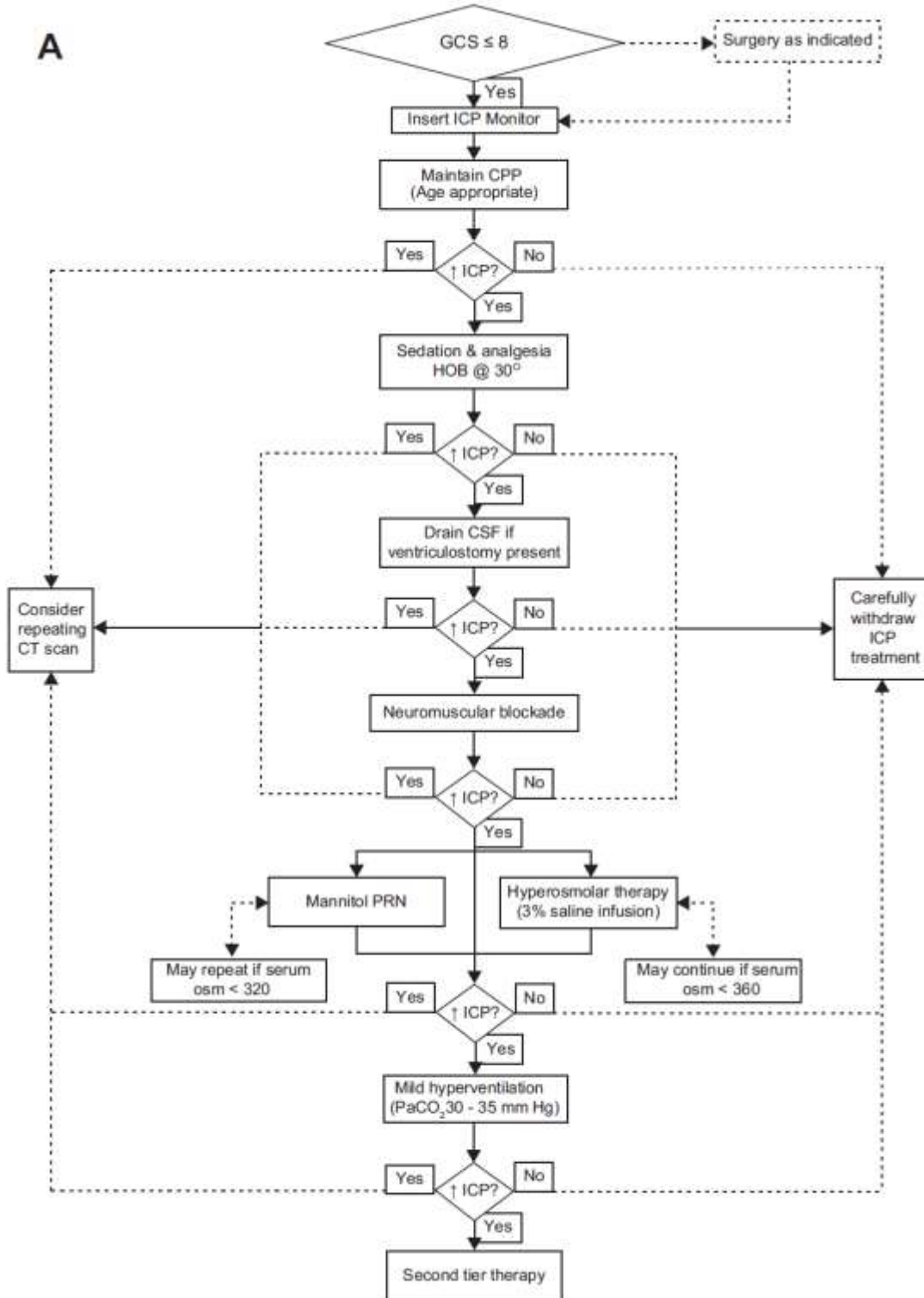
### Appendix 3 - Management of Severe TBI in the PICU

- 1) All patients with severe TBI
  - a) endotracheal intubation for controlled ventilation
    - i) target  $p_{aCO_2}$ : 35 - 40 torr
    - ii) target  $O_2$  saturation: 92 - 100%
    - iii) sedation as needed for controlled ventilation
  - b) central venous access
  - c) intracranial pressure [ICP] monitoring, initiated within 24 hours of admission
  - d) continuous arterial pressure monitoring
  - e) display of cerebral perfusion pressure
  - f) continuous pulse oximetry
  - g) continuous monitoring of end-tidal  $CO_2$
  - h) clinical neuro checks every hour
  - i) continuous monitoring of core temperature and maintenance of normothermia
    - i) acetaminophen / ibuprofen
    - ii) cooling blanket
  - j) bladder catheterization and hourly monitoring of urine output
  - k) naso- or orogastric tube drainage
  - l) earliest possible initiation of full enteral feedings
  - m) electrolytes, blood glucose, and arterial blood gas measurement every 12 hours
  - n) fitting of sequential compression devices, if possible
  - o) isotonic intravenous fluid at maintenance rates
  - p) elevation of head of bed 30 deg
  - q) Position head and neck in neutral position to avoid obstruction of jugular venous drainage; remove cervical orthosis without avoidable delay.
  - r) prophylactic antiepileptic drug therapy for 7 days.
    - i) Keppra
    - ii) Phenytoin
- 2) First Tier Therapy - for elevated intracranial pressure [ICP] above 20 torr continuously for more than 10 minutes or for recurring briefer elevations at the discretion of PICU attending in consultation with the neurosurgeon and the trauma surgeon.
  - a) electrolytes, serum and urine osmolality, blood glucose and arterial blood gas measurements every 6 hours.
  - b) optimization of sedation and analgesia
  - c) ventricular CSF drainage - as initial therapy if ventricular catheter already present; as supplement to hyperosmolar therapy if not.
    - i) antibiotic impregnated, tunneled ventricular drainage catheters
    - ii) inlet of drip chamber 15 cm above tragus
    - iii) continuous drainage
    - iv) sampling of CSF only for suspected infection

- v) no prophylactic systemic antibiotics
  - d) hyperosmolar therapy
    - i) hypertonic saline [3% or more] preferred
      - (1) continuous infusion
      - (2) supplemental boluses
    - ii) mannitol may be used in addition
    - iii) maintenance of euvolemia
    - iv) anticipation of need for pressors to maintain CPP
    - v) avoidance of extreme hyperosmolality: 320 mOsm/L for mannitol; 360 mOsm/L for hypertonic saline.
  - e) neuromuscular blockade
- 3) Second Tier Therapy - for elevated ICP refractory to first tier measures. There is no prescribed preference or sequencing among second tier therapies. They are to be implemented by consensus among the PICU staff, the neurosurgeon, and the trauma surgeon.
- a) decompressive craniectomy
    - i) hemicraniectomy for asymmetrical injuries
    - ii) bifrontal craniectomy or bilateral hemicraniectomy for diffuse injuries
  - b) lumbar CSF drainage
    - i) prerequisite: functioning ventricular CSF drain
    - ii) prerequisite: open basal cisterns
    - iii) inlet of drainage chamber at same level as ventricular drain
  - c) barbiturate coma
    - i) neurology consultation
    - ii) continuous EEG monitoring
    - iii) anticipation of need for pressors to maintain CPP
- 4) De-intensification of therapy
- a) to be initiated within 72 hours of ICP and CPP stability
  - b) reverse-order withdrawal of therapies from most potentially morbid to least.
  - c) ICP monitoring maintained until specific therapies for ICP elevation are discontinued.

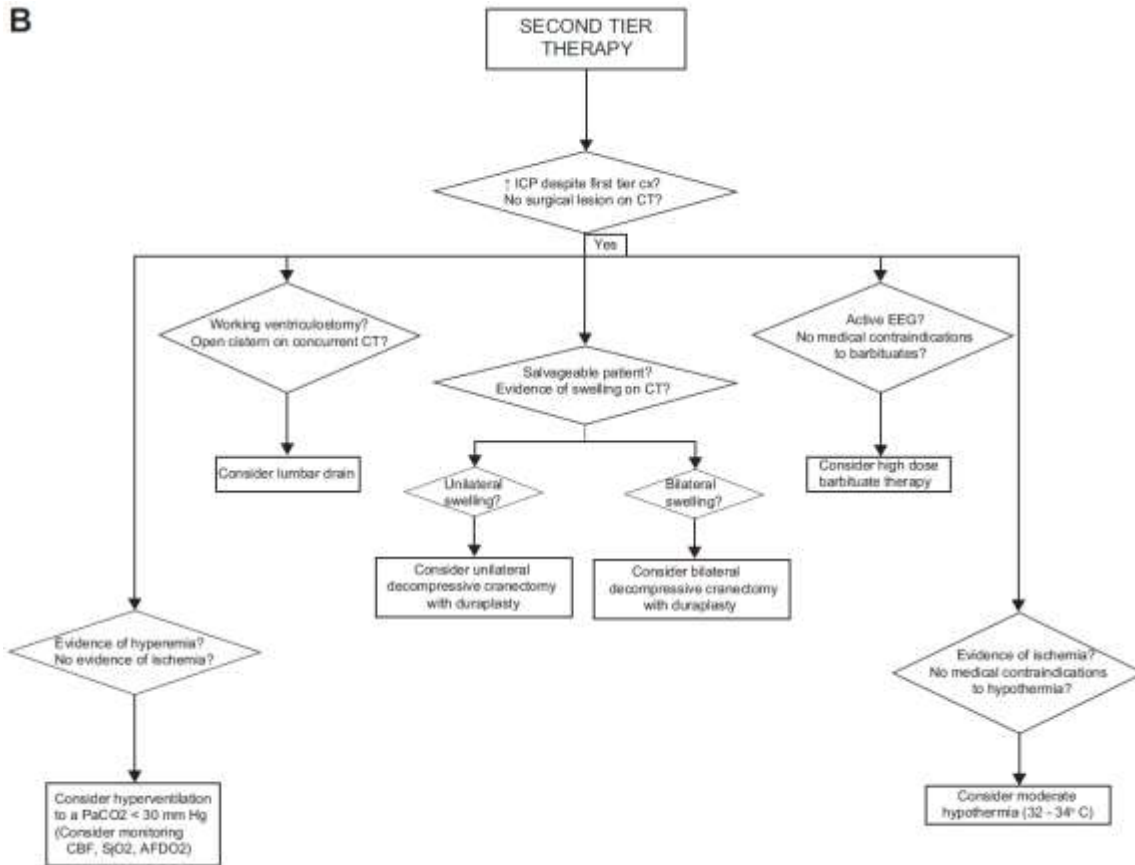
Appendix 4 - Algorithm for PICU Management of Severe TBI<sup>1</sup>

1) First tier therapy



2) Second tier therapy

**B**



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