

HOSPITAL CLINICAL GUIDELINE
Collaborative Practice Council

Title: Severe Traumatic Brain Injury: Adults and Children > 30 KG

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Title of Responsible Party : Executive Director, Critical Care Services

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Scope: Physicians, Critical Care Nurses, Pharmacists, and Respiratory Therapists

Key Words: @Neurotrauma, @ICP, @Severe TBI, @Clinical guidelines

PART I: GENERAL INFORMATION

Title of Guideline Document: Management of Severe Traumatic Brain Injury

Clinical Diagnosis or Condition: Traumatic Brain Injury/Increased Intracranial Pressure

Target Population: Adults and Children with a GCS 3 - 8; abnormal CT scan of brain; and/or abnormal clinical exam. (Note: Refer to guidelines for Children < 30 kg for age specific variances).

Primary Setting of Care: Adult ICU and Pediatric ICU

Purpose: Identify patients and define treatment options for managing severe traumatic brain injury

Objectives:

- 1 Establish monitoring parameters for treatment
- 2 Enhance cerebral oxygen delivery to brain
- 3 Optimize cerebral perfusion pressure (CPP) to brain
- 4 Control increased ICP

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PART II: CONTENT OF DOCUMENT

Patients with severe traumatic brain injury sustain the primary insult at the time of the accident. Secondary damage to the brain occurs as a result of increased pressure inside the cranium leading to perfusion deficits, reduced oxygen delivery to tissues, and cellular chemical alterations. These guidelines are developed to provide team members with information on a) identifying patients at risk for secondary injury and b) suggesting interventions to maintain adequate cerebral perfusion pressure and reduce increased ICP in order to enhance oxygen delivery to tissues.

1 Assessment

- 1.1 Clinical assessment of severity of brain injury includes: Glasgow Coma Scale; Level of Consciousness; motor strength; motor tone; cranial nerve exam (pupillary response, extraocular movements, facial symmetry, corneal and gag reflexes); systems assessment; and vital signs. Note any seizure activity.
- 1.2 Diagnostic assessment of brain injury includes:
 - 1.2.1 CT scan of brain
 - 1.2.2 Intracranial pressure (ICP) Monitor
 - 1.2.3 Oxygen saturation of venous blood in Internal Jugular vein- SjO₂
 - 1.2.4 LICOX Brain tissue oxygen monitor (PbtO₂)
 - 1.2.5 EEG or BIS Monitor
 - 1.2.6 Transcranial Dopplers
- 1.3 Identification of patients with severe head injury includes: GCS-3 - 8; Abnormal CT scan of brain; and/or abnormal clinical exam.

2 Plan

- 2.1 Secure airway and provide oxygenation, ventilation, & intravenous fluids during trauma resuscitation
 - 2.1.1 Maintain PaO₂ >100 mm Hg or SaO₂>100% and PaCO₂ 35-40 mm Hg
 - 2.1.2 Avoid hypotension: Increase MAP to maintain CPP >70 mm Hg
- 2.2 Maintain neck in neutral position with cervical collar
- 2.3 Administer Etomidate/Zemuron/Morphine Sulfate as indicated/ordered
- 2.4 Obtain CT scan of brain as indicated
- 2.5 Consider placement of ICP monitor/ventriculostomy and PbtO₂/SjO₂ oximetric catheter as indicated
- 2.6 Place arterial line and central intravenous catheters (vascular access and monitoring hemodynamic data)
- 2.7 Consider placement of thermodilution catheter or systemic oximetric venous catheter as indicated

3

Implementation

3.1 Implement initial resuscitation protocols

3.2 PHASE INTERVENTIONS:

3.2.1 Emergency Department

3.2.1.1 Airway: 100% FIO₂ BVM

3.2.1.2 Intubate for GCS 3-8 or unable to protect airway: Use RSI Protocol

3.2.1.3 Establish 2 large bore IVs – draw labs (CBC, BMP, & Coags)

3.2.1.4 NG/Foley

3.2.1.5 Mannitol 0.25-1 gram/kg for posturing or unequal/non-reactive pupils

3.2.1.6 Goals:

3.2.1.6.1 Keep SaO₂ 100%

3.2.1.6.2 Keep PaCO₂ 35-40 mm Hg

3.2.1.6.3 Keep MAP > 90 mm Hg

3.2.2 Operating Room: Prepare for ICP/LICOX insertion and other neurosurgical procedures as indicated

3.2.2.1 Place Arterial line/Central lines (CVP small children or PA catheter older children and adults)

3.2.2.2 Administer fluids to keep PCWP 8-12 mm Hg or CVP 4-8 mm Hg

3.2.2.2.1 Albumin/Normal Saline

3.2.2.2.2 Blood products

3.2.2.2.3 Reverse DIC - FFP/Cryo/Platelets for abnormal coags

3.2.2.3 Maintain MAP > 90 mm Hg or CPP > 60 mm Hg with fluids/vasopressors

3.2.2.3.1 Add Neosynephrine or Dopamine as indicated

3.2.2.4 Titrate PaCO₂ to keep PbtO₂ \geq 20 mm Hg and SjO₂ > 55%

3.2.2.5 Drain CSF for ICP > 20 mm Hg

3.2.2.6 Neurosurgical procedures: consider craniectomy for high ICP unresponsive to other measures

3.2.2.7 Goals:

3.2.2.7.1 Keep SaO₂ 100%

3.2.2.7.2 Keep PaCO₂ 35-40 mm Hg

3.2.2.7.3 Keep MAP > 90 mm Hg or optimal for patient

3.2.2.7.4 Keep PbtO₂ \geq 20 mm Hg and/or SjO₂ > 55% < 75%

3.2.2.7.5 Keep ICP < 20 mm Hg

3.2.3 ICU PHASE I: Initial 24 hours of admission....”Getting into the Zone”

3.2.3.1 Rule #1: Do Not Prognosticate!

3.2.3.2 Goals:

3.2.3.2.1 Keep SaO₂ 100%

3.2.3.2.2 Keep MAP optimal for patient

3.2.3.2.3 Keep PbtO₂ \geq 20 mm Hg and/or SjO₂ > 55% < 75%

3.2.3.2.4 Keep ICP < 20 mm Hg

- 3.2.3.3 If PbtO₂ < 15 mm Hg – place on FIO₂ 100% (up to 24-48 hours):
Temporary intervention only until PbtO₂ ≥ 20 then decrease FIO₂ to 30-50% based on patient needs
- 3.2.3.4 **Priorities:** Maximize these parameters in order to decrease FIO₂
 - 3.2.3.4.1 Titrate PaCO₂ 35-45 mm Hg to keep PbtO₂ > 20 mm Hg/SjO₂ > 55%
 - 3.2.3.4.2 Give volume- Maintain PCWP 8 mm-12 Hg or CVP 4-8 mm Hg
 - 3.2.3.4.2.1 Use Albumin or NS
 - 3.2.3.4.2.2 Use Packed RBCs to increase Hematocrit (goal >33) or Hemoglobin >11 if PbtO₂ < 20 mm Hg
- 3.2.3.5 **Determine optimal CPP for patient:**
 - 3.2.3.5.1 Begin with target CPP > 60 mm HG. Note: The individual patient's optimal CPP must be determined using the Goal CPP, a PbtO₂ > 20 mm Hg and an ICP < 20 mm Hg. For example, a patient with a CPP of 50, PbtO₂ 25 and ICP of 25 would not be adequate. CPP may need to be increased. Alternatively, a patient with a CPP of 55, PbtO₂ 25 and ICP of 12 may be ideal and no further increase in CPP needs to take place.
 - 3.2.3.5.1.1 Use fluids until euvolemic
 - 3.2.3.5.1.2 Add vasopressors to increase MAP once volume loaded
 - 3.2.3.5.2 Consider early use of Propofol 10-100 mcg/kg/min for increased ICP.
 - 3.2.3.5.2.1 Watch the PbtO₂ for any decrease while adjusting propofol.
 - 3.2.3.5.2.2 Note: Triglycerides and pH should be measured daily during Propofol infusions. If Propofol needed for periods longer than 48 hours for ICP control, consider an alternative medication such as pentobarbital
 - 3.2.3.5.3 Keep ICP < 15 mm Hg for children and < 20 mm Hg for adults
 - 3.2.3.5.4 Keep Temperature (brain temp) 36-37 degrees C
- 3.2.3.6 In severe head injured patients, order the following labs to be completed within 12 hours of admission: TSH, T3, T4, Cortisol and Lactate levels. Report abnormal levels to physician team. Repeat TSH, T3, T4 and Cortisol levels at 72 hours after admission. Repeat Lactate q 6 hours x 48 hours.
- 3.2.3.7 Closely monitor Intake and Output with the goal to bring fluid intake/output into balance within 48 –72 hours of admission. Monitor pH, Base deficit, and Lactate levels q 6 hours x 48 hours. Use end points of resuscitation to evaluate ongoing treatment: CPP > 60 mm Hg or optimal level, ICP < 20 mm Hg, PbtO₂ > 20 mm

Hg, Hematocrit > 30, pH 7.35-7.45, Base deficit 2 to -2, and Lactate Levels < 2.

3.2.4 **ICU PHASE II: Maintaining Therapy.... “Keeping the Brain in the Zone”**

3.2.4.1 Phase Goals: Maintain PbtO₂ ≥ 20 mm Hg, SjO₂ > 55% or < 75%, and ICP < 15 mm Hg for children and < 20 mm Hg for adults

3.2.4.2 Interventions:

3.2.4.2.1 Maintain FIO₂ per pulmonary needs

3.2.4.2.2 Titrate PaCO₂ to balance ICP < 20 mm Hg and PbtO₂ ≥ 20 mm Hg or SjO₂ > 55% < 75%

3.2.4.2.3 Drain CSF for ICP > 20 mm Hg or per physician order

3.2.4.2.4 Determine optimal CPP for patient. Target CPP > 60 mm HG

3.2.4.2.4.1 Keep PCWP 8-12 mm Hg or CVP 4-8 mm Hg using fluids

3.2.4.2.4.2 Use vasopressors to optimize MAP once euvoletic

3.2.4.2.4.3 Monitor I/O closely with goal of fluid balance (I=O)

3.2.4.2.5 Sedate via continuous Ativan or Versed. Use BIS to titrate sedation

3.2.4.2.6 Deliver pain control with continuous Morphine or

fentanyl

3.2.4.2.7 Provide chemical paralysis with paralytic of choice; adjust with neuromuscular blockade monitor and BIS monitor

3.2.4.2.8 Minimize stimulation and keep lights low

3.2.4.2.9 Keep temperature 36-37 degrees Celsius: using cooling measures

1 3.2.4.2.10 Mannitol 0.25 -.5 g/kg bolus if ICP > 15 mm keep serum osmo < 320; provide fluid replacement to maintain euvolemia. Monitor Sodium. If sodium approaches 155, hold mannitol and contact physician.

3.2.4.2.11 Consider Propofol drip or pentobarbital drip if unable to control ICP with medical/surgical therapies. Note: Triglycerides and pH should be measured daily during Propofol infusions. If Propofol needed for periods longer than 48 hours for ICP control, consider an alternative medication such as pentobarbital Titrate with BIS monitor per protocol.

3.2.4.3 **If PbtO₂ < 20 mm Hg or SjO₂ < 55%**

3.2.4.3.1 Administer FIO₂ 100% x 15 minutes

3.2.4.3.2 Drain CSF ICP > 15 mm Hg for children or ≥ 20 mm Hg adults

3.2.4.3.3 Increase PaCO₂ by decreasing rate/altering pressure and balance with ICP: Check ventilator modes and patient responses

- 3.2.4.3.4 Check CVP/PCWP and MAP: Optimize CPP
 - 3.2.4.3.4.1 Give IV NS or 5% albumine to increase CVP or PCWP
 - 3.2.4.3.4.2 Give packed RBCs if Hgb < 11 or Hematocrit < 33 if PbtO₂ < 20
 - 3.2.4.3.4.3 Start Vasopressors: Dopamine, Phenylephrine, Epinephrine, and/or Norepinephrine
 - 3.2.4.3.4 Mannitol (if ICP > 15 mm Hg children or > 20 mm Hg adults)
 - 3.2.4.3.5 Maintain adequate sedation and analgesia
 - 3.2.4.3.6 Cooling measures for temperature > 37 degrees C
 - 3.2.4.3.7 Consider barbiturate therapy if refractory to all medical/surgical interventions. Titrate with BIS 10-20 and SR > 60%
 - 3.2.4.3.8 Note: If shivering or problems with ventilator, consider paralytic
- 3.2.4.4 **If PbtO₂ > 20 mm Hg/SjO₂ > 55% and ICP > 20 mm Hg**
 - 3.2.4.4.1 Drain CSF
 - 3.2.4.4.2 Decrease PaCO₂ to decrease ICP
 - 3.2.4.4.3 Optimize CPP: check CVP/PCWP- if low give fluids then titrate vasopressors to maintain adequate MAP
 - 3.2.4.4.4 Give Mannitol 0.25-1 gm/kg IV
 - 3.2.4.4.5 Consider paralytic for ICP control
 - 3.2.4.4.6 Start/Titrate propofol or barbiturates for ICP control. If Propofol selected for ICP control – dose should not exceed 10-100 mcg/kg/min for a period of 48 hours. Triglycerides and pH should be measured daily during Propofol infusions. Consider pentobarbital therapy if ICP remains elevated requiring Propofol infusion greater than 48 hours. Titrate Pentobarbital infusion with BIS monitor 10-20 and SR > 60%
 - 3.2.4.4.7 Consider craniectomy

3.2.5 **ICU Phase III: WEANING PHASE**

- 3.2.5.1 Normalize PaCO₂
- 3.2.5.2 Discontinue paralytics
- 3.2.5.3 Wean Propofol or barbiturates
- 3.2.5.4 Normalize CPP/CVP/PCWP
- 3.2.5.5 Discontinue ICP/CSF drain
- 3.2.5.6 Decrease analgesia/sedation – wean and start methadone

3.3 Review algorithm on “Targeted Therapy for ICP Management” and Cerebral Oxygenation Optimization

- 3.3.1 Vasospasm: deliver hypervolemia, induced hypertension with systolic BP 160-180 mm Hg, and possible calcium channel blockers
- 3.3.2 Low MAP: volume load with 5% albumin or NS and add pressors prn as indicated to maintain CPP > 60 mm Hg

- 3.4 High ICP:
 - 3.4.1 Edema on CT- Mannitol 0.25-.5 g/kg IV and 5% Albumin to maintain euvoolemia
 - 3.4.1.1 Increased Cerebral blood volume - HOB 30 degrees, PaCO₂ Target with concurrent assessment of S_jO₂ > 55%/PbtO₂, Hypertensive CPP therapy, Barbiturates, and/or optimized hyperventilation if S_jO₂ > 75%
 - 3.4.1.2 Mass effect – Surgery
- 3.5 Begin nutrition via appropriate route as soon as possible. If enteral route established, attempt feedings via post-pyloric sphincter.
- 3.6 Order appropriate interventions on physician order sheet in medical record. Team will implement interventions ordered by physicians.
- 3.7 If S_jO₂ increases with increased hyperventilation >90% consider blood flow studies

4 **Monitoring: Diagnostics & Patient Responses**

- 4.1 Monitor changes in neurologic status and clinical exam
- 4.2 Reassess patient responses to ordered therapies
- 4.3 Monitor TSH, T3, T4, Cortisol, and Lactate levels.
- 4.4 Monitor ABG's: SaO₂, PaO₂, PaCO₂, HCO₃, B.E., and pH values
- 4.5 Monitor ICP/ MAP and Calculate CPP
- 4.6 Monitor S_jO₂, Calculate CEO/AVDO₂ values, and PbtO₂ levels
- 4.7 Monitor hemodynamic data as indicated: MAP, CVP, PCWP, Cardiac output/index, Systemic vascular resistance, SVO₂, and systemic oxygen consumption (depends on types of invasive lines)
- 4.8 Monitor serum electrolytes especially sodium, serum osmolarity, Potassium, calcium, and Magnesium
- 4.9 Monitor triglycerides and pH daily during propofol infusions. If the serum triglyceride level is > 400 mg/dL, notify MD of the level, the patient is at risk for propofol infusion syndrome.
- 4.10 Monitor CBC and other pertinent laboratory data
- 4.11 Record patient data on "Critical Traumatic Brain Injury Data Base" form and flow sheets in medical record.
- 4.12 Implement "ICP Weaning Algorithm" as ICP decreases to < 20 mm Hg for 24 hours without aggressive interventions per physician order
 - 4.12.1 Discontinue Propofol drip or Barbiturate Coma
 - 4.12.2 Normalize PaCO₂ to 35-45 then discontinue paralytic agents. Check for full recovery with neuromuscular blockade monitor.
 - 4.12.3 Discontinue sedation/analgesics as tolerated and begin Methadone protocol
 - 4.12.4 Discontinue S_jO₂ catheter per physician
 - 4.12.5 Hold CSF drainage per neurosurgeon order
 - 4.12.6 Discontinue ICP monitor and CPP therapy per neurosurgeon

5 **Evaluation/Outcomes**

- 5.1 Evaluate patient outcome following therapies using GCS, Rancho Los Amigos Scale, and/or FIM scales
 - 5.2 Consult Psychiatrist
 - 5.3 Obtain consults for Speech Pathology, Occupational Therapy, and Physical Therapy
 - 5.4 Obtain rehab consult to evaluate for rehabilitation and discharge needs
- 6 **Termination of Guidelines**
- 6.1 Patient demonstrating clinical improvement with interventions
 - 6.3 Physician order to terminate guidelines at any point during clinical course

Committee Approval: Trauma M & M, Children’s Critical Care, Pharmacy and Therapeutics, ICU Committee, Collaborative Practice Council

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Figure 1: Care of the Patient Adults and Children > 30 Kg Phase Algorithms

Resuscitation Phase: ED
 Establish/maintain airway
 Use 100% FIO2 BVM
 Intubate for GCS 3-8 or unable to protect airway
 Use RSI Protocol
 Establish 2 IVs – draw labs
 Place NG/Foley
 Give Mannitol 0.25-1.0 gm/kg IV if posturing, unequal or non-reactive

Resuscitation Phase:OR
 Prepare- ICP/LICOX placement and neurosurgical procedures
 Place Arterial line/central lines
 Administer fluids to keep CVP 4-8 mm Hg/PCWP 8-12 mm Hg
 Use 5% Albumin/NS
 Use Packed RBCs keep Hct>33
 Reverse DIC: FFP/Cryo/Plts for abnormal coagulation state
 Keep MAP > 90: add pressors
 Titrate PaCO2: PbtO2 \geq 20 and SjO2>55%
 Drain CSF ICP > 20 mm Hg
 Use Propofol as needed
 Consider craniectomy for \uparrow ICP
Goals: SaO2 100%, PaCO2 35-40, PbtO2 \geq 20, SjO2 > 55% & ICP < 20, CPP > 70 mm Hg

SP, Contant CF, et al. tissue Po2 to outcome injury. Critical Care 1576-1581.
with Severe Head Injury

ICU Phase I: 1st 24 hours
 If PbtO2 < 15 mm Hg – place on 100% FIO2 up to 24 hours
Priorities:
 -Titrate PaCO2: PbtO2 \geq 20/ SjO2 >55% /ICP <20
 -Give volume 5% albumin/NS to maintain CVP/PCWP
 --Administer Packed RBCs to increase hematocrit >33 if PbtO2 < 20 mm Hg
 -Determine optimal CPP for patient-optimize MAP with

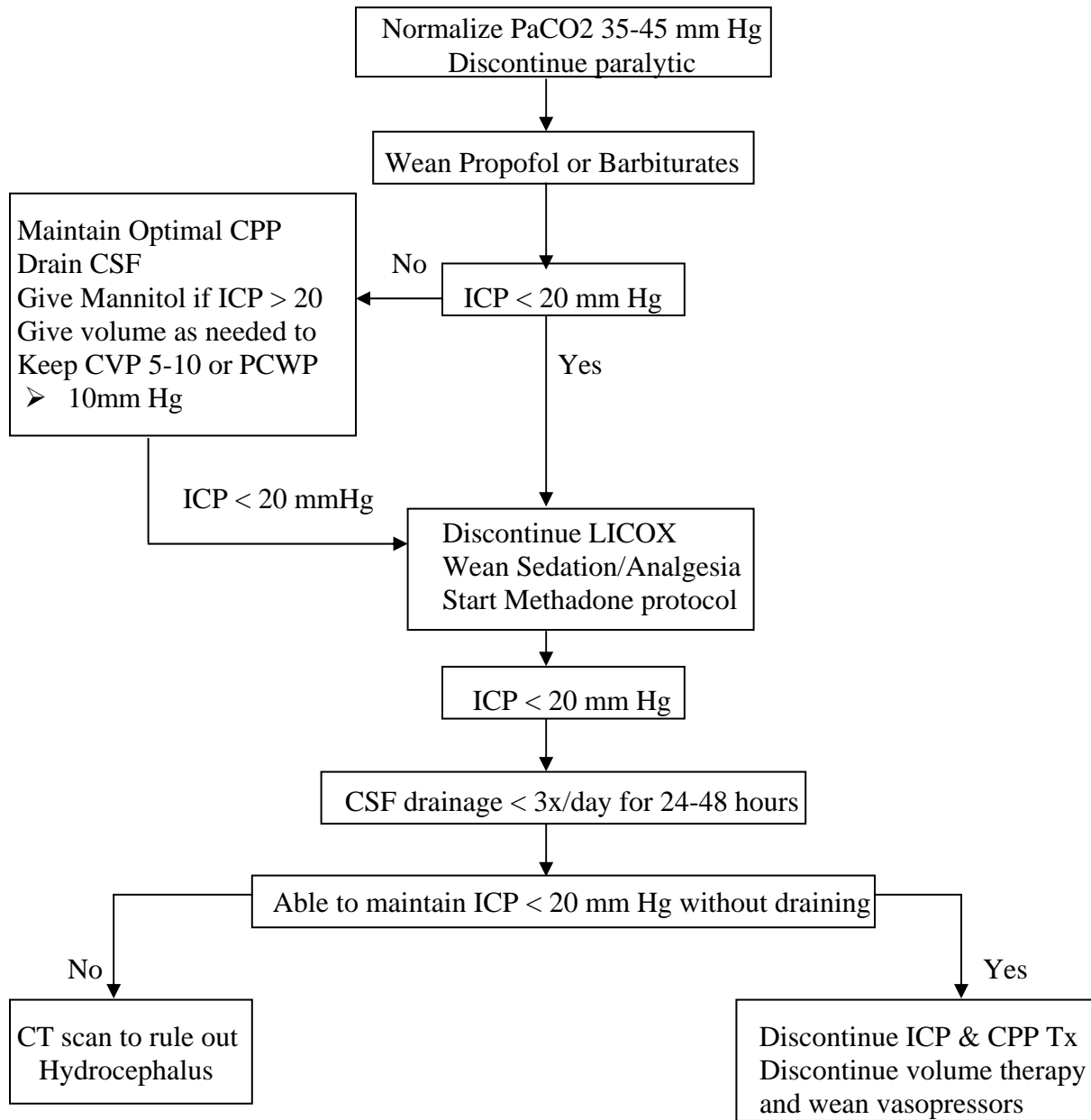
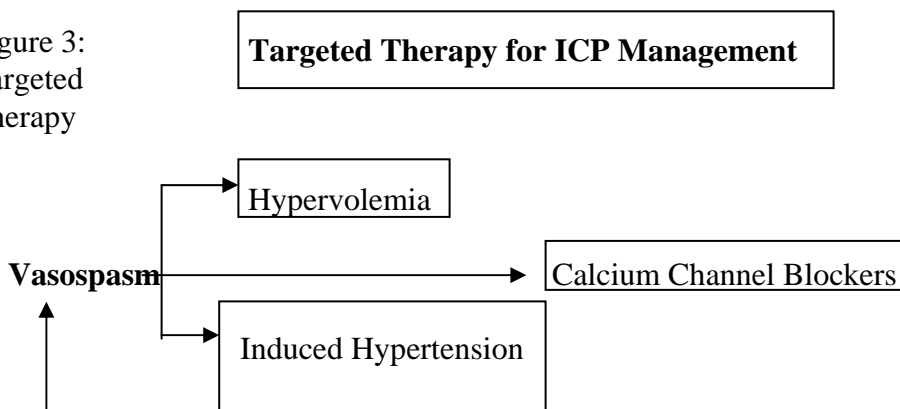
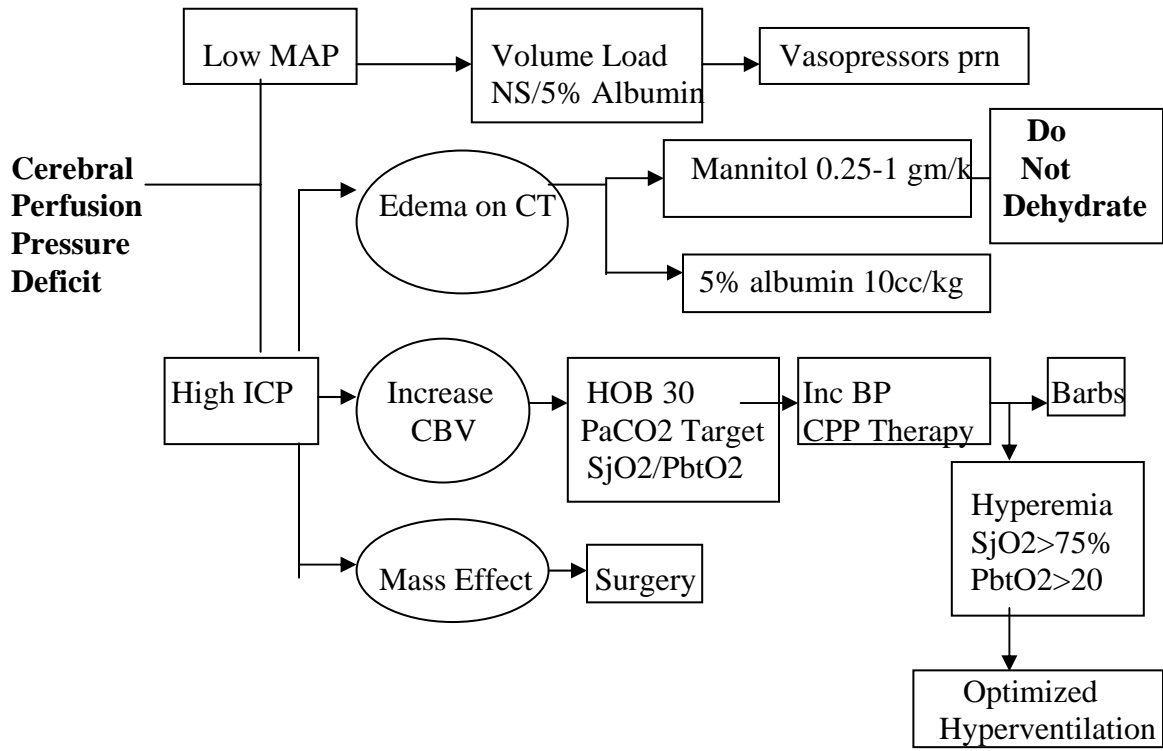


Figure 3:
Targeted
Therapy



Systolic BP 160-180



Adapted from:
Lang & Chestnut
ICP: Monitoring and Management 1994.
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Revised 4/2001, 6/2002