

Intracranial Pressure and Herniation

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https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4791176/



Intracranial Pressure (ICP) and Herniation

- **Objectives**
 - <u>Recognize</u> the signs and symptoms of cerebral herniation and elevated intracranial pressure
 - Manage with a stage approach to the reversal of herniation and/or reduction in intracranial pressure

Increased ICP or Herniation



Elevated ICP: ICP > 22 mmHg sustained for > 5 min Cerebral PERFUSION pressure = MAP - ICP

https://www.ncbi.nlm.nih.gov/pubmed/26426232

Etiologies of ICP Elevation aka "Brain Code"

Extra-axial Process	Focal Brain Process	Diffuse Brain Process
Epidural hematoma	Brian tumor(s)	Traumatic Brain Injury
Subdural hematoma	Ischemic stroke	Aneurysmal SAH
Subdural empyema	Intracerebral hemorrhage	Meningitis/encephalitis
Extra-axial brain tumor	TBI (hemorrhagic contusions)	Non-infectious neuro- inflammatory disorder
Pneumocephalus	Hydrocephalus	Hepatic encephalopathy, Toxic-metabolic encephalopathies, Hypoxic-ischemic encephalopathy









Increased ICP or Herniation

- Herniation syndromes **TISSUE SHIFTS**
- Types:
 - Subfalcine (cingulate)
 - Uncal
 - Central (Tentorial)
 - Tonsillar (\downarrow cerebellum)
 - Upwards (个 cerebellum)

Clinical Signs and Symptoms of Increased ICP or Herniation

"EARLY"	"LATE"
Headache	Changes in level of consciousness or \downarrow GCS or FOUR Score \ge 2 points
Irritability	Ipsilesional change in pupillary size, shape and light-responsiveness
Vomiting	Contralesional hemiparesis (new or worsening)
Photophobia, nystagmus, diploplia	Contralesional change in pupillary size and ipsilesional hemiparesis (Kernohan's phenomenon)
Lethargy	Cushing's triad: 个 SBP (widened pulse pressure), bradycardia, irregular respirations
Seizure	

64yo male auto vs pedestrian accident

GCS 7 in the ED

No focal neurological deficits

Temp 35.7^oC, HR 95 bpm

BP 115/62 mmHg, SP02 85%

Standard Measures to Treat 1 ICP

TIER 0

ABCs, Avoid hypotension and hypoxia!

HOB elevated > 30^o with head in midline (个venous return)

Normothermia (35.5°C-37.5°C) Normotension (CPP 60-70 mmHg) Euvolemic, Normonatremia (135-145 mEq/L) Normoglycemia

Treat vasogenic edema as indicated (e.g. steroids for tumors)

Head CT if not completed

- Our patient is intubated given his low GCS and hypoxia
- His CT brain shows bifrontal contusions and subdural blood
- Given the CT findings and his low GCS, and EVD is placed. Initial ICP is 29

Escalating Measures to Treat 1/1 ICP

Consider Additional Neuromonitoring

Consider Other Neuromonitors

Brain tissue oxygenation* (PbTO2)- Licox, Raumedic, etc

Jugular bulb venous oximetry or NIRS (Near Infrared Spectrscopy)

Cerebral microdialysis (research)

After several mannitol and hypertonic saline boluses and allowing his EVD to drain CSF several times, his ICP lowers to 27 mmHg

He is mildly hyperventilated to a PCO2 of 33 mmHg, but is ICP remains 27 mmHg

Post Tier 1

- If ICP stabilized with Tier 1, obtain head CT
- If not, proceed to Tier 2 treatment, then obtain head CT
- Review decompressive surgical options for patient based on head CT
- Consider modifying ICP, MAP, and CPP targets in appropriate clinical context

Escalating Measures to Treat ↑ICP

Decompression

- For those that are failing medical management
 - Review decompressive surgical options with neurosurgery
 - Evacuation of mass lesion or decompression craniectomy
- If the patient is ineligible for surgery or too unstable to obtain brain imaging, proceed to Tier 3 treatment

The patient is started on an infusion of 3% NaCl and his serum sodium is now 155 mEq/L

Propofol is running at a max dose of 200 mcg/kg/min

ICPs remain 26 mmHg

Repeat CTH does not show any new hemorrhage

Neurosurgery does not feel he is a surgical candidate

Refractory Intracranial Hypertension

Tier 3

Pentobarbital infusion for 24-96 hrs

- requires cEEG
- can titrate pentobarb to:
 - ICP control, or
 - EEG burst suppression 5-20 secs

Moderate hypothermia 32-34°C

Hyperventilation

- mild to moderate hypocapnea
 - PaCO₂ 25-34 mmHg
 - ideally with brain O2 monitoring
 - < 6 hours

The patient is loaded with pentobarbital

His EEG shows burst suppression in the 8-10 second range

ICPs lower to 16 mmHg

He is maintained on pentobarbital for 48hrs and then it is weaned off

ICPs remain 10-15 mmHg and the EVD is eventually removed

Handoff Checklist

- □ Clinical presentation (History, Brain-injury mechanism, SAH)
- Relevant past medical/surgical history
- Treatments administered
- □ Findings on neurological exam
- Relevant labs
- □ Brain imaging results (if available)

HOSPITAL "BRAIN CODE" ICP BOX?

Hyperosmolar Therapy

(2) 120mmEq/30ml 23.4% NaCl
(2) 500 ml buffered 3% NaCl
(8) 12.5G/50 ml 25% mannitol vials

Sedation

(2) 20 ml propofol vials(2) 2mg lorazepam

Other Fluid

(6) normal saline flush(2) liter NS

Other supplies

(2) 30ml syringes
(3) 60ml slip tip syringes
(6) 18G needles
(10) Alcohol pads
(2) 0.22 micron in-line filter

