Management of Intracranial Emergencies: Raised Intracranial Pressure

Jeffrey Singh MD FRCPC MSc
Toronto Western Hospital
Interdepartmental Division of Critical Care
University of Toronto
Disclosures

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Objectives

• To understand key determinants of intracranial pressure
• To gain a pragmatic algorithm to manage acute intracranial hypertension

I am going to focus on adults…
Key Concepts:

• Determinants of Intracranial Pressure

• Determinants of Cerebral Blood Flow

• Intracranial ‘compliance’
Why ICP Matters:

- Cerebral Perfusion Pressure

\[
CPP = P_{IN} - P_{OUT} = MAP - ICP
\]

- Normal ICP: < 15mmHg
ICP: Principles

Monro-Kellie Doctrine

Cranial compartment is fixed volume and incompressible

1. Brain parenchyma (80%)
2. CSF (10%)
3. Intravascular blood (10%)

Parenchyma 1200cc

Blood 150cc

CSF 150cc
Normal Brain

Parenchyma: 1200cc
Blood: 150cc
CSF: 150cc
Cerebral Edema

- Parenchyma: 1300cc
- Blood: 150cc
- CSF: 50cc
Cerebral Edema
Hydrocephalus

Parenchyma 1200cc

CSF 250cc

Blood 50cc
ICP: Intracranial Compliance

- Non-linear relationship
- Displacement of CSF into thecal sac
- Decrease in cerebral blood volume
Cerebral Blood Flow
Context is *everything*…

- Subtleties of management:
  - Fluid administration
  - $\text{CO}_2$
  - $\text{O}_2$
- Context of:
  - Clinical situation
  - Brain / Cerebrovascular physiology

*I am focusing on life-threatening ICP emergencies*
Emergent Management of Raised Intracranial Pressure
Illustrative Case

41 year old woman with HTN
- New left hemiplegia
- CT: no bleed
- MRI
  - R MCA infarct
  - R MCA Thrombus

Systemic thrombolysis administered
Illustrative Case

• Day 1
  – Worsening weakness
  – Confused and less verbal

• Day 2
  – Complains of worsening headache
  – Worsening agitation
  – MR / MRA
    • Ativan 4 mg
    • Snoring / obstructing airway
Illustrative Case

- 15 minutes after returning from MRI
  - Unresponsive
  - Fixed and dilated right pupil

WHAT HAS HAPPENED?

and

WHAT SHOULD BE DONE?
Emergent Management

1. HOB ≥ 30°
2. Hemodynamics: avoid hypotension
3. Intubate and hyperventilate
4. Osmotherapy
5. STAT CT for diagnosis and definitive management
Elevate Head of Bed

- HOB 30° - 45°
  - Decreases ICP
  - Increases CPP
  - Does not change cardiac output
  - Limits transmission of intrathoracic pressure

Durward et al. J Neurosurg. 1983
• Ensure adequate intravascular volume
  – Especially with sedation / induction for intubation
• Hypotension is **DEADLY**
CBV, SBP & Cerebral Autoregulation

Passive Dilation / Collapse
Autoregulation
Passive Dilation

Cerebral Blood Volume
Cerebral Blood Flow

Adapted from S. Mayer
Vasodilatory Cascade

- Decrease in CPP
- Increase in intravascular blood
- Increase in ICP
- Vasodilation

ICP or MAP
Improvement in CPP

Improving BP and CPP may induce vasoconstriction in areas with intact autoregulation = decrease intracranial blood = decrease ICP

Adapted from S. Mayer
Common Mistakes

• Intubation / Sedation:
  – Thinking the obtunded patient does not need an anesthetic
  – Getting caught up with premedication / lidocaine / etc.

Get help!

Do what you know… and do well
3 - Hyperventilation

- Decreases intravascular blood through cerebral vasoconstriction
  - ↓ pCO2 = ↓ blood flow = ↓ blood volume

- Hypocapnia
  - 30% decrease in CBF
  - 10% decrease in CBV

3 - Hyperventilation

- Little change in intracranial volume
- BIG change in pressure

...It’s all about context...
4 – Osmotic Agents

• 2 Effects:

1. Plasma expansion & decrease blood viscosity

2. Osmotic effect
   • Decrease intracellular fluid volume → decrease ICP

4 - Mannitol

• Administration / Dose
  – Pre-mixed 20% bag
  – 1-1.5 g / kg BOLUS
  – Maintain serum Osm < 320 mmol/L
    Not continual infusion

• Adverse Effects
  – Renal failure with ↑ administration
4 - Hypertonic Saline

- Similar efficacy to Mannitol (3, 6 & 7.2%)

- Administration / Dose
  - 150 cc 3% NaCl
  - 100cc 7.5% NaCl

Freshman et al. *J Trauma*. 1993
Qureshi et al. *Neurosurgery*. 1999
5 – Definitive Management

• STAT CT
  – Identify etiology of raised ICP
    • Hemorrhage
    • Hydrocephalus
    • Edema
  – Identify surgical intervention
Emergent Management

1. HOB ≥ 30°
2. Avoid hypotension
3. Intubate and hyperventilate
4. Osmotherapy
5. STAT CT for diagnosis and definitive management
Case Study

- 41 year old woman with stroke
- Snoring after repeat MRI
  - Unresponsive with fixed and dilated right pupil

Immediate Action:

1. HOB up
2. iv access
3. Intubated & hyperventilated (EtCO$_2$=30)
4. Mannitol 1.0g/kg
Case Study

Transferred to ICU

- Pupil down and reactive
- Trying to grab ETT
- CT in ICU shows expanding stroke with mass effect
Case Study

- Right Decompressive Craniectomy

- Patient stabilized
  - Extubated
  - Rehab then home
  - Walking with walker
  - Bone flap back in after 4 months
Summary

• Intracranial hypertension is an emergency

• Prompt identification and management can:

  Save lives
  Prevent disability
Slides / Questions?

jeff.singh@uhn.ca