Management of Traumatic Brain Injury (and other neurosurgical emergencies)

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Greetings from Michigan!
Objectives for Today’s Discussion

• How to manage refractory intracranial hypertension in the OR
• Intraoperative aneurysm rupture
• Major hemorrhage in spine surgery
• Risks of new “minimally invasive” spine procedures

• I have no financial disclosures
This is what it’s all about...

A Few Definitions:

• Intracranial pressure = ICP
• Mean arterial pressure = MAP
• Cerebral perfusion pressure = CPP = MAP-ICP
• TBI = traumatic brain injury
There are many reasons for intraoperative intracranial hypertension...
Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition

The scope and purpose of this work is 2-fold: to synthesize the available evidence and to translate it into recommendations. This document provides recommendations only when there is evidence to support them. As such, they do not constitute a complete protocol for clinical use. Our intention is that these recommendations be used by others to develop treatment protocols, which necessarily need to incorporate consensus and clinical judgment in areas where current evidence is lacking or insufficient. We think it is important to have evidence-based recommendations to clarify what aspects of practice currently can and cannot be supported by evidence, to encourage use of evidence-based treatments that exist, and to encourage creativity in treatment and research in areas where evidence does not exist. The communities of neurosurgery and neuro-intensive care have been early pioneers and supporters of evidence-based medicine and plan to continue in this endeavor. The complete guideline document, which summarizes and evaluates the literature for each topic, and supplemental appendices (A-I) are available online at https://www.braintrauma.org/coma/guidelines.

KEY WORDS: Severe traumatic brain injury, Adults, Critical care, Evidence-based medicine, Guidelines, Systematic review

Neurosurgery 2017; 80:6-15
Monro-Kellie Doctrine

Intracranial Contents

- Brain
- CSF
- Blood
The Intracranial Pressure-Volume Curve
Determinants of cerebral blood flow under normal conditions

Miller’s Anesthesia 2015
Cottrell and Young’s Neuroanesthesia 2010
When should we treat intracranial hypertension?

• It is the “burden” of intracranial hypertension that affects outcome
• ICP should be monitored in unconscious (or sedated) patients with abnormal head CT
• BTF would suggest treat for $ICP \geq 22$ mmHg
• ICP monitoring and CPP management have unclear effect on long-term outcomes
• This speaks to the need to individualize therapy
Stepwise approach to ICP management in the OR
OR checklist and first line therapies for intracranial hypertension

• Is cerebral venous drainage optimized?
• Are respiratory parameters okay?
  – Normocapnia
  – Normoxia
  – Ventilatory pressures

Adapted from Drummond, Patel & Lemkuil
Miller’s Anesthesia 2015

Borzage AJP 2016
OR checklist and first line therapies for intracranial hypertension

• Is the patient’s blood pressure adequate?
OR checklist and first line therapies for intracranial hypertension

• Are there cerebral vasodilators that can be eliminated?
• Are metabolic requirements increased for unrecognized reasons?
• Can anesthetic be altered to increase metabolic suppression?
• Is there intracranial pathology that is not visible?
  – Hematoma
  – CSF
  – Venous obstruction or infarction
When first line measures fail to help…

- **Osmotic diuresis**
  - Mannitol (2ml/kg of 20% solution or 0.25 – 1 gm/kg)
  - Hypertonic saline (HTS – 2ml/kg of 3% solution)
- **Hyperventilation**
- **CSF drainage** (AV Lele, J Neurosurg Anesthesiol 2017)
- **Optimization of blood pressure**
Hypertonic saline (HTS) and Mannitol:

• Establish osmotic gradient across intact blood brain barrier
• Both initially produce increase in cardiac output and improved laminar flow in microcirculation
• Both may have anti-inflammatory effects
• Very similar osmolarity (M = 1098, HTS = 1026 mOsm/l)
Advantages of each osmotic agent:

**Mannitol**
- Easily accessed
- Easily administered
- Rapid onset
- Familiarity

**Hypertonic saline**
- Probably more effective than mannitol
- ↓ daily and cumulative ICP burden
- Supports intravascular volume
- Rapid onset and sustained effect
- May be effective when other rx have failed
- Possibly more effective at ↑ CPP and brain oxygenation
Disadvantages of each osmotic agent:

**Mannitol**
- May crystallize
- Potential for rebound ↑ in ICP
- Intravascular volume depletion

**Hypertonic saline**
- May require central access
- Less familiarity with drug
- Caution with abnormal Na values

3, 7.5, 23.4% available
1.8% for peripheral administration
HTS provides improved ICP control compared to mannitol A Ali, JNA 2017

5 ml/kg 20% mannitol vs. 3% HTS
Effects of 3 ml/kg 20% Mannitol and 3% HTS

Hernandez-Pelazon Br J Neurosurgery 2016

(A) Osmolality in arterial blood
(B) Sodium in arterial blood

(C) Lactate in arterial blood
(D) Glucose in arterial blood
Third line measures for refractory intracranial hypertension:

- Hypothermia
- Metabolic suppression
- Decompressive hemicraniectomy (DC)
Decompressive Hemicraniectomy (DC):

- Not currently recommended by Brain Trauma Foundation*
- Is effective at reducing ICP and time in ICU
- If DC planned flap ≥ 12 x 15 cm recommended
- Does improve survival and functional status for malignant stroke in patients ≤ 60 years

*Courtesy of Dr. Aditya Pandey
University of Michigan

Intraoperative aneurysm rupture
In advance of high risk aneurysm clipping consider:

- Type and cross ≥ 2 u PRBC
- Large bore IV access (in addition to arterial line)
- Pacing pads on chest and attached to defibrillator/pacer
- Adenosine 0.3-0.4 mg/kg available in OR
- CMRO$_2$ depressant agents available (propofol)
- Pressors at hand
- Physiologic monitoring including EEG very helpful
In case of rupture:

• Call for help
• Discuss options with surgeons including adenosine or hypotension with CMRO$_2$ depressing agent until temporary clip placed
• Once clip placed consider volume replacement and/or induced hypertension
Major bleeding during spine surgery
Table 2. PMTSS Score Calculation

<table>
<thead>
<tr>
<th>Parameter (Allogeneic Transfusion Predictor)</th>
<th>Assigned Points According to Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 50 yr</td>
<td>1</td>
</tr>
<tr>
<td>Preoperative Hb</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 12 g/dl</td>
<td>2</td>
</tr>
<tr>
<td>12 ≤ Hb ≤ 14 g/dl</td>
<td>1</td>
</tr>
<tr>
<td>Spine fusion levels (n) &gt; 2</td>
<td>1</td>
</tr>
<tr>
<td>Transpedicular osteotomy</td>
<td>4</td>
</tr>
</tbody>
</table>

Anesthesiology 2009;110:1050-1060
Strategies for major bleeding during spine surgery

- Adequate venous access
- Appropriate positioning on bolsters
- Role of colloid?
- Tranexamic acid (TXA) – 10-100 mg/kg bolus followed by 1-10 mg/kg/hr.
- Consider baseline thromboelastometry (TEG or ROTEM)
- PRBC:FFP = 1:1, follow platelets closely
- Transfusion trigger depends on rate of blood loss
- Goal hematocrit vs. transfusion trigger
Iliac bifurcation at L3-4

(Images from Synthes Spine Technique Module)
Interbody fusion approaches
Journal of Spine Surgery 2015

Anterior, Lateral, Oblique (retroperitoneal, Anterior To Psoas), Transforaminal and Posterior Lumbar Interbody Fusion
In Conclusion:

• Management of ICP should follow logical physiologic principles in stepwise fashion
• Neurosurgical procedures are becoming increasingly complex on increasingly sick patients
• Some technical advances including endovascular and minimally invasive spine procedures are helpful given our aging patient population