**General Principles of Operative Neurosurgery**

**Last updated: September 5, 2017**

### NEUROANESTHESIA

1. **Blood Pressure**
   - **Jugular venous pressure**
   - **Venilation**
   - **Hematocrit**
   - **Temperature**
   - **Blood glucose level**
   - **Cerebral metabolic rate of oxygen (CMRO₂)**

2. **Anaesthetics**
   - **Inhalational**
   - **Halogenated agents**
   - **Intravenous**
   - **Opioids**

3. **Neuromuscular blockers**

4. **Medications**
   - **Antibiotics**
   - **Standard**
   - **Allergy to penicillins**
   - **Local Anaesthetics**
   - **Mannitol**
   - **Steroids**
   - **AED**

5. **Patient’s Position**

6. **Prep**

7. **Hematoma**

8. **Preoperative Assessment**

9. **Hemodologial Resuscitation**

10. **Hematostasis**
   - **Electrical hemostasis**
   - **Mechanical hemostasis**
   - **Systemic hemostasis**

11. **Chemical Hemostasis**

12. **Intraoperative Electrophysiologic Monitoring**

13. **Neuronavigation**

14. **Principles of Craniodomyes (incl. incision, closure)**

### NEUROANESTHESIA

#### BLOOD PRESSURE
- determines CPP.
  - **must need to be manipulated**
    - **reduced**, when working on aneurysm
    - **increased**, to enhance collateral circulation during cross clamping
  - arterial line is most accurate; for intracranial procedures, arterial line should be calibrated at external auditory meatus to most closely reflect intracranial blood pressure.
  - **only vasopressor which reduces CSF production** → Mephenephrine.

#### JUGULAR VENOUS PRESSURE
- influences ICP

#### VENTILATION
- goal: end tidal CO₂ (ETC0₂) 25-30 mmHg with correlating PaCO₂ of 30-35 mmHg.

N.B. Keep pCO₂ low for cranial procedures but use with care for stereotactic procedures to minimize shift of intracranial contents!!

#### HEMATOcrit
Low Hct - improved blood theology but decreased oxygen carrying capacity.

#### TEMPERATURE
- mild hypothermia provides some protection against ischemia.

*Each 1°C drop → cerebral metabolic rate of oxygen (CMRO₂) drops by 5%*

#### BLOOD GLUCOSE LEVEL
- hyperglycemia exacerbates ischemic deficits.

#### CEREBRAL METABOLIC RATE OF OXYGEN (CMRO₂)
- reduced with certain neuro-protective agents and by hypothermia.

### ANAESTHETICS

#### INHALATIONAL
- general principles → see p. 2023 >>
  - **most** reduce cerebral metabolism (except nitrous oxide) by suppressing neuronal activity.
  - disturb cerebral autoregulation and cause cerebral vasodilatation → CBV↑ → ICP↑.
  - if administration → CSF volume↑ → ICP↑.
  - most agents increase CO₂ reactivity of cerebral blood vessels → affect intra-operative EP monitoring.

#### NITROUS OXIDE (N₂O) **“LAUGHING GAS”**
- major component of general anesthesia - minimally influences respiration & hemodynamics.
- low blood & tissue solubility - rapid induction and emergence.
- due to movement speed, N₂O may retard oxygen uptake after N₂O anesthesia termination → diffusion hypoxia (H: 100% O₂).
- NB: at least 20% oxygen must always be co-administered.
- **potent analgesic** but weak general anesthetic! no respiratory depression, no muscle relaxation!
- provides only PARTIAL anesthesia (MAC - 104%) - no sufficient potency to be used alone (used in combination with potent volatile agents - permits lower dose of them).  
- 80% N2O cannot produce surgical anesthesia (add opioids for analgesia, thiopental for narcosis, neuromuscular blocker for muscle relaxation).  
- 30% N2O + O2 is useful anaesthesia in dental surgery.

- potent vasodilator → CBF ↑↑↑
- minimally increases cerebral metabolism
- least c/v effects, least hepatotoxicity
- most important clinical problem - nitrous oxide is 34 times more soluble than nitrogen and diffuses into closed gas spaces faster than nitrogen diffuses out → nitrous oxide increases volume / pressure in these spaces; nitrous oxide is contraindicated in presence of closed gas spaces:  
  1) pneumocephalus → may convert to "tension pneumocephalus" (prevention: filling cavity with fluid + turning off N2O ≥ 10 minutes prior to dural closure)  
  2) pneumothorax, pulmonary cysts  
  3) small bowel obstruction  
  4) middle ear blockage  
  5) retinal surgery (intracocular gas bubble is created).

- in chronic abuse may cause leukopenia.

**HALOGENATED AGENTS**

- all suppress EEG activity (except enflurane) - some degree of cerebral protection.

**ISOFLURANE**
- general aspects see p. 3905 >>
- can produce isoelectric EEG without metabolic toxicity - improves neurologic outcome in cases of incomplete global ischemia (although in experimental studies on rats, amount of tissue injury was greater than with thiopental).

**DESFLURANE**
- general aspects see p. 3905 >>
- cerebral vasodilator (increases CBF and ICP) but decreases CMRO (compensatory vasodilation).

**SEVOFLURANE**
- general aspects see p. 3905 >>
- mildly increases CBP and ICP, and reduces CMRO.

**ENFLURANE**
- general aspects see p. 3905 >>
- induces epileptiform EEG changes (relatively contraindicated in seizure disorders).

**INTRAVENOUS**

Barbiturates - see p. 3905 >>

- KETAMINE
  - see p. Rx3 >>

**PROPFOF**
- see p. Rx3 >>

**MIDAZOLAM (Versed®)**
- see p. Rx3 >>

**ETOMIDATE**
- see p. Rx3 >>

**DEXMEDETOMIDINE (Precedex®)**
- see p. Rx3 >>

**OPIOIDS**
- see p. 3905 >>

**NEUROMUSCULAR BLOCKERS**
- see p. 3905 >>

**MEDICATIONS**

**ANTIBIOTICS**

N.B. if operating for suspected infection – skip antibiotics until cultures are sent!

- antibiotic prophylaxis not indicated for EVD insertion or drains.
- intraperative redosing - to ensure adequate serum and tissue concentrations if:
  1) procedure duration exceeds 2 half-lives of antibiotic
  2) excessive blood loss during the procedure
- postoperatively (order 1st dose now) – for 24 hours

**STANDARD**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Manufacturer’s labelling</th>
<th>American Society of Health-System Pharmacists, Infections Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America (ASHPS/IDSA/SIS/SHEA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose</td>
<td>1 g IV or IM</td>
<td>2 g IV (1 g if patient &lt; 60 kg; 3 g if patient &gt; 120 kg; 30 mg/kg for kids)</td>
</tr>
<tr>
<td>Initiate</td>
<td>30-60 minutes prior to surgery</td>
<td></td>
</tr>
<tr>
<td>Re-dose intraop (P2I 1-2.2 hrs)</td>
<td>0.5-1 g after 2 hours within 60 minutes prior to surgical incision</td>
<td></td>
</tr>
<tr>
<td>Postoperatively</td>
<td>0.5-1 g every 6-8 hrs for 24 hrs</td>
<td></td>
</tr>
</tbody>
</table>
ALLERGY TO PENICILLINS

Type I Hypersensitivity (i.e. anaphylaxis) only:
- type 1 reactions occur 30-60 minutes after administration.
- CEPHALOSPORINS and CARBAPENEMS can safely be used in patients with an allergic reaction to penicillins that is not type 1 reaction (e.g. anaphylaxis, urticaria, bronchospasm) or exfoliative dermatitis (Stevens-Johnson syndrome, toxic epidermal necrolysis).

LOCAL ANESTHETICS

Pharmacology - see p. 2229
- for craniotomies:
  - inject local anesthetic with epinephrine after prepping but before going to scrub arms – gives time for epinephrine to work (excellent hemostasis).
  - inject in two layers (skin, under pericranium) – excellent hemostasis!

MANNITOL

- 1 g/kg bolus.
- timing:
  a) when Foley is in, before even incision (Dr. Broaddus) – maximum action starts after 30 minutes and lasts several hours.
  b) at start of bone work (Dr. Ritter, Dr. Rivet) – mannitol increases bleeding due to hypoviscosity effect.

STEROIDS

Dexamethasone:
- Dr. Broaddus – steroids are best when given before insult!

AED

- if cerebral cortex will be involved; continue 7 days postop.

PATIENT’S POSITION

Watch this at first opportunity: http://www.neurosurgicalatlas.com/grand-rounds/Patient-Positioning-for-Intracranial-Surgery-A-Guide-for-Residents-an-Fe

- head lowering (Trendelenburg) - increases arterial blood flow, but also increases ICP by impairing venous outflow.
- prone position + excessive fluids:
  1) facial edema (risk factor for posterior ischemic optic neuropathy with blindness)
  2) airway edema (no cuff leak – unable to extubate)
  3) abdominal volume is made pendulous between bars – decreased spinal venous epidural bleeding but also kidney perfusion ↓ (decreased UO).
- during procedure, patient’s position may change and be unnoticed due to draping.
- Dr. Broaddus likes to avoid any rotations (of head or bed) – everything must be in perpendicular planes – helps with spatial orientation even without navigation.
SKULL CLAMPS

- see p. Op140 >>

N.B. after application of skull clamp, the only allowed patient torso movement is Trendelenburg / Reverse Trendelenburg or Left / Right rotation. No flexing of torso after pin application – causes stress on pins and neck!

PREP

- no hair clip (Dr. Ritter, Dr. Broaddus) or minimal clip (Dr. Holloway).
- chlorhexidine sponge (general cleaning) → isopropyl alcohol gauze (degreasing) → mark** skin incision (this way marking stays well) → ChloraPrep x2 (3 minutes apart)**
- *Dr. Ritter - not needed if done chlorhexidine towels at home
- **no per Dr. Ritter – child’s parents do not like it.
- ***chlorhexidine is contraindicated at age < 2 months

HEMOSTASIS

- brain is vascular organ; 15~20% of cardiac output is distributed to brain.
- much of neurosurgical training is focused on how to avoid and stop bleeding:
  - stray in midline
  - stay on bone (“bone is home” – subperiosteal dissection)
- avoiding bleeding is easier that stopping it.

PREOPERATIVE ASSESSMENT

1. History (personal and familial) - bleeding / clotting problems.
2. Laboratory studies: PT/INR, aPTT, platelet count, BUN & creatinine, LFT

HEMATOLOGICAL RESUSCITATION

1. Normalize temperature (patient’s and fluids)
2. Correct platelets – goal > 100 (< 50 is absolute contraindication to neurosurgery)
3. Correct ionized calcium
4. Correct INR – goal < 1.4
5. Correct DIC and/or low fibrinogen (< 150) with cryoprecipitate.
- rapid correction in life-threatening circumstances - use Factor VII
6. Involve anesthesia, hematology (massive transfusion protocol team)

HEMOSTASIS

- obtain proximal and distal control of major vessels early
- avoid and control bleeding in potential spaces:
  - epidual: tack-ups along craniotomy perimeter, tenting sutures (in middle of craniotomy flap)
  - epidual veins of spine

ELECTRICAL HEMOSTASIS

- Bipolar; irrigation is important!
- Monopolar

MECHANICAL HEMOSTASIS

a. Finger pressure
b. Elevation to control venous bleeding
c. Skin clips: Raney vs. Michel
d. Warm water
e. Coton (understand why there are so many sizes and shapes of “cottonoids”)
f. Contact Agents: surgical flow seal, Oxycel, gel foam, etc., bone wax, thrombin, fibrin glue, peroxide, etc.

SYSTEMIC HEMOSTASIS

TRANEXAMIC ACID (TXA) - synthetic analogue of lysine – inhibits activation of plasminogen to plasmin, slowing the degradation of fibrin
- 10 mg/kg at the start of surgery → 5 mg/kg/hour for 24 hours after surgery.
- used in craniosynostosis surgery.

CHEMICAL HEMOSTASIS

- see p. Op140 >>