General Principles of Operative Neurosurgery

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NEUROANESTHESIA

Blood Pressure
- determines CPP
  - may need to be manipulated:
    a) reduced - when working on aneurysm
    b) 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 (→ ICP) isnorepinephrine.

Inhalational
- goal: end tidal CO₂ (ETCO₂) 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!!

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

Ventilation
- mild hypothermia provides some protection against ischemia.
- hyperventilation exacerbates ischemic deficits.
- gas exchange: PaCO₂ of 35 mmHg
- cerebral metabolic rate of oxygen (CMRO₂) drops by 7%

Blood Glucose Level
- microvascular dysfunction
  - reduced with certain neuro-protective agents and by hypothermia.

Anesthesics
- most reduce cerebral metabolism (except nitrous oxide) by suppressing neuronal activity.
  - disturb cerebral autoregulation and cause cerebral vasodilatation → CBV? → ICP?
  - if administration > 2 hrs → CSF-volume? → ICP?

NITROUS OXIDE (N₂O) + “LAUGHING GAS”
- major component of general anesthesia - minimally influences respiration & hemodynamics.

Blood Glucose Level
- hyperglycemia exacerbates ischemic deficits.
- cerebral metabolic rate of oxygen (CMRO₂)

Inhalational
- general principles (see p. 9105) →
  - must reduce cerebral metabolism (except nitrous oxide) by suppressing neuronal activity.
  - disturb cerebral autoregulation and cause cerebral vasodilatation → CBV? → ICP?
  - if administration > 2 hrs → CSF-volume? → ICP?
  - most agents increase CO₂ reactivity of cerebral blood vessels → affect intra-operative EP monitoring.

Surgical site infection (SSI) prophylaxis (see p. Op120) →

Chemical Hemostasis
- systemic hemostasis
- mechanical hemostasis
- skull clamps
- cross clamping
- intraoperative

Surgical risk calculator (based on ACS NSQIP database):
https://riskcalculator.facs.org/RiskCalculator/PatientInfo.jsp
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).

N.B. at least 20% oxygen always must be co-administered!

potent analgesic but weak general anesthetic! no respiratory depression, no muscle relaxation?

– provides only PARTIAL anesthesis (MAC - 1.0) - no sufficient potency to be used alone
(used in combination with potent volatile agents - permits lower dose of them).

– 80% N2O cannot produce surgical anestheisa (add opioids for analgesia, thiopental for
narcosis, neuromuscular blocker for muscle relaxation).

– 30% N2O + O2 is useful analgesia in dental surgery.

potent vasodilator – CBF

– minimally increases cerebral metabolism

least c/v effects, least hepatotoxicity – safest inhalational anesthetic!!!

– high incidence of postoperative nausea & vomiting

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 those 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) renal surgery (intraocular 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. 3050 >>
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. 3050 >>
cerebral vasodilator (increases CBF and ICP) but decreases CMRO (compensatory
vasoconstruction).

SEVOFLURANE general aspects see p. 3050 >>
mildly increases CBF and ICP, and reduces CMRO.

ENFLURANE general aspects see p. 3050 >>
induces epileptiform EEG changes (relatively contraindicated in seizure disorders).

INTRAVENTOUS

Barbiturates - see p. 3050 >>

KETAMINE - see p. 833 >>

PROPOFOL - see p. 833 >>

MIDAZOLAM (Versed®) - see p. 833 >>

ETOMIDATE - see p. 833 >>

DEXMEDETOMIDINE (Precedex®) - see p. 833 >>

OPIOIDS

- see p. 3050 >>

NEUROMUSCULAR BLOCKERS

- see p. 3050 >>

MEDICATIONS

ANTIBIOTICS

See also – p. Op120 >>

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

– antibiotic prophylaxis not indicated for EVD insertion or drains.

– intraoperative redosing - to ensure adequate serum and tissue concentrations if:
  a) procedure duration exceeds 2 half-lives of antibiotic
  b) excessive blood loss during the procedure

– postoperatively (order 1st dose now) – for 24 hours.

STANDARD

Cefazolin (Ancef®)

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<th>Manufacturer’s labeling</th>
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<td>American Society of Health-System Pharmacists, Infections Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America (ASHPO/IDSA/SIS/SHEA)</td>
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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 prep 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 (either cut or retracted excessively); 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
- supine patient position is adequate for lesions anterior to and within the central lobule; consider using the lateral position if the lesion is situated just posterior to the lobule (alternatively, the supine position can be employed with the ipsilateral shoulder highly elevated on a bulky gelrest).
- 1/2 = park bench
- head lowering (Trendelenburg) - increases arterial blood flow, but also increases ICP by impairing
VENOUS OUTFLOW
- Using 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. Broadus 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. Broadus) or minimal clip (Dr. Holloway)
- Chlorhexidine sponge (general cleaning) → isopropyl alcohol gauze (degreasing) → mark
- Skin incision (this way marking stays well as opposed to marking before chlorhexidine sponge) → 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 (use Betadine).

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:
  1. Stay in midline
  2. Stay on bone (“bone is home” – subperiosteal dissection)
  3. Avoiding bleeding is easier than stopping it.

PREOPERATIVE ASSESSMENT
2. Laboratory studies:
   1) Coag (PT/INR, aPTT)
   2) CBC (WBC, Hb, platelet count)
   3) BMP (BUN & creatinine)
   4) UA
   5) 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.
6. Involve anesthesiology, hematology (massive transfusion protocol team)

HEMOSTASIS
- Obtain proximal and distal control of major vessels early.
- Avoid and control bleeding in potential spaces:
  1. Epidural: tack-ups along craniotomy perimeter, tenting sutures (in middle of craniotomy flap)
  2. Epidural veins of spine

ELECTRICAL HEMOSTASIS
- See p. Op140
- 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
f. Coton (understand why there are so many sizes and shapes of “cottonoids”)

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 and spine surgery.
- Risk of thromboembolic complications.

CHEMICAL HEMOSTASIS

GENERAL PRINCIPLES OF OPERATIVE NEUROSURGERY