General Principles of Operative Neurosurgery

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**Intraoperative electrophysiologic monitoring** – [see p. D25 >>](http://www.neurosurgeryresident.net/D.%20Diagnostics%5CD20-29.%20Electrophysiology%20%28EEG%2C%20evoked%20potentials%2C%20MEG%2C%20EMG%2C%20nerve%20conduction%29%5CD25.%20Evoked%20Potentials.pdf)

**Neuronavigation** – [see p. Op30 >>](http://WWW.NEUROSURGERYRESIDENT.NET/OP.%20OPERATIVE%20TECHNIQUES%5C030.%20Neuronavigation/Op30.%20Neuronavigation.pdf)

**Principles of craniotomies** (incl. incision, closure) – [see p. Op300 >>](http://WWW.NEUROSURGERYRESIDENT.NET/OP.%20OPERATIVE%20TECHNIQUES%5C300-399.%20Cranial/Op300.%20Craniotomies.pdf)

**Surgical site infection (SSI) prophylaxis** – [p. Op120 >>](Op120.%20General%20Principles%20of%20Perioperative%20Neurosurgery.pdf#Postop_infection)

**Surgical risk calculator** (based on ACS NSQIP database):

<https://riskcalculator.facs.org/RiskCalculator/PatientInfo.jsp>

Neuroanesthesia

Blood Pressure

- determines CPP.

* may need to be manipulated:
1. **reduced** - when working on aneurysm
2. **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↓) is norepinephrine.

Jugular venous pressure

- influences ICP

Ventilation

* goal - end tidal CO2 (ETC02) 25-30 mmHg with correlating PaC02 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 rheology 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 7%

Blood glucose level

* hyperglycemia exacerbates ischemic deficits.

Cerebral metabolic rate of oxygen (CMRO2)

* reduced with certain neuro-protective agents and by hypothermia.

Anesthetics

Inhalational

general principles – [see p. 3905 >>](http://WWW.NEUROSURGERYRESIDENT.NET/USMLE%202/Intensive%20Care%20%283901-3950%29/3905.%20Anesthesia%2C%20Pain%20management.pdf)

* 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↑.
* most agents increase CO2 reactivity of cerebral blood vessels → affect intra-operative EP monitoring.

Nitrous Oxide (N2O s. “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).

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 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 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 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 (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. 3905 >>](http://www.neurosurgeryresident.net/USMLE%202%5CIntensive%20Care%20%283901-3950%29%5C3905.%20Anesthesia%2C%20Pain%20management.pdf#ISOFLURANE)

* 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 >>](http://www.neurosurgeryresident.net/USMLE%202%5CIntensive%20Care%20%283901-3950%29%5C3905.%20Anesthesia%2C%20Pain%20management.pdf#DESFLURANE)

* cerebral vasodilator (increases CBF and ICP) but decreases CMRO (compensatory vasoconstriction).

sevoflurane [general aspects see p. 3905 >>](http://www.neurosurgeryresident.net/USMLE%202%5CIntensive%20Care%20%283901-3950%29%5C3905.%20Anesthesia%2C%20Pain%20management.pdf#SEVOFLURANE)

* mildly increases CBP and ICP, and reduces CMRO.

Enflurane [general aspects see p. 3905 >>](http://www.neurosurgeryresident.net/USMLE%202%5CIntensive%20Care%20%283901-3950%29%5C3905.%20Anesthesia%2C%20Pain%20management.pdf#ENFLURANE)

* induces **epileptiform EEG changes** (relatively contraindicated in seizure disorders).

Intravenous

**Barbiturates**

- see [p. S50 >>](http://WWW.NEUROSURGERYRESIDENT.NET/S.%20Symptoms%2C%20Signs%2C%20Syndromes/S50-64.%20Intracranial%20pressure%2C%20Brain%20edema%2C%20Herniation%2C%20Hydrocephaly/S50.%20GENERAL%20-%20Intracranial%20Hypertension.pdf#BARBITURATES)

Ketamine

- see [p. Rx3 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Rx.%20Treatment%20Modalities/Rx3.%20Other%20Sedatives-Anxiolytics.pdf#Ketamine)

Propofol

- see [p. Rx3 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Rx.%20Treatment%20Modalities/Rx3.%20Other%20Sedatives-Anxiolytics.pdf#Propofol)

Midazolam (Versed®)

- see [p. Rx3 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Rx.%20Treatment%20Modalities/Rx3.%20Other%20Sedatives-Anxiolytics.pdf#Midazolam)

Etomidate

- see [p. Rx3 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Rx.%20Treatment%20Modalities/Rx3.%20Other%20Sedatives-Anxiolytics.pdf#Etomidate)

Dexmedetomidine (Precedex®)

- see [p. Rx3 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Rx.%20Treatment%20Modalities/Rx3.%20Other%20Sedatives-Anxiolytics.pdf#DEXMEDETOMIDINE)

Opioids

- see [p. 3905 >>](http://WWW.NEUROSURGERYRESIDENT.NET/USMLE%202/Intensive%20Care%20%283901-3950%29/3905.%20Anesthesia%2C%20Pain%20management.pdf#Opioids)

Neuromuscular Blockers

- see [p. 3905 >>](http://WWW.NEUROSURGERYRESIDENT.NET/USMLE%202/Intensive%20Care%20%283901-3950%29/3905.%20Anesthesia%2C%20Pain%20management.pdf#Muscular_blockers)

Medications

Antibiotics

See also – [p. Op120 >>](Op120.%20General%20Principles%20of%20Perioperative%20Neurosurgery.pdf#Postop_infection)

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:
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

Cefazolin (Ancef®)

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Manufacturer’s labeling** | **American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America (ASHP/IDSA/SIS/SHEA)** |
| Dose | 1 g IV or IM | 2 g IV (1 g if patient < 60 kg; 3 g if patient > 120 kg; 30 mg/kg for kids) |
| Initiate | 30-60 minutes prior to surgery | within 60 minutes prior to surgical incision |
| Re-dose intraop(T½ 1.2-2.2 hrs) | 0.5-1 g after 2 hours | in 3-4 hours |
| Postoperatively | 0.5-1 g every 6-8 hrs for 24 hrs |  |

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).

Vancomycin

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Dose | 15 mg/kg (e.g. 1 g) IV; same for kids |
| Initiate | within 120 minutes of incision\* |
| Re-dose intraoperatively(T½ 4-11 hrs) | after 6-8 hours |
| Postoperatively | 1 g every 12 hrs 2 doses |

\*The Society of Thoracic Surgeons recommends over 60 minutes with completion within 1 hour of skin incision!

* for patients colonized with MRSA, single 15 mg/kg preoperative dose may be added to other recommended agents.

Clindamycin

* 600 mg (20 mg/kg for kids) IV 30-60 minutes before procedure with no follow-up dose needed.





Local Anesthetics

Pharmacology - see [p. 2229 >>](http://WWW.NEUROSURGERYRESIDENT.NET/USMLE%202/Surgery%20%282201-2250%29/2229.%20Local%20Anesthetics.pdf)

* 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:
1. when Foley is in, before even incision (Dr. Broaddus) – maximum action starts after 30 minutes and lasts several hours.
2. 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.

Doses – see [p. Rx0 >>](../Rx.%20Treatment%20Modalities/Rx0.%20Medications%20in%20Neurosurgery.pdf#AED)

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).
* ¾ = park bench
* 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 [>>](http://www.neurosurgeryresident.net/Op.%20Operative%20Techniques%5COp140.%20Surgical%20Instruments%2C%20Materials.pdf#HEAD_HOLDERS)

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 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:
* stay in midline
* stay on bone (“bone is home” – subperiosteal dissection)
* avoiding bleeding is easier that stopping it.

Preoperative Assesment

1. History (personal and familial) - bleeding / clotting problems.
2. Laboratory studies:
	* 1. coags (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.
* rapid correction in life-threatening circumstances - use Factor VII
1. Involve anesthesia, hematology (massive transfusion protocol team)

Hemostasis

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

Electrical hemostasis

- see [p. Op140 >>](http://www.neurosurgeryresident.net/Op.%20Operative%20Techniques%5COp140.%20Surgical%20Instruments%2C%20Materials.pdf)

1. Bipolar; irrigation is important!
2. 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 and spine surgery.
* risk of thromboembolic complications.

Chemical Hemostasis

- see [p. Op140 >>](http://www.neurosurgeryresident.net/Op.%20Operative%20Techniques%5COp140.%20Surgical%20Instruments%2C%20Materials.pdf)

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