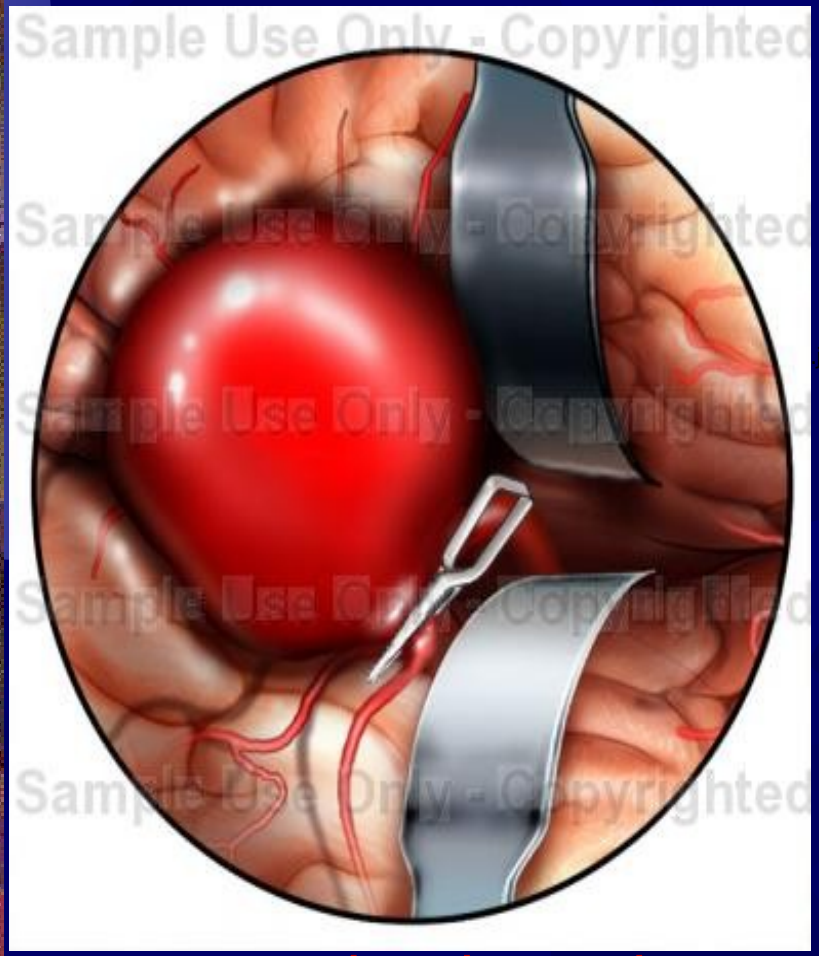
Cerebral Aneurysm: Anesthetic Management



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Pre-operative Evaluation & Preparation

- **Assess the neurological status & SAH grade:**

  Poor grades are more likely to be associated with:

  -Elevated ICP

  -Impaired cerebral auto-regulation

  -Arrhythmia, myocardial dysfunction

  -Electrolyte abnormality, hypovolemia

  -Poor outcome

Pre-operative Evaluation & Preparation

- **Review Intracranial pathology:**
  CT & angio:
  -Site & size of aneurysm
  -Extent of SAH, hydrocephalus
  -Vasospasm, collateral circulation

- **Evaluate other systemic functions likely to be affected by SAH:**
  CVS, Respiratory system & s.electrolytes

Pre-operative Evaluation & Preparation

- **CVS: ECG changes (40-100%)**

  -exclude dyselectrolytemia (hypokalemia, hypocalcemia)

  -ST elevation, symmetrical T wave inversion & prolonged QT: sensitive indicator of LV dysfunction

  -exclude cardiac causes (Echo, cardiac enzymes)

  -diagnostic dilemma should not delay surgery

  -may alter anesthetic plan

Pre-operative Evaluation & Preparation

- **Intravascular volume & serum electrolyte disturbances:**
  Correlates with clinical grade
  -Hypovolemia
  -Hyponatremia
  -Hypokalemia
  -Hypocalcemia

- **Respiratory system:**
  -Neurogenic pulmonary edema
  -Aspiration pneumonia

Pre-operative Evaluation & Preparation

- **Review on-going treatment:**
  -Anticonvulsants: interaction with NDMR & fentanyl
  -Nimodipine: perioperative hypotension
  -Steroids
  -Antifibrinolytic: not used now a days

- **Other co-morbid illnesses**

- **Communicate with neuro-surgeon:**
  -Position
  -Requirement of special monitoring

Pre-operative Evaluation & Preparation

- **Timing of surgery:**
  Early surgery (within 3 days of SAH):
  -Edematous brain
  -Less optimized patient

  Delayed surgery (after 7 to 10 days):
  -More chance of rebleeding

- **Type of surgery:** coiling or clipping

- **Optimization of patient:** correct physiological & biochemical disturbances

Premedication

- Sedatives are best avoided:
  - barbiturates/narcotics: respiratory depression
  - interfere with neurological assessment
- Anxious hypertensive patients: anxiolysis
- Already intubated & mechanically ventilated: sedation +/- muscle relaxation

- Anticholinergics: glycopyrrolate

- Continue nimodipine, dexamethasone & anticonvulsant

General Anesthesia: Induction

- **Anesthetic concerns:**
  -Aneurysm rupture: laryngoscopy & intubation
  -Cerebral ischemia: induction agents

- **Anesthetic goals:** minimize TMP, maintain adequate CPP
- CPP = MAP – ICP
- TMP = MAP – ICP
- Balance benefit of improved perfusion against risk of rebleeding
- Try to maintain TMP & CPP at pre-op level

Induction

Good SAH grade

- Near normal ICP
- Less prone to develop ischemia
- More chance of rupture
- Can tolerate fall in BP up to 30-35%
- Can not tolerate much fall in CBF: don’t hyperventilate

Poor SAH grade

- Raised ICP
- Relatively protected against rupture
- More at risk of ischemia
- Can not tolerate much fall in BP
- Hyperventilation improves CPP

Anesthetic Agents

- **IV induction is preferred:** titrated dose of thiopentone or propofol

- **Prevent hypertensive response to laryngoscopy & intubation:**
  -Adequate depth of anesthesia
  -Lidocaine, beta-blockers, narcotics

- **Muscle relaxant**

Patient with full stomach

- Balance the risk of aspiration against risk of aneurysm rupture
- MRSI
- Opioids
- Calculated vs. titrated dose of thiopentone
- +/- IPPV with cricoid pressure

Difficult airway

- FOB guided intubation
- Avoid translarygeal injection of LA
- Obtund cough reflex with iv narcotics
- Spray as you go technique
- Lidocaine nebulization

Intra-op Monitoring

Routine monitoring

- SPO2
- EtCO2
- NIBP
- ECG
- Temperature
- Urine output

Special monitoring

- IBP
  - -ABG, S.electrolyte
  - -Serum osmolarity
  - -Blood glucose
- CVP/ PAWP
- NMT
- EEG
- TCD
- SSEP/ BAEP

CVP/ PAC

- Indications:
  - -Pre-existing hypovolumia
  - -Large intra-op fluid shift with use of osmotic/ loop diuretics
  - -Potential risk of aneurysm rupture requiring fluid resuscitation
  - -Institution of triple-H therapy
  - -Coexisting CAD/ myocardial dysfunction
- IJV: ? Risk of venous obstruction
- Avoid excessive trendelenberg tilt & neck rotation

Positioning of Patient

- **Anterior circulation aneurysm** (frontal-temporal incision):

  -supine position
- **Basilar tip aneurysm** (subtemporal incision):

  -lateral or supine
- **Vertebral or basilar trunk aneurysm** (suboccipital incision):

  -seated or park-bench position
- **Take care of:**

  -Bony prominences, eyes & peripheral nerves

  -Tracheal tube position

  -Venous drainage from head & neck

  -VAE

Maintenance of anesthesia

- **Goals:**
  -Relaxed brain
  -Adequate cerebral perfusion
  -Avoidance of rapid increase in TMP
  -Absolute immobility
  -Prompt awakening

- **Anesthetic agents:**
  -O2+N2O+Iso (sevo/des)
  -Short acting opioids (fenta/sufenta)
  -Vec / roc

TIVA

- Propofol + short acting opioid + short/ intermediate acting muscle relaxant
- Better control over cerebral dynamics
- Rapid, predictable titration
- Delayed recovery
- Preferred in poor SAH grade

Crucial Points of Increased Stimulus

- Laryngoscopy & intubation
- Positioning
- Placement of pin-head holder
- Raising bone flap
- Retraction of cranial nerves & brainstem

-Little or no stimulus once dura is open

Brain Relaxation

- **Three basic measures:**
  - -Brain tissue volume reduction (mannitol)
  - -CSF volume reduction (lumber CSF drain)
  - -Cerebral blood volume reduction (hyperventilation)
- **Mannitol 20% (0.5-2 gm/kg)**
  - -Triphasic action
  - -Reduces CSF production
  - -Anti-oxidant
  - -Theoretically should not be given before dura is open

Brain Relaxation

- **Lumber drainage of CSF:**

  -Minimize sudden CSF loss during drain placement: risk of rebleeding

  -Contraindication: intracerebral hematoma

  -Theoretically: drain after opening of dura

  -20-30 ml before dural opening

  -Rate of drainage: don’t exceed 5ml/min

  -Rapid drainage: reflex hypertension

Brain Relaxation

- **Hyperventilation:**

  (2-3% CBF change per mm Hg $PaCO_2$ change)

  -Mild hypocapnia (30-35mmHg) before dura is open

  -Moderate hypocapnia (25-30mmHg) after opening of dura

  -Relative normocapnia during aneurysm clipping/ induced hypotension

  Balance the benefit of CBF reduction with risk of cerebral ischemia

Brain Relaxation

- **Other modalities:**
  -Head up tilt
  -Frusemide
  -Omit N2O
  -Reduce volatile anesthetics
  -Bolus/ infusion of iv anesthetics
- **Rule out:**
  -Inadequate depth of anesthesia
  -Hypoxia, hypertension, hyperthermia
  -Venous obstruction at neck
  -Intracerebral hematoma

Fluid & electrolyte balance

- Before clipping: maintain normovolemia
- After clipping: slight hypervolemia
- Hypovolemia is detrimental during temporary clipping & induced hypotension
- Avoid glucose containing fluid
- Preferred iv fluids:
  -Normal saline
- Colloid: 5% albumin
- Avoid hetastarch, dextran
- Treat electrolyte abnormality
- Treat hyperglycemia (target 80-120mg/dl)

Controlled Hypotension vs. Temporary Occlusion

- **Purpose:**
  -to reduce the risk of aneurysm rupture
  -to achieve blood less field
  -better visualization
- **Controlled hypotension:**
  -Systemic hypotension using hypotensive agents
  -Risk of global ischemia
  -Higher incidence of cerebral vasospasm
  -poor outcome
  -Not commonly used now a days

Temporary Occlusion

- Temporary clipping of feeding artery
- Risk of vessel damage
- Risk of regional ischemia
- Dependent on collateral circulation
- Shorter duration (15-20 min)
- Methods to extend the duration of occlusion: cerebral protection

Temporary Occlusion

- **Mannitol:** up to 2 gm/kg
- **Sendai cocktail: (Suzuki et al, 1987)**
  -500ml 20% mannitol
  -Vitamin E 500mg
  -Dexamethasone 50mg
- Up to 60 min of occlusion possible
- Recommended safe duration: 15-20 min
- **Thiopentone/ Etomidate:** burst suppression dose
- **Hypothermia**
- **MAP to be increased after application of clip to improve collateral circulation**

Temporary Occlusion

- **Hypothermia:**
  -Mild hypothermia (32-35 deg): not convincing result
  -Moderate hypothermia
  -Deep hypothermic arrest: giant aneurysm

- **Monitoring of upper limit of occlusion duration:**
- EEG: not effective beyond burst suppression
- SSEP: anterior & posterior circulation
- BAEP: vertebral-basilar aneurysm
- Spontaneous breathing

Cerebral Vasospasm & Anesthesia

Patient without pre-op symptom of vasospasm:

- Always at risk of developing vasospasm
- Maintain normovolumia until clipping
- Then careful volume loading (MAP slightly higher than base-line)
- Post-op hypertension: don’t treat aggressively

Cerebral Vasospasm & Anesthesia

Pre-op symptomatic vasospasm

- Volume loading under invasive monitoring
- SBP: 120-150mmHg before clipping
- SBP: 160-200mmHg after clipping
- CVP: 8-12mmHg
- PAWP: 15-18mmHg
- Induced hypotension is contraindicated
- Papaverine

  -Increased ICP, hypotension, s/s resembling MH, facial nerve palsy, pupillary dysfunction

- **Delayed surgery:** low risk of vasospasm

Intra-op Aneurysm Rupture

- **Incidence**
  - -Aneurysm leak: 6%
  - -Frank rupture: 13%
  - -Combined incidence: 19%
- **When does it occur?**
  - -Before dissection (7%)
  - -During dissection (48%)
  - -During clip placement (45%)
- Increases overall mortality & morbidity
- Better prognosis if occurs after opening of dura

Intra-operative Aneurysm Rupture Management

- Small leak: suction & application of permanent clip by surgeon
- Larger leak: application of proximal & distal temporary clip
- Clipping was not planned & minor blood loss: induced hypotension to facilitate surgical control
- Major blood loss: fluid resuscitation
- Good communication between anesthesiologist & surgeon: video monitor

Emergence & Recovery

Extubate or not extubate??

- SAH grade I & II: uneventful surgery: reverse & extubate

- SAH grade III:
  -Pre-op ventilatory status
  -Duration & intra-op course

- SAH grade IV & V:Keep intubated, provide ventilatory support, neuro ICU care
- Intra-op aneurysm rupture/ vertebral-basilar aneurysm: immediate extubation may not be possible

Concerns During Extubation

- Fully awake patient
- Prevent stress response judiciously
- Iv lidocaine, beta-blocker,vasodilators with caution
- Accept modest level of hypertension (SBP<180mmHg): prevent vasospasm
- Multiple aneurysm: keep MAP within 20% of base line

Post-op Care

- Neurosurgery ICU
- Monitoring:
  Hemodynamics, ICP, neurological status
- Institute triple-H therapy
- Post-op CT/ angio
- Pain management:
  -NSAIDs
  -Opioids under close monitoring

Aneurysm Rupture & Pregnancy

- Incidence: not different from general population
- More often during 3rd trimester
- Responsible factors: (?)
  -maternal blood volume
  -SBP, stroke volume
  -Uterine contraction
  -Labour pain
  -Auto-transfusion
- Maternal outcome: not different from non-gravid population (mortality 35%)
- Fetal outcome: 17% mortality
- Maternal & fetal outcome is better with surgery than conservative management

Diagnosis

- Exclude:
  -Pituitary apoplexy
  -Cerebral sinus thrombosis
  -Intracranial arterial occlusion
  -PDPH
  -Pre-eclampsia
- Proper shielding of uterus during radiation exposure
- Iodinated contrast: fetal dehydration

Obstetric management

- **GA < 32 wks:** immediate surgical clipping
- **32-36 wks:**

  Aneurysm surgery followed by full term delivery

  Keeping obstetric team available

  Continuous fetal HR monitoring

  Fetal distress? / imminent delivery?

  -Halt aneurysm surgery

  -Immediate CS

Obstetric management

- **Near term fetus or signs of fetal distress:** CS followed by clipping
- **Gravid patient with surgically inaccessible or undetermined aneurysm:** CS vs. vaginal delivery
  Labor analgesia
- **Moribund mother in 3rd trimester:** CS

Anesthetic Considerations

- Increased risk of aspiration
- Increased risk of having difficult airway
- Position: Left uterine displacement
- Decreased MAC
- Fetal-maternal oxygen exchange:
  -Avoid & treat maternal hypotension
  -Place of induced hypotension?
  -Maintain $EtCO_2$ around 30mmHg

Anesthetic Considerations

- Teratogenic effects of drugs
- CS prior to aneurysm surgery:
  - -Maintain adequate depth
  - -Neonatal resuscitation
  - -Oxytotic drugs can be used
- Aneurysm surgery before CS:
  - -Continuous fetal monitoring

Drugs with Adverse Uteroplacental Effects

Drugs	Adverse effects
Phenytoin	Minimal
Thiopentone	Neonatal depression due to maternal hemodynamic effect
Etomidate	Uterine hypertonus, vasoconstriction & fetal distress
Mannitol	Oligohydromnios, fetal dehydration, hyperosmolarity, hypernatremia
Frusemide	Electrolyte abnormality
Nitroprussid e	Decreased uterine vascular resistance, fetal cyanide toxicity
Nitroglycerin	Decreased uterine vascular resistance
Hydralazine	Decreased uterine vascular resistance
Propranolol	IUGR, premature labour, fetal distress, neonatal acidosis, hypoglycemia, bradycardia, apnea

Giant Aneurysm

- Diameter > 2.5 cm: significant mortality/morbidity
- May present as a mass lesion
- Technical difficulty: lack neck, wall may be traversed by perforators
- Two approaches:

  -Distal & proximal temporary clamping

  -Dissection under DHCA

Brain Protection in Circulatory Arrest

- Barbiturates:
  -Thiopentone 30-40mg/kg over 30 min
  -3-5mg/kg bolus, then inf.0.1-0.5 mg/kg/min
- Deep hypothermia (13-21 deg C)
- Circulatory arrest up to 60 min
- Monitors:
  -brain temp,
  -EEG, SSEP, BAEP
  -TCD
  -TEE

Management

- Hypothermia:
  -increased SVR: vasodilator
  -terminate electrical activity of heart
- Coagulopathy:
  -Proposed etiology
  -May cause intra-cranial bleed
- How to reduce the risk?
  -Dissect before inducing hypothermia
  -Maintain ACT between 400-450sec
  -Reverse with protamine: ACT 100-150sec
  -Re-transfuse phlebotomized platelet rich blood

Complications & Management

- Hyper-viscosity: phlebotomy
- Hyperglycemia
- Rest of anesthetic management: same

Cerebral Protection

Non-pharmacological

- Hypothermia
- Prevention of
  - -Hypoxia
  - -Hypercarbia
  - -Hyperglycemia
  - -Metabolic acidosis
  - -Electrolyte disturbance
  - -Hypotension
- Normalization of ICP
- Hemodilution

Pharmacological

- Barbiturates
- Propofol
- Etomidate
- Benzodiazepines
- Opioids
- CCB
- Iso, sevo, des
- Lidocaine
- Anticonvulsants

Cerebral Protection

Newer modalities

- Ischemic preconditioning
- Erythropoietin
- Magnesium
- Mannitol, vit-E, steroids, deferoxamine
- Sodium channel blocker: riluzole
- Tirilazad

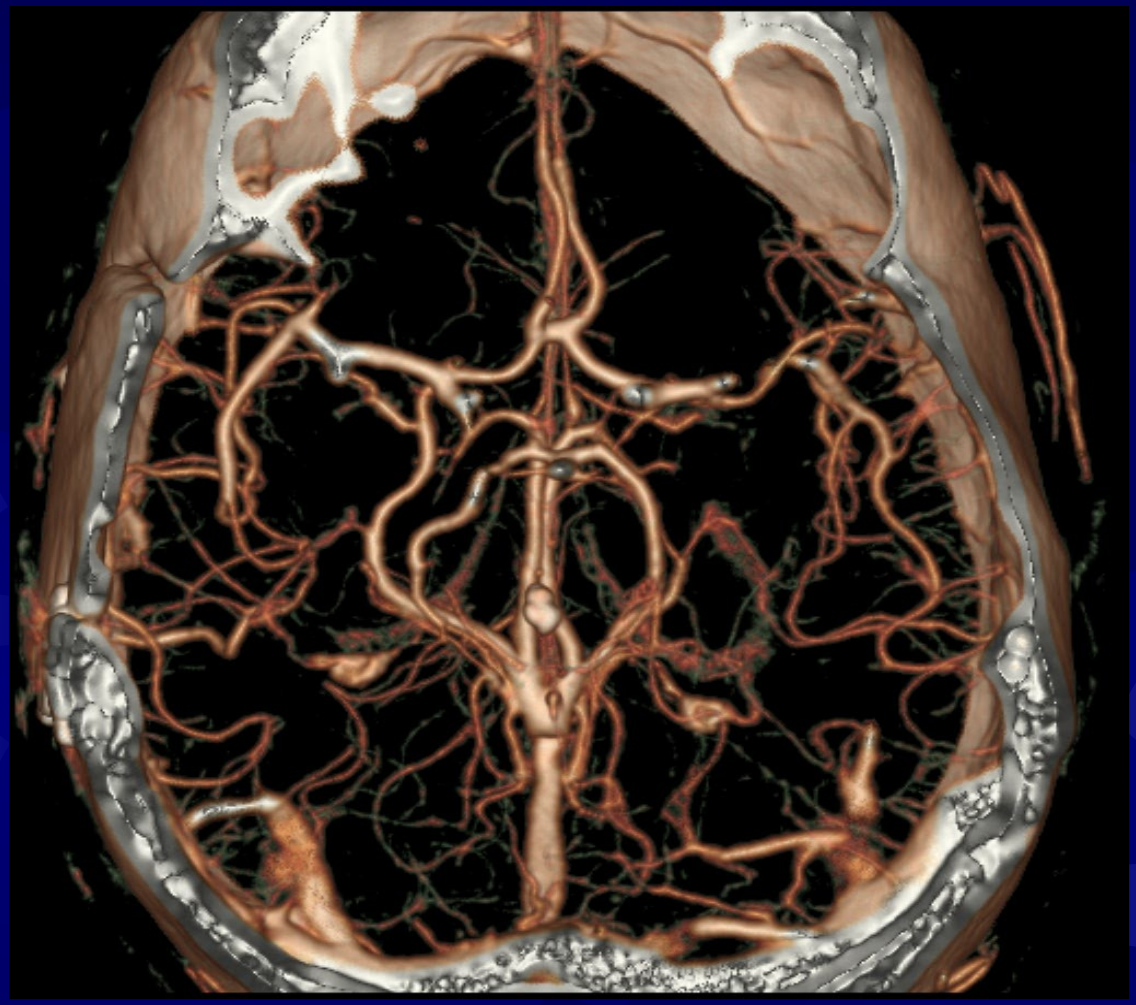
Anesthesia for Coiling

- Under GA/ sedation
- Anesthetic considerations are same with few exceptions:

  -Location: neuro-radiology suite

  -Blood loss: less

  -No need for brain relaxation



Thank You

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Grading of SAH

- WFNS Grading :

Grade	GCS	Motor Deficit
I	15	Absent
II	13-14	Absent
III	13-14	Present
IV	7-12	+/-
V	3-6	+/-

Modified H & H Grading

Grade	Description	Mortality (%)
Grade 0	Unruptured aneurysm	--
Grade I	Asymptomatic or minimal headache with normal neurologic examination	2
Grade II	Moderate to severe headache, nuchal rigidity, no neurologic deficit other than cranial nerve palsy	5
Grade III	Lethargy, confusion, or mild focal deficit	15 — 20
Grade IV	Stupor, moderate to severe hemiparesis, possible early decerebrate rigidity, vegetative disturbances	30 — 40
Grade V	Deep coma, decerebrate rigidity, moribund appearance	50 — 80

Grading System of Fisher

1 No subarachnoid blood detected

2 Diffuse or vertical layers < 1 mm thick

3 Localized clot and/or vertical layer > 1 mm

4 Intracerebral or intraventricular clot with diffuse or no SAH

Hypothermia

Body temperature (Deg C)	Normal CMRO2	Period of tolerated circulatory arrest
38	100	4-5
30	50	8-10
25	25	10-20
20	15	32-40
10	10	64-80