Posterior Fossa Surgery

Posterior Fossa Surgery is performed for many indications. Complications of Posterior Fossa Surgery are most often related to positioning, mass effects on and the proximity to structures vital to life (Brainstem, respiratory center, cerebellum, cranial nerves). Posterior fossa surgery is not undertaken lightly, and even small injuries can leave significant neurologic deficits.

ANESTHETIC CONSIDERATIONS PATIENT:

- Risk of Increased ICP and Obstructive Hydrocephalus
- Risk of Brainstem Herniation secondary to increased ICP in posterior fossa (preceded by Cushing's triad)

ANESTHETIC CONSIDERATIONS PROCEDURE:

1. Considerations for Positioning (Lateral vs. park bench vs. prone vs. sitting positions)
2. Shared Airway
3. Venous Air Embolism and Paradoxical Air Embolism (sitting and prone)
4. Potential for intraoperative hemodynamic instability
5. Risk of Injury to Crucial Brain Structures, Nerves and Blood Vessels resulting in significant neurologic deficits
6. Risks of Excessive Prolonged Neck Flexion – Macroglossia, Upper Airway Edema, C-spine ischemia causing paralysis
7. Risk of Pneumocephalus and Tension Pneumocephalus – avoid N2O
8. Bleeding and associated intracranial sequelae.

ANESTHETIC GOALS:

- Prevent iatrogenic increases in ICP
- Maintain cerebral perfusion (CPP 60-70)
- Surgical field optimization.
- Monitor Brain and Cranial Nerve Function as indicated (EEG, BEAP, SSEP, VAP, MEP, EMG)
- Ongoing Communication with surgeon (ex. CVS changes and Evoked Potential Changes)
- Appropriate Fluid Management: Maintain Normovolemia and avoid reduction of serum osmolarity.
- Anticipate Venous Air Embolism: appropriate monitoring, prophylaxis and treatment
- Facilitate rapid postoperative neurological assessment
- Appropriate Postoperative Disposition and Extubation Based on Intra-Operative Course

PATHOPHYSIOLOGY AND EPIDEMIOLOGY

- The incidence of posterior fossa tumors is greater in children than in adults.
  - More than half of all pediatric brain tumors are located in the infratentorial compartment.
- Common types of infratentorial tumors are: medulloblastoma, cerebellar astrocytoma, brainstem glioma, ependymoma, and metastatic tumors.
- Less common tumors include: acoustic neuroma, meningioma, ganglioglioma, chordomas, hemangioblastoma and others.
- Medulloblastoma occurs more frequently in males.

HISTORY

- The posterior fossa compartment is a very limited space, even small tumors will lead to an increase in ICP, rapid obstruction of CSF flow, and hydrocephalus with negative effects on the brainstem respiratory and cardiovascular regulatory centers.
- The typical clinical history may include the following signs and symptoms:
  - Worsening headaches, most often in the morning, accompanied by nausea and vomiting.
  - Cerebellar symptoms - abnormal gait or unsteadiness of arm movements
  - Rapid obtundation, stupor, and/or coma may develop if intratumoral hemorrhage occurs, requiring urgent decompression.

ANATOMY

- The posterior fossa contains within the narrow space of the brainstem many crucial neural structures:
  - The Cerebellum
  - Ascending and descending sensorimotor pathways
  - Cranial nerve nuclei
  - Cardiorespiratory centers
  - The reticular activating system
  - Neural networks that underlie crucial protective reflexes, such as eye blink, swallowing, gag, and cough.
- Blood supply to the structures of the Posterior Fossa are from the Vertebrobasilar system

PHYSICAL AND SYSTEM BASED CONSIDERATIONS

- Airway
  - Limited access to airway intraoperatively due to positioning and surgical site
  - Risk of upper airway obstruction due to swelling of pharyngeal structures
    - Result of foreign bodies (usually oral airways) causing pressure on these structures in the circumstances of lengthy procedures with sustained neck flexion
  - Risk of Airway obstruction due to brain stem injury
- Breathing/Respiratory
  - Risk of Respiratory Instability/Irregularity - Cushing triad of HTN, bradycardia, and respiratory irregularity
    - ICP increases sufficiently to cause herniation of the brain stem
  - Risk of Neurogenic Pulmonary Edema
  - Risk of Surgical Damage to Respiratory Centres
    - Nearly always associated with circulatory changes
- CVS
  - Hemodynamic lability should be anticipated and treated during surgery in this region.

    - Bradycardia can be treated with atropine, but it should also prompt communication with the surgeon, as its development may affect surgical technique. Coagulopathy can also develop intraoperatively.
    - Cushing triad of HTN, bradycardia, and respiratory irregularity
        - ICP increases sufficiently to cause herniation of the brain stem
    - Cardiovascular response To surgery in this area may include bradycardia and hypotension, tachycardia and hypertension, bradycardia and hypertension, and ventricular dysrhythmias.
        - Common during procedures on the floor of the fourth ventricle or near the cerebellopontine angle
    - Risk of Significant Hemorrhage
    - VAE and Paradoxical Air Embolism
    - Hemodynamic effects of Surgical Positioning (sitting vs. prone)
- CNS
    - The Monroe-Kellie doctrine states that in the setting of a nondistensible cranial vault, the volume of blood, CSF, and brain tissue must be in equilibrium
    - Risk of increased ICP and associated symptoms (e.g., HA, N/V, visual changes, recent onset of Sz),
    - Risk of neurological deficits from compression/surgical damage of brain structures and nerves
        - Compression by masses, edema, hemorrhage, hydrocephalus
    - Obstructive hydrocephalus
    - Risk of brain stem injuries
        - Present as an abnormal respiratory pattern or as an inability to maintain a patent airway following extubation.
    - Pnuemocephalus/Tension Pneumocephalus (Avoid N2O)
    - Quadriplegia

SPECIFIC SURGICAL TREATMENTS

- Microvascular Decompression of Cranial Nerves V, VII, and IX
    - The surgery entails dissecting along the intracranial portion of the nerve, identifying offending blood vessels that encroach on the nerve, and placing an insulating Teflon pad between vessel and nerve.
    - Surgical Risks:
        - Ischemic damage to blood vessels and the structures they supply,
        - Retraction–related damage to nerves (esp. Facial (VII) and Vestbulocochlear (VIII). – Role for BAEP monitoring
            - Failure to release retraction in a timely manner results in postoperative hearing loss.
- Vestibular Nerve Schwannoma
    - Hearing loss and facial nerve palsy are concerns during surgical resection
    - For tumors up to about 2 to 3 cm in size, monitoring of BAEPs can increase the chances of preserving hearing.
    - The facial nerve can be monitored through spontaneous and stimulated EMG.
- Vascular tumors (ex. Meningioma)
    - May benefit from preoperative embolization due to risk of significant blood loss.

INVESTIGATIONS

- CBC, Electrolytes, Creatinine, Urea, INR, PTT
- ECHO for sitting position patients to check for a patent foramen ovale (alternate position should be considered for those who have one).
- CT Head, MRI Head – check for mass effect, tumor location and significant adjacent structures
- The use of lumbar punctures is contraindicated in patients with posterior fossa tumors and obstructive hydrocephalus because of the risk of tonsillar herniation.

PREOPERATIVE MANAGEMENT AND OPTIMIZATION

- Consider preoperative embolization for large vascular tumors
- Brain edema treated with dexamethasone - usually dosed every 6 h
- No Sedation for patients with the possibility of ↑ ICP
- Consider ventriculostomy under local anesthesia to decrease ICP prior to induction of general anesthesia.
- Given the high risk of thromboembolic complications in neurosurgical patients, precautions including support hose and sequential compression devices are indicated.

ANESTHETIC OPTIONS

- General Anesthesia
    - Awake Craniotomy is not a reasonable option

ANESTHETIC SETUP AND MONITORS

- Standard CAS Monitors
- Temperature Probe (often a prolonged surgery – Controversial value of mild hypothermia)
    - Esophageal, tympanic membrane, pulmonary artery, and jugular bulb temperature all are similar and provide a reasonable reflection of deep brain temperature, whereas bladder temperature does not.
- Awake Arterial Line
    - Patients have hemodynaic lability intraoperatively - Blood pressure responses also may serve to of excessive or unrecognized irritation, traction, or compression of neurologic tissue (ex. Cranial Nerves, Respiratory Centre)
- Central Line in Neck - A multiorifice catheter can be placed in the right atrium to evacuate air.
    - Consider pulmonary arterial catheter for patients in the sitting position with evidence of antecedent coronary artery or valvular heart disease
- Consider Precordial Doppler or TEE for VAE detection (esp if patient in sitting position)
    - Doppler placement in a left or right parasternal location between the second and third or third and fourth ribs has a very high detection rate for gas embolization
    - TEE is more sensitive than precordial Doppler to VAE
- Consider EEG and Evoked Potential Monitoring
    - Brainstem Auditory Evoked Potential (BAEP)
    - Somatosensory Evoked Potential (SSEP)
    - Visual Evoked Potential (VEP)
    - Motor Evoked Potential (MEP)

- Electromyelogram EMG(spontaneous or evoked by local electrical stimulation)
  - Can be used to monitor cranial nerves V, VII, IX, XI, and XII.
- Global well-being of the brainstem may be monitored by combining multiple modalities of evoked potentials, such as BAEPs, SSEPs, and MEPs
- Significant Neurologic deficit may still occur with Evoked Potential Monitoring that indicated no compromise of structures being monitored
- **Be aware of the Anesthetic Effects on Evoked Potential Monitoring**
  - Cortical evoked potentials with long latency involving multiple synapses are exquisitely sensitive to influence of anesthetic while short latency brainstem and spinal components are resistant to anesthetic influence. Thus, BAEP can be recorded under any anesthetic technique whereas VEP and SSEP are very sensitive.
  - Signals are generally not affected by opioids
  - Benzo's have small effects compared to volatiles
  - Volatiles and N2O affect signals greatly
  - Propofol and thiopental attenuate the amplitude of virtually all modalities of evoked potential but do not obliterate them – Role for TIVA
  - Ketamine and etomidate have been reported to enhance the quality of signals in patients with weak baseline signals, although the clinical significance and interpretation of signals obtained under these circumstances remain unclear.

INTRAOPERATIVE MANAGEMENT OF ANESTHESIA

- **Positioning**
  - Pressure points should be identified and padded carefully. Pressure and traction on nerves must be avoided.
  - For cranial procedures, almost invariably some component of head-up posturing (e.g., 15 to 20 degrees) is appropriate to ensure optimal venous drainage.
  - **Semilateral position** (Janetta position) is used for retromastoid access.
    - Extreme head rotation, sufficient to cause compression of the contralateral jugular by the chin, should be avoided.
  - **Lateral position** can be used for access to the posterior parietal and occipital lobes and the lateral posterior fossa,
    - An axillary roll is important for preventing brachial plexus injury.
  - **Prone position** is used for spinal cord, occipital lobe, craniosynostosis, and posterior fossa procedures.
    - For cervical spine and posterior fossa procedures, the final position commonly entails neck flexion, reverse Trendelenburg, and elevation of the legs.
    - A complication of the prone position is retinal ischemia and blindness owing to orbital compression causing central retinal vessel occlusion
      - low arterial pressure, low hematocrit, and lengthy surgical procedures are statistically associated with the phenomenon.
      - Risk factors include hypertension, diabetes, smoking, hyperlipidemia and hypotension
    - Direct pressure also can result in various degrees of pressure necrosis of the forehead, maxillae, chin And other pressure points
    - Extreme flexion of the neck can cause compression ischemia of the base of the tongue (and the soft palate and posterior wall of the pharynx)
      - can cause postextubation airway obstruction of rapid onset
  - **Sitting Position**
    - Referencing or correct transducers and NIBP to the interaural plane. CPP (MAP − estimated ICP) should be maintained at a minimum value of 60 mm Hg in healthy patients
    - Hazards associated with the sitting position:
      - Circulatory instability (hypotension, decreased cardiac output)
      - Macroglossia
      - Quadriplegia
      - Pneumocephalus
      - Venous air embolism (VAE) and paradoxical air embolism (PAE) Pressor administration is required in some patients.
    - Advantages of the sitting position include excellent surgical exposure and enhanced cerebral venous and CSF drainage, thereby minimizing blood loss and reducing ICP.
    - Contraindication to the sitting position exists (i.e., patent foramen ovale)http://www.mdconsult.com/books/linkTo?type=bookPage&isbn=978-0-443-06959-8&eid=4-u1.0-B978-0-443-06959-8..00063-7--bib61&appID=MDC
- **Induction**
  - Avoid increases in ICP and Cerebral Blood Flow and Large Swings in Blood Pressure
  - ETT is indicated
  - Shorter Acting NMBD if MEP or EMG are to be monitored
- **Maintenance**
  - Anesthetic consistant with brain relaxation and ICP, CBF and CPP goals
    - Sub-MAC volatile, mild-moderate hyperventilation, opioid infusion, TIVA, mannitol, dexamethasone (for edema)
    - CSF drainage may be required
    - CBF changes by approximately 3% of baseline for each 1 mm Hg change in PaCO2
      - CO_2 reactivity is preserved under all anesthetic conditions.
    - CBF increases once PaO2 drops below 50 mmHg and with anemia
    - CBF remains approximately constant through a MAP range of 60 to 150 mm Hg
      - Significant variability between individuals and with non-intact BBB
    - CBF is increased by volatiles at MAC and above
    - IV anesthetics generally decrease CBF (exception is Ketamine)
  - Avoid and treat high ICP

Interventions for Inadequate Cerebral Perfusion Pressure and Increased ICP

Reduce brain water	1. Mannitol 2. Hypertonic saline 3. Furosemide
Remove cerebrospinal fluid	1. External ventricular drain 2. Lumbar drain 3. (Hypertonic fluid)
Decrease cerebral blood volume	1. Head-up tilt 2. Neutral neck position 3. Metabolic suppression (propofol or barbiturate) 4. Mild to moderate hyperventilation 5. No direct jugular compression
Elevate mean arterial pressure	1. Adequate intravascular volume resuscitation 2. Support with vasopressor
Decrease airway pressure	1. Avoid Bronchospasm 2. Avoid Straining, coughing 3. Diagnose and treat obstruction and pneumothorax
Other	1. Titration of $Paco_2$ (≥25 mm Hg) 2. Treat Pain 3. Diagnose and Treat Seizures 4. Discontinue vasodilators 5. Surgical Control – Bone Flap

  - NMBA use based on monitoring (contraindicated in MEP and EMG)
  - Boluses of short-acting anesthetic agents for stimulating components of surgery (pinning, scalp incision, Bone Flap)
  - Fluid management for neurosurgical anesthesia:
    - Maintain normovolemia,
    - Avoid reduction of serum osmolarity.
  - Surgeons should request transient ↑ MAP to 90–100 mmHg to test hemostasis after the tumor has been resected.
  - Spontaneous ventilation is now rarely used because the proximity of the cardiomotor areas to the respiratory centers should permit cardiovascular signs to serve as an indicator of impending injury to the latter.
  - Insufficient evidence to strongly recommend mild hypothermia
  - Avoid N2O
- **Emergence**
  - "smooth" emergence—one free of coughing and straining and arterial hypertension.
  - Typically awakened immediately at the end of the procedure to allow a neurologic evaluation.
    - Extubation may not be possible immediately post-op if respiratory centre or other vital structures have been damaged – discuss with surgeon

DISPOSITION & MONITORING

- May require prolonged intubation and ICU admission due to edema, irritation and injury of posterior fossa structures or pharyngeal edema
  - CN dysfunction (esp. IX, X, and XII) can result in loss of control/patency of the upper airway
  - Swelling of the brainstem and other areas can result in impairment of CN function and respiratory drive, decreased level of consciousness and altered cardiomotor function
  - **A meeting should occur between the anesthesiologist and the surgeon to make decisions as to whether extubation is appropriate, and where postoperative observation should occur**
  - Tracheal intubation is essential postoperatively following resection of intramedullary tumors
- Postoperative pain medications should be chosen to minimize effects on the patient's sensorium and the pupillary reactivity.

COMPLICATIONS

- Sitting position
  - Implicated as a cause of rare instances of unexplained postoperative paraplegia - neck flexion may result in stretching or compression of the cervical spinal cord.
    - Relative contraindication to the use of this position in patients with significant degenerative disease of the cervical spine
  - Airway Obstruction
- Pneumocephalus
  - May present as Headache or delayed recovery of conscoiusness
  - Air enters the cranium while the patient is in a head-up position at a time when the volume of the intracranial contents is reduced. When the cranium is closed and the volume of intracerebral contents increases the air pocket becomes an unyeilding mass
  - Avoid use of N_2O
  - Tension pneumocephalus is one of the causes of delayed awakening or nonawakening after posterior fossa and supratentorial procedures
- Venous Air Embolism (VAE)
  - During posterior fossa procedures done in the sitting position, VAE is detectable by precordial Doppler in approximately 40% of patients and by TEE in 76%
  - The incidence of VAE during posterior fossa procedures performed in nonsitting positions is much less (12% using precordial Doppler)

- During controlled ventilation of the lungs, sudden attempts by patients to initiate spontaneous breaths ("gasp reflex") may be the first indication of venous air embolism.
- Hypotension, tachycardia, cardiac arrhythmias, and cyanosis are late signs of VAE.
- Detection of the characteristic "millwheel" murmur, as heard through an esophageal stethoscope, is a late sign of catastrophic venous air embolism
- Sensitivity of monitors:
  - TEE>Precordial Doppler>increase in PAP>decrease in ETCO2> increase in ETN2
- Treatment of VAE
  1. Notify surgeon so that the surgical field can be flooded with saline or packed and bone wax applied to the skull edges until the entry site is identified.
  2. Jugular Compression may slow air entrainment and cause back bleeding,
  3. Discontinue N2O
  4. Central venous catheter aspirated in an attempt to retrieve the entrained air.
  5. Intravascular volume infusion to increase central venous pressure.
  6. Vasopressors to treat hypotension.
  7. If the above measures fail, the patient should be placed in a head-down position and the wound closed quickly.
     1. Often recommended that hemodynamically significant VAE should be placed in a lateral position with the right side up.
        a. The rationale is that air would remain in the right atrium
  8. Persistent circulatory arrest necessitates the supine position and institution of resuscitation efforts using advanced cardiac life support algorithms
  9. Use of positive end-expiratory pressure is not of value in preventing VAE
  10. Hyperbaric therapy may be useful in the treatment of VAE and PAE within 8 hours.
- Paradoxical Air Embolism
  - Possibility of the passage of air across the interatrial septum via a patent foramen ovale (known to be present in approximately 25% of adults)
  - Death due to paradoxical air embolism results from obstruction of the coronary arteries by air, leading to myocardial ischemia and ventricular fibrillation. Neurologic damage may follow air embolism to the brain.

- Hematoma formation
- Cranial nerve injuries.
- Damage to respiratory centers and other vital brain structures
  - Brain stem injuries often present as an abnormal respiratory pattern or as an inability to maintain a patent airway following extubation.

REFERENCES

- Barash 6th edition
- Miller 7th edition
- Anesthesia and Co-Existing Disease
- Anesthesiologist's Manual of Surgical Procedures 4th ed
- Clinical Anesthesiology 4th ed.