CRANIOTOMY FOR TUMOR

Surgical Specialty:	Neurosurgery
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Background:

- General Considerations
    - Brain tumors are the 2nd most common pediatric cancer and the most common solid pediatric tumor making up about 15-20% of childhood malignancies.
    - Brain tumors are the leading cause of childhood cancer death.
    - Medulloblastoma is the most common type of malignant brain tumor.
    - Presentation varies with the size and location of the tumor.
- Patient Considerations
    - Infants often present with non-specific signs and symptoms, such as macrocephaly, irritability, failure to thrive, etc.
        - Hydrocephalus is better accommodated by open fontanelles.
    - Older children often present with focal neuro deficits and signs of increased intracranial pressure (ICP) and hydrocephalus
    - Posterior fossa tumors: medulloblastoma, astrocytomas, brainstem gliomas, ventricular ependymoma
        - Hydrocephalus, ataxia, cranial nerve palsies
    - Supratentorial: craniopharyngiomas (optic gliomas, hypothalamic, pituitary adenomas)
        - Often hypothalamic or pituitary symptoms
    - Associated Comorbidities/Syndromes
        - Certain syndromes can increase the risk of developing brain tumors
            - Neurofibromatosis-I: Neurofibromas tend to be vascular and may bleed more during surgical resection
            - Tuberous sclerosis: often associated with epilepsy
            - Li Fraumeni syndrome: associated with multiple malignancies; Top 3: choroid plexus carcinoma, medulloblastoma, glioma

Anesthetic Planning:

- Pre-Anesthetic Evaluation
    - Type of tumor and treatment to date
        - Associated symptoms
            - Neurodeficits

            - Seizures
            - Endocrine issues: panhypopituitarism, diabetes insipidus (DI), thyroid dysregulation
            - Hydrocephalus: Ventriculoperitoneal shunts/ external ventricular drain (EVD)
    - Important to assess for signs of increased intracranial pressure
        - Cushing's triad: Hypertension, bradycardia, and irregular respirations (Cheyne-Stokes)
        - Vomiting
        - Altered mental status
    - Serum sodium levels
        - Syndrome of inappropriate anti-diuretic hormone secretion (SIADH)/DI
    - Discussions to have with surgeon/family
        - Code Status
        - Positioning/neuromonitoring
        - Disposition: PICU for neuro checks, possible ICP monitoring
        - Increased risks for prolonged intubation, blood transfusion
- Specific or Unique Room Set-Up Requirements
    - Airway: Endotracheal tube
        - Positioning for posterior fossa tumors often involves flexion of the neck that can predispose ETT to kinking- consider nasal intubation in small patients or reinforced tube to minimize this risk.
    - Drugs/Infusions:
        - Dural relaxation: mannitol, furosemide, hypertonic saline (3%)
        - Anti-epileptic
            - Levetiracetam
        - Steroids
            - Dexamethasone
        - Vasopressors
        - TIVA if neuromonitoring (typically propofol, remifentanil/sufentanil infusions) to reduce interference with intraoperative neurophysiologic monitoring.
        - Avoid neuromuscular blockers if monitoring motor evoked potentials (MEPs)
    - Monitors
        - Standard American Society for Anesthesiologists monitors
        - Arterial line
        - Consider precordial Doppler (if high risk for venous air embolism (VAE))
        - Potential for ICP monitoring via EVD
        - Foley for urine output
    - Blood Availability
        - Packed red blood cells should be readily available.
    - PICU Bed Availability
        - For frequent neuro checks and monitoring
    - Potential post-operative CT scan if concerns for drain placement or bleeding

Intraoperative Considerations:

- General
    - Large bore peripheral intravenous catheters, arterial line, +/- central line if limited peripheral access or increased risk for VAE/hemodynamic change, EVD if indicated
    - Stealth guidance can sometimes produce artifact on monitors
- Induction

- Mask induction is acceptable if the patient has stable ICP and hemodynamics w/ minimal aspiration risk
- IV induction if ICP is a concern
- Caution with ketamine as it increases cerebral metabolic rate of oxygen ($CMRO_2$) and ICP
- Caution with succinylcholine if long-term spinal cord dysfunction (risk of hyperkalemia). Succinylcholine is not contraindicated as the minimal ICP bump can be pretreated with a defasiculating dose of non-depolarizing muscle relaxant.

- Positioning
  - Depends on the tumor location
    - Mayfield pins
    - Beach chair (increased VAE risk)
  - Often the bed is turned with the head away from the anesthesia machine (consider circuit extension)
- Maintenance
  - Total intravenous anesthesia (TIVA) if neuromonitoring is used
  - Avoid neuromuscular blockade if monitoring MEPs
  - High MAC of volatiles can disrupt cerebral vascular autoregulation
    - $\leq$ 50% volatile is generally considered safe with high ICP. Uncoupling of cerebral blood flow and BP occurs at levels >50% volatile
  - Caution with nitrous oxide if recent craniotomy in the past 4 weeks (potential residual pneumocephalus)
- Hemodynamic/Physiologic goals
  - Maintain adequate Cerebral Perfusion Pressure (CPP)=Mean arterial pressure (MAP) minus central venous pressure (CVP). Of note, ICP takes place of CVP if available.
  - The arterial line transducer should be at the level of the head (external auditory meatus)
  - $EtCO_2$ goals may shift during surgery: Hyperventilation may be needed for dural relaxation and to reduce ICP
    - Note that low $EtCO_2$ may reduce ICP but comes at the cost of reduced cerebral blood flow and can cause ischemia if prolonged.
  - Fluid management: Maintain euvolemia with iso/hypertonic fluids.
    - Normal saline or Plasmalyte
    - Lactated Ringers is NOT considered isotonic (273 mOsm/L)
- Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
- Emergence/Disposition
  - Awake extubation, often need immediate neuro exam
    - In cases such as transsphenoidal resection, deep extubation is sometimes indicated to reduce cough (reduce cerebrospinal fluid leak risk).
  - Postoperative nausea and vomiting risk is high
  - Pain is often low-moderate
- Post-op Pain
  - Long-acting narcotics as needed
  - Local anesthesia to anesthetize the skin.

Case-Specific Complications/Pitfalls

- SIADH/DI
  - Monitor serum sodium levels
  - Often develops post-operatively but can be intraoperative
  - Management: urine and serum electrolyte monitoring, vasopressin/DDAVP, fluid management
- Venous Air Embolism
  - Increase risk when the surgical site is above the heart (ie: beach chair) and CVP is low
  - Precordial Doppler is most sensitive non-invasive and earliest detective device: should be placed at the $4^{th}/5^{th}$ intercostal space at the right sternal border
  - Presentation: Sudden decrease in $EtCO_2$
  - Management: Surgeon floods field with saline, Trendelenberg (left lateral if possible), jugular compression, 100% oxygen, intravenous fluids to optimize preload, vasopressor support, may consider aspirating central line, PALS for cardiac arrest
- Arrhythmias
  - Heart block and bradycardia can occur with surgical manipulation
  - Often resolves when manipulation stops
  - PALS resuscitation, if indicated
- Seizure
  - Often due to surgical manipulation or irritation of the dura
  - Often presents as hypertension, tachycardia
  - Management: The surgeon can apply cold saline to the brain. Administer intravenous midazolam or propofol to stop the seizures. Also, consider administering levetiracetam.
- Bleeding
  - Blood products should be readily available
  - The surgeon can sometimes apply clips or put the patient in reverse Trendelenberg position to reduce bleeding
  - Management: pressor management, fluid resuscitation, +/- blood product transfusion

References

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