ENDOSCOPIC THIRD VENTRICULOSTOMY (ETV)

Surgical Specialty:	Neuroanesthesia
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Background:

- General Considerations:
  - ETV is an alternative to ventriculoperitoneal (VP) shunt placement for patients with non-communicating hydrocephalus.
  - There are no significant differences between ETV and VP shunt for symptom improvement. However, ETV is associated with a lower incidence of major complications, infections, and reoperation. ETV patients also have a shorter duration of surgery and hospital stay.[1]
    - Indications for ETV
      - Congenital aqueductal stenosis
      - Meningomyelocele/Chiari malformation/Dandy-Walker malformation
      - Pineal tumors/posterior fossa tumors resulting in obstruction
      - Arachnoid cyst
    - Description of Procedure[2]
      - Entry point via the anterior fontanel or a burr-hole (the same location where a VP shunt would be inserted).
      - The endoscope traverses the lateral ventricle, through the foramen of Monro to the floor of the third ventricle. A fenestration is made and irrigation may be used to clear any bleeding.
      - ETV creates a natural bypass within the brain, allowing cerebrospinal fluid (CSF) to drain, thereby avoiding VP shunt placement.
      - There is the potential for blood loss as the fenestration is near the basilar and posterior cerebral arteries.
      - ETV has recently been combined with choroid plexus cauterization, especially in infants under 1 year of age to increase the success rate.[3]
- Patient Considerations
  - Hydrocephalus Considerations
    - Neurologic and functional status of the patient
    - Patients may present with symptoms of increased intracranial pressure (ICP)
      - Headache
      - Hemodynamic alterations (i.e., bradycardia/hypertension)
      - Emesis, dehydration, electrolyte abnormalities, and a need for rapid sequence induction (RSI)
      - Can cause macrocephaly and increase airway management difficulty

- Associated Comorbidities/Syndromes
  - Epilepsy
    - Continue anticonvulsants perioperatively and monitor interactions (NMBAs)

Anesthetic Planning:

- Pre-Anesthetic Evaluation
  - Additional labs/tests indicated during work-up
    - Complete blood count and coagulation labs to assess hemoglobin, platelets, and bleeding risk.
    - A chemistry panel may be indicated if the patient has significant emesis.
  - Discussions to have with surgeon/family
    - Postoperative disposition
    - Possible need for postoperative intubation and ventilation
- Specific or Unique Room Set-up Requirements
  - Airway
    - If significant hydrocephalus results in macrocephaly, anticipate a potentially difficult airway. Have a shoulder roll and advanced airway equipment ready, especially if there is no prior airway history.
  - Drugs/Infusions
    - Short-acting opioids, acetaminophen, non-steroidal anti-inflammatory drugs (NSAID). Consider judicious administration of long-acting opioids but avoid interfering with timely neurological evaluation post-procedure.
    - Atropine should be available in anticipation of possible bradycardia with ICP increases or neurosurgical manipulation.
  - Monitors
    - Standard American Socitey of Anesthesiologists monitors should be used.
    - Arterial line is usually not indicated unless dictated by patient comorbidities.
    - Accurate temperature monitoring with an esophageal or rectal temperature probe.
  - PICU Bed Availability
    - Institution-dependent but usually not indicated unless dictated by comorbidities i.e., severe obstructive sleep apnea requiring continuous positive airway pressure or bilevel positive airway pressure.

Intraoperative Considerations:

- General
  - Typically, ETV is a short, minimally invasive procedure, sometimes aided with image-guided navigation.
  - Abrupt changes in ICP are possible.
- Induction
  - Patients may arrive intubated if ICP crises occurred prior to the procedure and the patient required intubation for airway protection.
  - Inhalational or intravenous induction may be used.
  - Consider intravenous induction with RSI if there is increased ICP or preoperative nausea or emesis.
- Positioning
  - Supine position.

    - Head position may vary per surgeon preference: neutral or slightly flexed, sometimes in a horseshoe head support.
    - Head of bed turned (90 or 180 degrees per surgeon preference).
    - The surgeon typically stands at the head of the bed.
    - Avoid movement of the operating table and patient when the endoscope is maneuvered within the ventricular system.
- Maintenance
    - Volatile anesthetic with short-acting opioids.
    - Local anesthetic administered by the surgeon at the beginning of the procedure
    - Muscle relaxation or infusion of an ultra-short-acting opioid such as remifentanil
- Hemodynamic/Physiologic goals
    - Maintain normovolemia
    - Patients usually do not require a blood transfusion
    - Avoid hypercapnia as increased $PaCO_2$ will increase cerebral blood flow and ICP.
- Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
    - General endotracheal intubation is required due to muscle relaxation necessary to prevent patient movement and control ventilation/CO_2 level.
    - Neuromonitoring is not indicated
    - Avoid increases in ICP while preserving cerebral blood flow
    - Special attention should be paid to thermoregulation
        - Irrigation with cold fluids may cause bradycardia and hypothermia.
        - All irrigation fluids should be warmed to body temperature.
        - The use of a forced-air warming blanket is strongly recommended.
- Emergence/Disposition
    - Rapid awakening for first neurologic assessment in the Operating Room
    - Pain control with acetaminophen, NSAIDs, and carefully titrated low-dose opioids.
    - Many surgeons prefer head-of-bed elevated to at least 30 degrees to encourage drainage
    - The patient will be transported to the post anesthesia care unit (PACU) and then to the floor or pediatric intensive care unit (PICU) (seizure monitoring, mental status observation, or prolonged intubation)
- Post-op Care
    - Frequent neurological assessments are performed on the neurosurgical floor or PICU, depending on hospital policy and nursing comfort

Case-Specific Complications/Pitfalls

- Basilar artery injury
    - Can be injured by the catheter tip.
    - Can be life-threatening due to massive intraventricular and subarachnoid hemorrhage.
    - If bleeding is massive, may need to convert to open craniotomy.
- Bradyarrhythmias- fairly common with 41% incidence[4]
    - Manipulation of delicate structures around the third ventricle (hypothalamus and brain stem) and irrigation fluids can lead to bradycardia, hypotension, hypertension, cardiac arrest.
- Increased ICP
    - This can lead to decreased cerebral perfusion or ischemia.
- Hypothermia
    - Due to cold irrigation fluids.

- Neurogenic pulmonary edema
    - Secondary to vigorous intraventricular irrigation.
    - May need PICU postoperatively if hypoxic and need advanced airway support.
- Venous air embolism
- In a multicenter study from the Hydrocephalus Clinical Research Network, the most common surgical complications were:[5]
    - Intraoperative visible foriceal injury (16%)
    - Intraoperative severe bleeding (1.8%)
    - Postoperative CSF leak (4.4%)
    - Postoperative hyponatremia (3.9%)
    - Permanent neurologic deficit (0.5%)

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Created: 8/15/22; Last revised: 10/17/23