SELECTIVE DORSAL RHIZOTOMY

Surgical Specialty:	Neurosurgery
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Background:

- General Considerations
  - Selective dorsal rhizotomy (SDR) is a neurosurgical procedure performed with the intention of alleviating lower extremity spasticity in children with cerebral palsy (CP) to improve muscle control for balance, posture, sitting, and walking abilities. This potentially decreases the need for future orthopedic procedures.
  - A single-level lumbar laminectomy is performed to expose the rootlets of the cauda equina. The sensory nerve rootlets are identified based on their anatomical position as they exit dorsally and are confirmed with electromyography. Abnormal sensory rootlets that cause increased muscle tone are then cut.[1] This increased tone is due to the absence of inhibitory signals from the brain. To address this issue without inducing motor weakness, SDR selectively severs only the sensory nerve rootlets, which contribute to maintaining motor tone, leaving the motor ones intact. This procedure helps restore a more balanced tone without compromising motor function.
  - These patients tend to have significant post-operative pain due to the surgical incision, laminectomy, nerve root manipulation/irritation, and muscle spasms.[2]
- Associated Comorbidities/Syndromes
  - Cerebral Palsy with spasticity
  - Possible seizure disorder

Anesthetic Planning:

- Pre-Anesthetic Evaluation
  - Additional labs/tests indicated during work-up
    - No specific labs or tests
    - Inquire if anti-spasm or seizure medications were taken on the day of surgery.
  - Discussions to have with surgeon/family
    - Discuss with parents the necessity of lying flat for 24-72 hours after the operation. This may make eating and drinking challenging and may be distressing for some younger patients.
- Specific or Unique Room Set-up Requirements
  - Airway

        - The procedure necessitates prone positioning, so endotracheal intubation is preferable.
    - Monitors
        - Standard ASA monitors
        - Multimodal intraoperative neuromonitoring (IONM) including Somatosensory Evoked Potentials (SSEP), Motor Evoked Potentials (MEP), and Electromyography (EMG)
        - Frequently neurophysiology staff will have Electroencephalography (EEG) available with their monitoring, which can assess the depth of anesthetic. Otherwise, Bispectral Index (BIS) monitoring may considered in the setting of Total Intravenous Anesthesia (TIVA).
    - Drugs/Infusions
        - SSEP and MEP monitoring as well as nerve stimulation by neurophysiology, so avoid long-acting neuromuscular blockade and consider TIVA. Potential options include:
            - Remifentanil
                - 0.05-1 mcg/kg/min infusion
                - Optimal as it is easily titratable with bursts of stimulation
            - Propofol
                - 100-300 mcg/kg/min infusion titrated to effect
            - Fentanyl
                - 0.5-4 mcg/kg/hr
            - Dexmedetomidine
                - 0.2-1 mcg/kg/h
                - Pending institutional and neurophysiologist preferences (see below)
            - Ketamine
                - 0.1-0.2 mg/kg/h
                - Pending institutional and neurophysiologist preference (see below)
    - Access
        - If planning TIVA, ideally set up for two PIVs
        - No procedure-related indication for arterial or central access, although it may be warranted based on patient comorbidities.
    - PICU Bed Availability (if indicated)
        - Depending upon institutional practices, this may be the required initial post-operative location due to the frequency of neurological examination
        - ICU care may be required depending upon the medications needed postoperatively to assist in pain relief and tolerating the period of lying flat
            - This may include epidural infusion, dexmedetomidine, concurrent narcotic and sedating medications like benzodiazepines or muscle relaxants.
    - Other Indicated Resources
        - Pediatric pain service (if available)

Intraoperative Considerations:

- General
    - The procedure is essentially a single-level laminectomy (T12 or L1) with minimal blood loss. There are long periods of low surgical stimulation alternating with sudden bursts of stimulation (neurophysiology stimulation of nerve rootlets).

- Induction
    - A variety of techniques are available for induction depending upon the anesthesia team's preference. Long-acting neuromuscular blockade should be avoided. If long-acting neuromuscular blockade is necessary for airway management, it should be reversed prior to the start of the procedure.
- Positioning
    - The patient will need to be in the prone position for several hours, which may be challenging with significant spasticity. Take care when padding extremities and bony prominences (such as the anterior of the hips) and ensure two bite blocks are in place to prevent tongue injury.
    - Consider upper extremity IV placement as neuromonitoring will use the lower extremities for monitoring/stimulation. This also may prevent lower body forced air warmer placement.
- Maintenance
    - TIVA or mixed intravenous and inhaled anesthetic technique depending upon institutional practice with intraoperative neuromonitoring. A narcotic infusion is recommended to avoid having to bolus during the procedure during periods of stimulation.
    - There is mixed evidence on dexmedetomidine's impact on evoked potentials. Institutional preference for the use of ketamine in these cases may vary. Discuss the use of these medications with your neurophysiology team if administration is planned.
    - Avoid boluses of sedative medications that can change the frequency or amplitude of evoked potentials. If boluses are required, communicate with the neurophysiology team as continuous neuromonitoring is used to determine sites of dorsal nerve root ablation.
- Hemodynamic/Physiologic goals
    - No specific requirements other than the standard homeostatic goals of general anesthesia
    - Temperature management can be challenging given many children with CP have lower weights relative to surface area.
- Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
    - Muscle relaxation is contraindicated during the procedure as neuromonitoring (with stimulation) is necessary to identify which rootlets are causing the most spasticity (and therefore which ones to cut).
- Emergence/Disposition
    - If the post-operative pain control plan includes an epidural[2-3], this is placed during closure. After the dura is closed, the surgeon may tunnel the epidural into the surgical field and lay it atop the dura or thread it 1-2 cm into the epidural space. The surgeon may then continue closure over the epidural catheter, and the epidural is available for use.
- Post-op Care
    - Most protocols require patients to lie flat 24-72 hours after the procedure.
    - Pain/muscle spasm control
        - Multimodal analgesia with scheduled acetaminophen, NSAID, and muscle relaxant (diazepam or methocarbamol most often used). Discuss the timing of initiation of NSAID with the surgeon – some will want to delay or avoid use in the immediate postoperative period.

- Epidural infusion has been shown to provide excellent pain control with a much more preferable side effect profile with regards to respiratory depression, nausea, vomiting, and itching.[2-4]
    - Typically 0.2% ropivacaine at a rate of 0.4 mg/kg/hr
        - The infusion may include additives like clonidine, fentanyl, or hydromorphone depending upon provider preference
            - There is an increased risk of nausea and itching with narcotic in epidural infusion.
    - The epidural infusion is usually run until POD 2-3 when the patient no longer has to lie flat.
- If epidural analgesia is not feasible, systemic narcotics may be used in infusion or PCA form depending upon the mental status of the patient and provider preference. Given the higher likelihood of respiratory depression with systemic narcotics, consider additional monitoring and ICU placement for at least the first 24 hours.
- Intrathecal morphine may be used for analgesia, but the timing of the injection is important as the dura will be open during the majority of the procedure.
    - The surgeon may inject it during closure, but remember it may not be effective for 45-60 minutes after injection.
    - Post-operative narcotics and sedatives must be carefully monitored for the first 24 hours after injection as there is a risk of respiratory depression, and intrathecal narcotics also carry an increased risk of nausea and pruritus.[5]
- Dexmedetomidine may be required to assist patient tolerance of lying flat, which may also require a step-down or PICU bed post-operatively

Case-Specific Complications/Pitfalls

- When intermittent stimulation occurs, it will be tempting to increase anesthetic depth based on HR and BP increases. However, this stimulation is usually brief, and doing so may make blood pressure management challenging and result in your patient being over-anesthetized with burst suppression on EEG, which will hamper neuromonitoring. As they are monitoring EEG signals, the neurophysiology staff is a valuable resource for the assessment of anesthetic depth especially when TIVA is used. Alternatively, a BIS trend can be used. A narcotic infusion can blunt some of the hemodynamic effects, but mostly patience is advocated during these periods.
- Frequent or strong stimulation from neuromonitoring can cause a seizure, especially in patients who normally have seizures and who did not take their morning seizure medication. Should this be the case, it will be readily seen by neuromonitoring on EEG or by the room at large should the patient start actively convulsing. In this case, inform the neurophysiology staff of any medications given to abort the seizure (midazolam, propofol bolus, increased inhaled anesthetic) and the procedure will stop and the patient will be monitored until they are no longer burst suppressed. Then the procedure may resume.
- Short-term complications may include bleeding, infection, or CSF leak at the surgical site. Long-term complications are rare but may include hyperesthesia, urinary or bowel incontinence, and weakness or loss of previous ability to walk.

References

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