POSTERIOR SPINAL FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

Surgical Specialty:	Orthopedic Surgery
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Background:

- General Considerations
  - Adolescent Idiopathic scoliosis (AIS) is the most common type of childhood scoliosis with no known cause, and is most common in females aged 10-18 years old.
  - Surgery is recommended for spine curvatures greater than 40 degrees (Cobb angle), unless symptoms are significant with smaller curvatures.[1,2]
  - Posterior spinal fusion (PSF) is the most common surgical approach for AIS.
  - Metal screws are implanted in pedicles of the affected spine segments and then secured to one or two metal rods that are used to straighten the spine curve.[1]
  - Goals are to correct the degree of spine curve and stop/prevent progression of curvature. Depending on the degree of curvature, complete correction may not be obtainable due to compression of nerve roots exiting the spinal canal.
  - Intraoperative neuromonitoring is extensively used during implant placement and correction, with SSEP, MEP, and EMG all potentially needed.
- Patient Considerations
  - Most patients do not experience back pain and are otherwise healthy and active.
  - Some patients experience respiratory symptoms with a larger degree of curvature.
  - Important to identify personal and/or religious objections to receiving blood products
  - Make note of any baseline neurologic deficits (including cognitive deficits that might make a postoperative neurologic exam challenging).

Anesthetic Planning:

- Pre-Anesthetic Evaluation
  - Additional labs/tests indicated during work-up
    - Pulmonary function testing as needed/indicated
    - Echocardiography for significant curvature or respiratory compromise
    - Consider Blood Type and Screen, CBC, Coags, BMP, and HCG (females)
    - Prepare 2 Units PRBC

    - Discussions to have with the surgeon/family
        - Any known preoperative neurologic deficits
        - Potential for blood transfusion
        - Potential neurologic exam during the procedure (a "wake-up test")
        - Facial swelling given multiple hours in the prone position
        - Possibility of remaining intubated at the end of the procedure (in case of concern for tracheal or facial edema at the end of the procedure or prolonged emergence)
- Specific or Unique Room Set-Up Requirements
    - Airway – Standard endotracheal tube
        - Prone pillow, ETT extension
        - Bite block(s) – avoid tongue injury with neuromonitoring stimulation
    - Intraoperative Drugs/Infusions – tailored for optimal SSEP/MEP signals
        - Standard induction medications
            - Lidocaine, fentanyl, propofol
            - Discuss muscle relaxation with surgeon and neuromonitoring team (sometimes used during surgical exposure after baseline SSEP/MEP readings, otherwise avoided given neuromonitoring)
            - Other common agents include:
                - Benzodiazepines – no impact on SSPE/MEP signals
                - Ketamine – may increase SSEP/MEP signals
                - Dexmedetomidine – may decrease MEP signals – discuss its use with the neuromonitoring team
                - Intrathecal narcotic – no impact on SSEP/MEP[3]
        - Antifibrinolytics (dosing varies per surgeon/institution preference)
            - Tranexamic Acid; 20mg/kg bolus over 20min (max 2g), 10mg/kg/hr infusion
            - Aminocaproic Acid; 100mg/kg bolus over 20min (max 5g), 10mg/kg/hr
        - Maintenance of Anesthesia – Total IV anesthetic, as volatile agents decrease MEP signals in a dose-dependent manner.[3] It is important to try to rely on infusions more than bolus dosing, as this can affect neuromonitoring signals. Consider any of the following:
            - Narcotic infusion
                - Fentanyl (1-2 mcg/kg/hr)
                - Sufentanil (0.1-0.5 mcg/kg/min)
                - Remifentanil (0.05-0.3 mcg/kg/min) – will need additional long-acting pain management plan like methadone or intrathecal morphine if using remifentanil.
            - Propofol (50-250 mcg/kg/min)
            - Dexmedetomidine (0.2-0.4 mcg/kg/hr)
            - Ketamine (0.25-1 mcg/kg/min)
        - Vasoactive infusions – permissive hypotension for exposure (SBP <80 mmHg); normotensive during rod manipulation. Titrate to desired hemodynamic goals. Consider the following:
            - Phenylephrine (0.1-1mcg/kg/min)
            - Nicardipine (2.5-15mg/hr)
            - Esmolol (50-250mcg/kg/min)
        - Antibiotics – per institutional protocol, commonly Cefazolin

- Monitors
  - Standard monitors (ECG, O2 saturation, temperature, blood pressure, EtCO2)
  - Arterial line
  - Bispectral Index (BIS) or electroencephalography (EEG)
- Blood Availability (if indicated)
  - Cell saver is often used intraoperatively to decrease the need for transfusion.
  - Crossmatched blood should be made available, although blood transfusion is less likely with the use of anti-fibrinolytic and cell saver.
- PICU Bed Availability
  - Institution-specific – some institutions recover all PSF patients in the PICU for the first 24 hours for neurologic monitoring, or if vasopressors are needed for specific BP goals. Otherwise, patients are step-down or floor status.

Intraoperative Considerations:

- General
  - Temperature management can be challenging given the level of patient exposure during the placement of lines, neuromonitoring leads, a Foley catheter, and padding, as well as positioning and preparation/surgical scrub. Initial warming of the OR and potentially preoperative warming should be considered, as well as forced air warmer(s) and fluid warming during the procedure.[4]
- Induction
  - Standard induction medications (inhaled or IV) may be used based on the patient's physiology and comorbidities.
- Positioning
  - Prone (be sure to frequently check the positioning of face/eyes for pressure to avoid injuries)
  - Possible that the surgeon will want traction for the head, although this is much more common in neuromuscular repairs
- Maintenance
  - Optimize anesthetic plan with the neuromonitoring team. TIVA is most common, given the requirements of neuromonitoring. Volatile agents can be used (up to 0.5 MAC), but this may decrease MEP signals. Titrate anesthetic to BIS 40-60 if using, or can check EEG tracing with the neuromonitoring team to preferentially maintain theta waveforms
- Hemodynamic/Physiologic goals
  - Many surgeons will request a lower mean arterial blood pressure (MAP) during surgical exposure of the spine to minimize blood loss, usually around MAP 60-65 mmHg if tolerable based on the patient's physiology.
  - Intraoperative arterial blood gas can be used to help monitor for bleeding, hypotension, or loss of evoked potentials.
  - During the correction of the spine (rod placement), the surgeon may request increased MAP (greater than 70 mmHg)
  - Normovolemia can be challenging given the significant insensible losses with surgical exposure and potential blood loss. Intraoperative use of a Foley catheter can help with fluid management, as overuse of fluids can lead to face/tongue swelling and inability to extubate at the end, while under-resuscitation can result in hypotension during and after surgery.

- Surgical Considerations
    - Neuromonitoring (SSEP, MEP, EMG) is done during screw placement and surgical correction (rod/straightening), and therefore, neuromuscular blockade is avoided during this time. It can be given to assist surgical exposure after pre-incision baseline readings are obtained and then reversed at the beginning of screw placement if necessary
    - Blood loss can be significant and may require transfusion. Antifibrinolytics and cell saver can significantly reduce the incidence of blood transfusion.[4]
- Emergence/Disposition
    - These patients are usually extubated at the end of the procedure. Be sure to discuss with the surgical team if any sort of neurologic test (moving arms and legs on command) is desired before extubation. ICU care is patient-specific and institution-dependent.[1]
- Post-op Care
    - Pain control is institution-dependent, but the most common issues are incisional pain and muscle spasm. A multimodal treatment and recovery approach is recommended and has been shown to decrease length of stay.[1,2]
        - Multimodal Pain Management – pain can be significant given the size of the incision and dissection through a large amount of muscle. Options/doses include:
            - Methadone (PO preop or IV at beginning of procedure, 0.1-0.2 mg/kg)
            - Acetaminophen (PO preop or IV 15mg/kg, max 1g)
            - Gabapentin (PO preop)
                - <12yo and/or <40kg – 15mg/kg
                - >12yo and 40-59kg – 600mg
                - >12yo and >60kg – 900mg
            - NSAID (ketorolac 15-30mg, discuss use with surgeon)
            - Intrathecal morphine (3-5 mcg/kg) can aid in postoperative pain control if methadone is not used. This is institution-dependent and may be done by the anesthesia team after induction or intraoperatively by the surgeon after exposure. If used, additional narcotics are limited for the next 12-24 hours due to the risk of respiratory depression. Intrathecal methadone may take up to an hour to be effective, so a short-acting narcotic like fentanyl may be necessary for surgical exposure.
    - Hospital stay is commonly less than 5-7 days

Case-Specific Complications/Pitfalls

- Neuromonitoring signal loss/decrease that does not recover
    - The surgeon may ask you to remove traction if applicable, and they may remove some or all of the hardware
    - Neuromonitoring may check the placement of their leads
    - Increase blood pressure if hypotensive
    - Correct anemia
    - Optimize oxygenation
    - Make sure the patient is normothermic
    - Warm saline to flood the field
    - Neuromonitoring may request that the anesthetic be reduced or any recent changes reversed.

  - Consider methylprednisolone for spinal cord protection – 30mg/kg bolus with repeated dosing or infusion for up to 24 hours.
  - Wake-up test – may be requested by the attending surgeon if the above do not resolve signal changes.
    - Discontinue anesthetics, reverse NMB (if applicable), naloxone 1 mcg/kg q5min if BIS >75 or EEG otherwise indicative of emergence. If using remifentanil, consider keeping it running at a lowered dose to aid ETT tolerance.
    - It may take 20-30 minutes for the patient to respond.
- Vision loss; Ophthalmology consultation, post-op imaging

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