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PEDIATRIC SPINAL ANESTHESIA

Surgical Specialty:	Pediatric Pain/Regional Anesthesia
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Background:

- General Considerations
    - Spinal Anesthesia (SA) is performed via injection of local anesthetic (+/– adjuvant) into cerebrospinal fluid (CSF) located in the lumbar intrathecal space.
    - This technique provides reliable anesthesia over thoracic, lumbar, and sacral dermatomes, including motor, sensory, and autonomic blockade, with limited duration of action.
    - In pediatric patients, SA is used in lieu of general anesthesia (GA) for surgical procedures located below the umbilicus with an expected duration of less than 2 hours.[1-2]
    - SA in infants and children avoids exposure to potentially neurotoxic general anesthetic agents, affords a remarkably stable hemodynamic profile until 5-8 years of age given the immaturity of the sympathetic nervous system, prevents instrumentation and manipulation of the airway, allows for less administration of medications perioperatively, and results in earlier reuniting with caregivers, quicker return to feeding, and shorter overall length of hospital stay.[1-5]
    - Surgeon, anesthesiologist, and perioperative nursing buy-in and training are critical for the implementation of a successful spinal anesthesia program.
- Patient Considerations
    - SA is ideal for premature neonates, term neonates, infants, and children aged 0 days to 2 years, although it can be used in older children in appropriate situations.
    - Standard GA considerations apply to SA cases as the backup for SA is GA.
    - Unless the use of a caudal catheter is planned to extend the duration of the block, surgical procedures should be limited to less than 2 hours.
    - SA may be used safely in ambulatory centers with appropriate ambulatory patient selection (see Post-op Care considerations below).[6]
- Associated Comorbidities/Syndromes
    - The presence of central nervous sytem abnormalities (e.g. neural tube defects, tethered cord, Chiari malformation, increased intracranial pressure), concerning sacral dimple without associated workup, trauma, or coagulopathic disease may preclude the use of SA.
    - Use SA with caution in patients with known difficult mask ventilation.

Anesthetic Planning:

- Pre-Anesthetic Evaluation
    - Standard preoperative anesthetic evaluation (i.e. fasting status, presence of respiratory symptoms or illness, etc.) as well as spinal-specific considerations such as the presence of sacral dimple, allergy to local anesthetic agents, rash or infection over the site of needle placement, and coagulopathy.
    - Discuss Risks/Benefits/Alternatives to proceeding under SA with parents and surgeon
        - Benefits of SA listed above.
        - SA is 100% elective. The alternative to SA is GA.
        - Risks associated with SA include failure of block requiring conversion to GA, headache, infection, hematoma, and rarely, high/total spinal anesthesia or nerve injury.[1]
    - Additional labs/tests indicated during work-up
        - Evaluation of sacral dimple with ultrasound or magnetic resonance imaging.
    - Discussions to have with surgeon/family
        - Failure of block requiring conversion to GA.
        - Caregivers may adamantly refuse the use of GA. In these cases, should the intrathecal space be unable to be accessed, parents and surgeons may consider cancellation of surgery; however, parents MUST accept GA as a backup should the spinal fail after the procedure is underway.
- Specific or Unique Room Set-up Requirements
    - Airway[1-2]
        - Natural airway. Nasal cannula may be placed for administration of supplemental oxygen if needed (rare) as well as for CO_2 monitoring.
        - Airway equipment (e.g. mask, supraglottic airway, endotracheal tube) for conversion to GA if SA fails.
    - Drugs/Infusions[2]
        - Topical local anesthetic cream (e.g. LMX), placed over L1-S1, for a minimum of 30 minutes prior to spinal injection
            - EMLA cream should be used with caution in preterm infants and infants < 3 months of age
        - Spinal Cocktail
            - Medications[2]
                - Bupivacaine 0.5% isobaric preservative-free (+/– 1:200,000 epinephrine) – 1 mg/kg up to 5 kg, 5 mg for > 5 kg
                - Clonidine IT 1 mcg/kg
            - Onset = 10-15 seconds
            - Duration of Action[7, 8]
                - Bupivacaine 0.5% isobaric plain = 30-45 minutes
                - Bupivacaine 0.5% isobaric with 1:200,000 epinephrine = 60-90 minutes
                - Bupivacaine 0.5% isobaric with 1:200,000 epinephrine and clonidine = 90-120 minutes
        - Oral sucrose
        - Premedication (as needed for positioning)
            - Midazolam PO 0.5-0.7 mg/kg, IN 0.2-0.3 mg/kg
            - Dexmedetomidine intranasal 1-3 mcg/kg
        - Intraoperative Sedation

            - Most children fall asleep naturally without further sedation.
            - Dexmedetomidine intravenous load 0.5-1 mcg/kg and/or infusion 0.5-1.2 mcg/kg/hour
        - Rescue Medications (in the event of high spinal anesthesia)
            - Atropine, epinephrine, neuromuscular-blocking agents
        - Postoperative Analgesia
            - Acetaminophen PO
            - Ibuprofen/Ketorolac as needed
            - Nerve Block (e.g. penile block, ilioinguinal block, etc.)
    - Monitors[1-2]
        - Standard American Society of Anesthesiologists monitors.
        - Place pulse oximeter and blood pressure cuff on lower extremities.
        - Consider the use of qualitative ventilatory monitoring as respiratory rate measured via EKG-chest wall impedance.
    - Blood Availability
        - Usually not required.
    - PICU Bed Availability
        - Usually not required.
    - Other Indicated Resources
        - Bring sucrose, pacifier, blanket, and/or personal comfort objects with the patient to the operating room (OR).
        - Veinfinder or ultrasound in OR, as intravenous access may be difficult in these patients.
        - 1.5-inch spinal needles, cutting versus pencil point, 22G versus 25G.

Intraoperative Considerations:

- General
    - All-stop patient/procedure time out with verification of maximum local anesthetic dose.
    - Avoid sedative medications if possible.
- Induction
    - Positioning for SA
        - Consider marking iliac crests prior to sterile preparation to aid in visual approximation of the needle insertion site.
        - The patient should be sitting with head tucked and spine curved for easier identification of landmarks, increased intervertebral distance, and CSF pooling with gravity.[9]
        - Goals of positioning include maintenance of airway patency, stabilization of the head and neck, and minimizing movement.
        - Children may cry and resist positioning. Children should not be firmly positioned until immediately before spinal injection to avoid further distress.
        - 1-2 holders may be necessary to hold children securely.
    - Technique
        - Insert the spinal needle midline through the skin at the level of the iliac crest, which correlates to L4-L5 in infants (termination of conus may be as low as L2-L3 in infants).
        - Consider taking the stylet out of the needle upon passing through the dermis to allow for easier identification of CSF flow.
        - Advance the needle steadily to the intrathecal sac. A pop may or may not be felt upon entrance of the sac.

        - Brace the needle. +/– aspiration of CSF prior to local anesthetic injection.
        - Re-aspirate at the end of the injection to clear the needle of local anesthetic prior to removing it from the spine.
        - The IV should be placed in a numb lower extremity after injection, as afforded by the hemodynamic stability of spinal anesthesia in neonates and infants.[4]
- Positioning for Surgery
    - Supine with loose tape over legs to prevent leg lifting and inadvertent high spinal anesthesia.
    - Place the electrocautery grounding pad on the back prior to positioning supine. The patient's lower extremities should not be raised to place the grounding pad on the back.
    - The patient should be positioned near the head of the OR table for access to the airway if needed.
- Maintenance
    - Spinal anesthetic as described above.
    - Most patients will fall asleep without further medication as a result of natural sleep (regular naptimes) and sensory deafferentiation.[2]
    - Patients may be entertained with music, videos, toys, etc.
    - Gentle restraints/sedation if needed for disruptive patients or for patchy/receding spinal blockade.
- Hemodynamic/Physiologic goals
    - Pediatric patients will usually cry during holding and the spinal placement itself. Most will calm down once supine.
    - After injection, pediatric patients receiving SA display remarkable hemodynamic stability, with minimal changes in blood pressure and heart rate, decreased risk of hypotension in comparison to GA, and no changes in cerebral oxygenation.
    - The need for treatment of hypotension or bradycardia is rare.
    - SA avoids intubation and manipulation of the airway, resulting in minimal risk of hypoxemia, bronchospasm, laryngospasm, and stridor.
    - For mild desaturations resulting from breath holding or obstruction, consider the addition of oxygen via a low-flow nasal cannula.[1-5]
- Surgical Considerations
    - Surgeons and OR staff should be aware that SA has a limited duration of action. Surgical preparation and scrub should occur expeditiously after IV placement to allow for maximum surgical time.
    - Awake and potentially moving patient.
    - Nerve block by the surgeon should be considered if spinal blockade begins to fade. Discussion regarding pre-incision nerve block is recommended.
- Emergence/Disposition
    - No emergence required.
    - Log-roll patient, as opposed to lifting legs, if < 30 minutes from spinal injection.
    - May bypass post anesthesia care unit (PACU) Phase 1 if all discharge criteria are met.
- Post-op Care
    - Standard PACU discharge criteria.
    - Discharge criteria for ex-premature infants after SA is identical to GA given the risk of late apnea.[10]
    - Patients must move both lower extremities prior to discharge from PACU. PACU staff should document this in the medical record.
    - No need to void prior to discharge.[2]

Case-Specific Complications/Pitfalls

- Spinal Anesthesia Failure (19% per GA vs. spinal (GAS) Trial, more recent studies document ~10%)[3]
    - Failed initial placement (inability to obtain CSF (dry tap) or bloody tap)
        - Usually requires conversion to GA.
    - Injection with lack of or partial blockade
        - May require conversion to GA.
        - Can overcome partial blockade with sedation (dexmedetomidine), securing lower extremities, pre-incision nerve block, and a motivated surgeon.
    - Failure during surgical procedure
        - See above suggestions for managing partial blockade.
- High Spinal Anesthesia (3.8% rate of "higher-than-intended" block)[1]
    - Signs
        - Respiratory compromise or apnea (0.6% oxygen desaturation)
        - Bradycardia (1.6%)
        - Lack of arm movement
        - Loss of consciousness
    - Treatment = support airway and circulation until spinal anesthesia recedes

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