

30. BASIC PEDIATRIC REGIONAL ANESTHESIA

INTRODUCTION

Military anesthesia providers often encounter pediatric patients while delivering medical care in the field. The application of regional anesthesia in children can be extremely useful in austere situations, particularly when limited resources are available (eg, scarce oxygen supply, lack of postoperative analgesics, insufficient postoperative nursing expertise). Prior to providing any pediatric regional anesthetic, the provider should not only be experienced in the specific regional anesthesia technique but also be comfortable with pediatric patient care, because almost all pediatric regional anesthesia is done while the child is either heavily sedated or under general anesthesia. To provide safe anesthetic services to pediatric patients, medical staff must recognize the myriad physiologic and pharmacologic differences between pediatric and adult patients.

DIFFERENCES BETWEEN PEDIATRIC AND ADULT PATIENTS

Pharmacokinetics. Local anesthetics preferentially bind to α -1 acid glycoprotein (AAG) found in plasma. Neonates have very low levels of AAG, 20% to 40% of normal adult values. Normal levels are not reached until 1 year of age. Low levels of AAG lead to higher serum levels of unbound local anesthetic, and this “free” drug is responsible for toxicity. Infants also have decreased clearance and a longer elimination half-life of local anesthetic compared to adults. All these factors contribute to the increased general risk of local anesthetic toxicity resulting from a preponderance of free drug circulating in the pediatric patient’s plasma during regional anesthesia.

Developmental and Anatomic Differences.

Myelination is not complete until 12 years of age. Incomplete myelination allows for better pen-

etration of local anesthetic into the nerve fibers. Reduced milligram doses from dilute local anesthetic solutions can provide a complete block in children. Also, loose fascial attachments around the nerves facilitate the spread of local anesthetic. Consequently, a regional block in children may spread further than the provider intends. Additionally, because the local anesthetic spreads easily in children, the duration of the block may be shortened compared to an adult. In general, as the patient’s age increases, local anesthetic latency of onset and duration of action increases as well. Table 30-1 lists anatomic differences between children and adults.

PEDIATRIC REGIONAL ANESTHESIA

All blocks should be conducted with intravenous access and with standard American Society of Anesthesiology monitoring applied. Appropriate resuscitation equipment should also be available. In austere environments, adjustments to this standard may be necessary, based on the availability of medical equipment.

Caudal Block

Indications. Use for patients < 8 years old to provide intraoperative and postoperative analgesia for

abdominal and lower extremity surgery.

Positioning. Place the child in the lateral decubitus position with knees pulled up toward the chest.

Landmarks. Bilateral posterior superior iliac spine (PSIS) and sacral hiatus (SH). These three points should form an equilateral triangle. The SH is bounded by the sacral cornua. The sacral cornua are palpable on either side of the midline about 1 cm apart.

Technique. After sterile preparation and drape, insert a 20-gauge or 22-gauge angiocatheter at a 70° angle to the skin over the SH. A pop will be felt as the needle passes through the sacrococcygeal membrane. Once the sacrococcygeal membrane is pierced, drop the needle angle to 20° to 40° from the skin and advance the needle and the catheter 2 to 4 mm. Then advance the catheter off the needle (the catheter should advance easily). A stimulating needle can also be used. If the stimulating needle is in the caudal space, anal sphincter activity will be visible with a stimulation of 1 to 10 mA. If using a stimulating needle, do not advance greater than 2 to 4 mm past the sacrococcygeal membrane to prevent risk of dural puncture.

Drug Dosing. See Table 30-2.

TABLE 30-1
ANATOMIC DIFFERENCES BETWEEN PEDIATRIC AND ADULT PATIENTS

Age	End of Spinal Cord	End of Dural Sac	Intercristal Line	CSF Volume	Intercranial vs Spinal CSF (%)
Neonate	L3	S4	L5–S1	NA	NA
1 Year	L1	S2	L4–L5	4 mL/kg	50
Adult	L1	S2	L3–L4	2 mL/kg	25

CSF: cerebrospinal fluid
NA: not applicable

TABLE 30-2
PEDIATRIC DRUG DOSING FOR CAUDAL OR EPIDURAL BLOCKS

Age	Bupivacaine	Ropivacaine	Clonidine	Fentanyl
Single Injection				
< 1 yr old	0.25%, 1 mL/kg	0.2%, 1.2 mL/kg	1.0–1.5 µg/kg	2 µg/mL
> 1 yr old	0.25%, 1 mL/kg, max 20 mL	0.2–0.5%, max 20 mL or 3.5 mg/kg	1.0–1.5 µg/kg	2 µg/mL
Continuous Injection				
< 3 mo old	0.0625%–0.125%, 0.2 mg/kg/h	0.1%–0.2%, 0.2 mg/kg/h	0.12–0.2 µg/kg/h	1–2 µg/mL
< 1 yr old	0.125%, 0.3 mg/kg/h	0.1–0.2%, 0.3 mg/kg/h	0.12–0.2 µg/kg/h	1–2 µg/mL
> 1 yr old	0.125%, 0.3–0.4 mg/kg/h	0.1%–0.2%, 0.4 mg/kg/h	0.12–0.2 µg/kg/h	1–2 µg/mL

Lumbar Epidural

Indications. Use to provide anesthesia and or continuous analgesia for abdominal or lower extremity surgery in children of any age.

Positioning. Place the child in the lateral decubitus position with knees pulled up toward the chest.

Landmarks. Intercristal line (posterior line between the superior aspect of the two iliac crests).

Technique. After sterile preparation and drape, insert a short, 18-gauge Tuohy or Crawford needle with a 20-gauge epidural catheter. Loss of resistance with saline is the preferred technique. Catheters can frequently be threaded from the lumbar to the thoracic level with the Tuohy bevel directed cephalad. If catheters will be threaded to the thoracic level, the distance must be measured prior to insertion. Depth to the epidural space can be determined as follows:

- Neonate ≈ 1 cm
- Children 10 kg–25 kg ≈ 1 mm/kg

- Children > 25 kg: $0.8 + (0.05 \times \text{wt [kg]}) = \text{depth in cm}$

Drug Dosing. General pediatric estimate of dosing for caudal or epidural injections: 0.25% ropivacaine or bupivacaine, 1 mL/kg bolus, max 20 mL. Table 30-2 provides more specific information.

Subarachnoid Block

Indications. Lower abdominal and lower extremity procedures lasting less than 90 minutes. Subarachnoid block is an extremely effective and useful technique in resource-limited environments. Children have remarkable hemodynamic stability under spinal anesthesia.

Positioning. Lateral decubitus or seated. Careful attention must be paid to avoid excessive neck flexion in young infants, which causes airway obstruction.

Technique. After sterile preparation, a short (1.5–2 in) 25- or 22-gauge spinal needle should be used at the L4–L5 or L5–S1 interspace in infants. The L3–L4

interspace is acceptable in children greater than 1 year of age.

Drug Dosing. See Table 30-3. Hyperbaric or isobaric solutions should be used.

Possible Complications. Postdural puncture headaches are rare in children. Dose for blood patch: 0.3 mL/kg blood.

Teaching Points. Do not lift the child's legs in the air after the block or a high spinal will occur.

Although the local anesthetic dose may appear large, recall that children have a large cerebrospinal fluid volume relative to adults (see Table 30-1). The duration of the block increases with the patient's age.

TABLE 30-3
PEDIATRIC SPINAL DOSING

Age	Bupivacaine (mg/kg)	Tetracaine* (mg/kg)	Ropivacaine (mg/kg)
Infants	0.5–1.0	0.5–1.0	0.5–1.0
1–7 yrs old†	0.3–0.5	0.3–0.5	0.5
> 7 yrs old†	0.2–0.3	0.3	0.3–0.4

*With tetracaine, use epinephrine wash (epinephrine aspirated from vial and then fully expelled from the syringe prior to drawing up local anesthetic) to increase duration up to 120 minutes.

†Additives: clonidine 1–2 µg/kg for children > 1 year of age.

Peripheral Nerve Block

Indications. Perioperative analgesia for upper extremity, lower extremity, thoracic, or breast surgery.

Drug Dosing. Local anesthetics for these blocks are dosed by weight rather than by a set volume. The maximum dose of bupivacaine is 2.5 mg/kg. Slightly higher dosing for ropivacaine (10% higher) may be acceptable. Children less than 8 years of age should receive 0.25% bupivacaine or 0.2% ropivacaine. If the peripheral nerve block (PNB) is placed after general anesthesia is induced, do not use neuromuscular blocking agents until after the block is placed. When performing a continuous peripheral nerve block, do not exceed the maximum doses

TABLE 30-4

DRUG DOSING FOR PEDIATRIC SINGLE-INJECTION PERIPHERAL NERVE BLOCK*

Block	Dose Range (mL/kg)	Midrange Dose (mL/kg)	Maximum Volume (mL)
Parascalene	0.2–1.0	0.5	20
Infraclavicular	0.2–1.0	0.5	20
Axillary	0.2–0.5	0.3	20
Paravertebral	0.5–1.0	0.7	5
Femoral	0.2–0.6	0.4	17
Proximal sciatic	0.3–1.0	0.5	20
Popliteal	0.2–0.4	0.3	15
Lumbar plexus	0.3–1.0	0.5	20

*Children < 8 yrs: 0.2% ropivacaine or 0.25% bupivacaine. Children > 8 yrs: 0.5% ropivacaine or 0.5% bupivacaine. Do not exceed maximum recommended doses of local anesthetic.

listed for continuous caudal or epidural local anesthetic. Table 30-4 provides local anesthetic dosing for pediatric PNBs.

Upper Extremity Blocks

Three upper extremity blocks are commonly performed in children: (1) the parascalene block, (2) the infraclavicular block, and (3) the axillary block. The supraclavicular block is not recommended for use in children.

Parascalene Block

The parascalene block was developed to provide a safer alternative in children to the supraclavicular block.

Positioning. Place the patient supine with a

rolled towel under the shoulder and arm at the side.

Landmarks. Midpoint of the clavicle, posterior border of the sternocleidomastoid, and the transverse process of C6. The level of C6 is at the same level as the cricoid cartilage. Draw a line between the transverse process of C6 and the midpoint of the clavicle (Figure 30-1).

Technique. The needle puncture site is at the point between the lower one third and upper two thirds of this line. Insert the stimulating needle perpendicular to the skin and directed posteriorly until upper extremity twitches are noted. If no twitches are elicited, redirect the needle laterally. Then inject an appropriate dose (based on child's age and weight) of local anesthesia. Depth of plexus ≈ 1–2 cm.

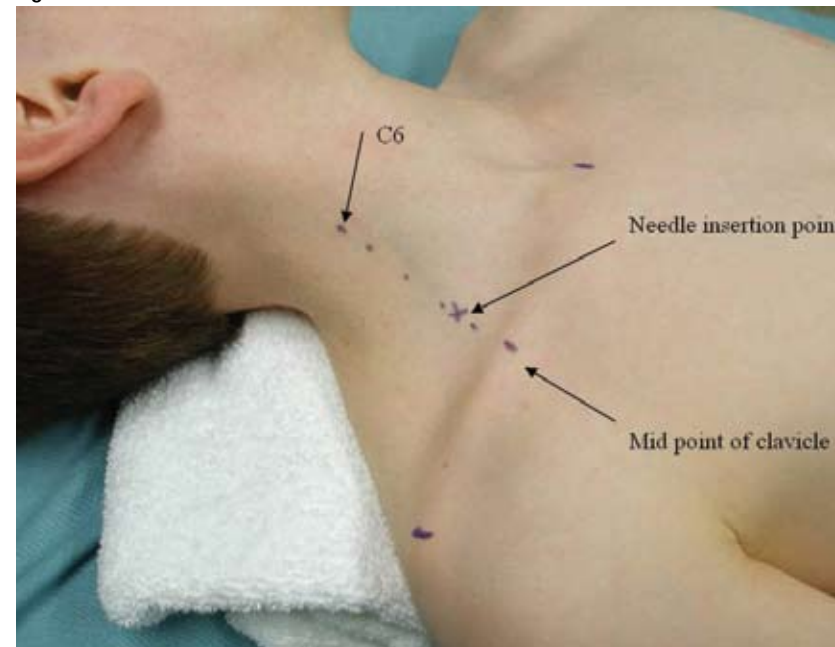
Equipment. 22-gauge, 5-cm stimulating needle.

Infraclavicular Block

Positioning. Place the patient supine with the operative extremity at the side and head turned to the opposite side.

Landmarks and techniques. Two approaches are used in children for the infraclavicular block: (1) the **deltopectoral groove approach**, with the same the landmarks and technique as in an adult, and (2) the **mid-clavicular approach**, in which the midpoint of the clavicle is the landmark. Insert the needle at a 45° angle to the skin, pointed toward the axilla. A 22-gauge, 5-cm needle is used for children under 40 kg.

Figure 30-1. Parascalene block landmarks



Axillary Block

Positioning. Same as adult.

Landmarks. Same as adult.

Technique. Same as adult, but use a 22-gauge, 5-cm needle.

Lower Extremity Blocks

Lower extremity blocks include the femoral, lumbar plexus, and sciatic blocks.

Femoral Block

The position, landmarks, and desired motor response with simulation are the same as in an adult. Use a 22-gauge, 5-cm or 1.5-in (3.8-cm) needle.

Lumbar Plexus Block

Only practitioners with experience with this technique should use this block in children.

Position. Lateral decubitus position with the knees pulled up toward the chest.

Landmarks. Draw a line between the spinous process of L4 and the ipsilateral PSIS. The needle insertion point is at the point between the medial two thirds and the lateral one third of the line (Figure 30-2).

Technique. Advance a 5- or 10-cm stimulating needle parallel to the bed until quadriceps twitches are elicited. If the needle contacts the L5 process, withdraw and redirect it cephalad. Average depth to plexus: 2.5 cm (5-kg child) to 6.5 cm (50-kg child).

Sciatic Block

Multiple approaches to the sciatic nerve block may be used in children. Which approach to use should be determined by provider experience with any particular technique.

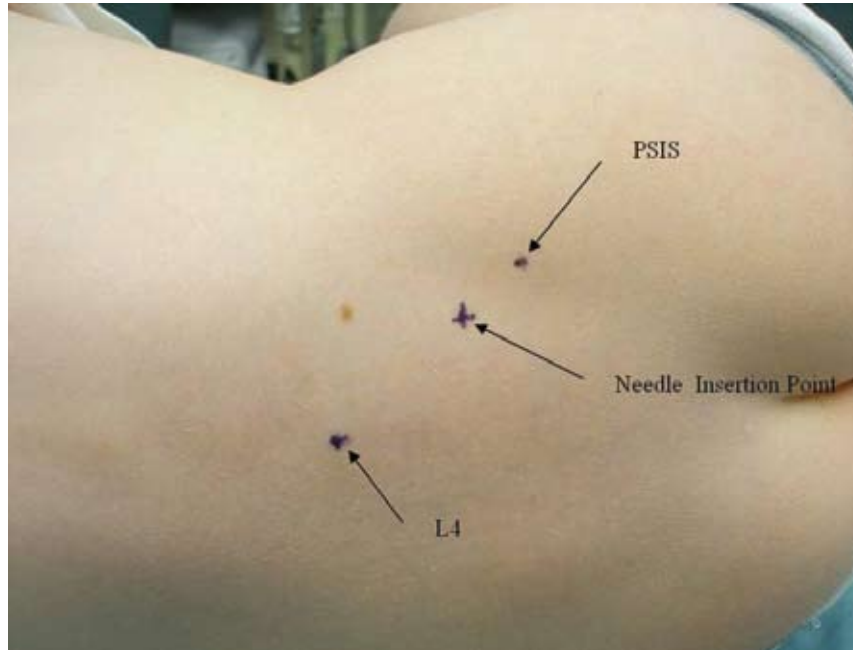


Figure 30-2. Lumbar plexus block landmarks. PSIS: posterior superior iliac spine.

- Posterior or classic sciatic block. The positioning, landmarks, and technique are the same as for an adult. Average distance to the nerve: 2 cm (5-kg child) to 4.5 cm (50-kg child).
- Raj or infragluteal sciatic block. The positioning, landmarks, and technique are the same as for an adult.
- Popliteal sciatic block. This is the most commonly reported as well as the safest approach to the sciatic nerve in children.

Positioning. The popliteal approach to the sciatic nerve can be done in the prone, lateral (operative leg up), or supine position, with an assistant elevating the leg. To appreciate the appropriate stimulation pattern of the tibial nerve, the patient's foot and ankle must be free to move.

Landmarks. The popliteal crease, the biceps femoris tendon, and the tendons of the semimembranosus and semitendinosus muscles.

Technique. Bisect the triangle formed by the landmarks. The needle insertion point is 1 cm below the apex of the triangle and 0.5 cm lateral to the bisecting line. Needle length is 5 cm for a small child or 10 cm for a larger child. Direct the needle cephalad at a 70° angle to the skin until plantar flexion is elicited. Distance from the popliteal crease to the bifurcation of the sciatic nerve: $27 + (4 \times \text{age in years}) = \text{distance in mm}$.

Thoracic Paravertebral Block

Indications. Anesthesia and analgesia for breast and chest wall procedures.

Positioning. Sitting or lateral decubitus.

Landmarks. Spinous process. Needle insertion point is 1 to 2 cm lateral to the superior aspect of the spinous process.

Technique. Same as for an adult, but use a 22-gauge Tuohy needle. The insertion point should be 0.5 to 1cm past the transverse process. Estimated depth to the paravertebral space: $20 + (0.5 \times \text{wt [kg]}) = \text{depth in mm}$.

INJECTION TECHNIQUE FOR PEDIATRIC REGIONAL ANESTHESIA

Use the following for all pediatric regional anesthesia except the subarachnoid block:

- Aspirate prior to injection.
- Inject test dose (0.5–2 mL) of local anesthetic solution containing 0.5 $\mu\text{g}/\text{kg}$ of epinephrine.
- Look for signs of positive test dose (tachycardia is not reliably seen in patients under general anesthesia):
 - ST segment elevation,
 - T-wave amplitude of $> 25\%$, or
 - blood pressure elevation.
- Inject the remaining volume of local anesthetic slowly (120–180 seconds).
- Aspirate every 3 to 5 mL.
- Continue to closely monitor electrocardiograph and blood pressure during injection.
- Carefully test dose any catheter prior to bolusing or starting a continuous infusion.

Teaching Point. Review Figure 45-8 in *Miller's Anesthesia*, 6th edition, showing the distance from skin to plexus or nerve for common PNBs correlated with patient weight.