Regional anesthetic techniques in children have become more popular in the past decade. This is in part because of recent research indicating biobehavioral changes associated with untreated pain in children. Most regional techniques in children are performed under heavy sedation or general anesthesia. Concerns regarding safety and the medico-legal liability of performing regional blocks under anesthesia must be weighed against the trauma and potential danger of placing blocks in awake, uncooperative children. A large body of clinical experience supports the safety and efficacy of regional blocks placed under general anesthesia in children. There is evidence-based literature to show that combined regional and general anesthesia may actually improve outcome and thereby decrease hospital stay. The availability of better equipment and safer local anesthetic agents has also improved the safety of regional anesthetic techniques. Overall, the incidence of complications with the use of regional techniques in children is not significantly different from that in the adult population. The benefits of regional techniques include avoidance of perioperative opioids and their associated side effects, early ambulation, and excellent pain control. The preemptive
**PHARMACOLOGY AND TOXICITY OF LOCAL ANESTHETICS**

The primary local anesthetic agents used in pediatric regional techniques are 2-chloroprocaine, lidocaine, bupivacaine, ropivacaine, mepivacaine, and tetracaine. Levobupivacaine has recently been studied and may replace the racemic mixture of bupivacaine because of its decreased potential for central nervous system toxicity and cardiotoxicity. All local anesthetics block the generation and propagation of impulses in excitable tissues. This action results in effective regional blockade when these drugs are deposited near peripheral nerves, nerve roots, or the spinal cord. This also causes the adverse central nervous system and cardiac effects of local anesthetic toxicity that occur when plasma concentrations are elevated by accidental intravenous administration or increased systemic uptake secondary to relative overdose. The pharmacology of local anesthetics in children is similar to that in adults. In neonates and infants, however, the greater total body water results in a larger volume of distribution and therefore longer elimination half-life. Decreased protein binding, both qualitative and quantitative, results in greater unbound fraction of drug (particularly bupivacaine) and, therefore, increased potential for toxicity. In addition, with age, the endoneurium becomes less permeable, so both latency and duration of nerve blockade increase.

**Local Anesthetic Agents**

2-Chloroprocaine 2% or 3% has a short time to onset of action and a short duration of action. It is useful for testing the function of caudal or...
epidural catheters. Though experience is limited, it has been recommended as a safer alternative for continuous catheter infusion in preterm and high-risk infants.\textsuperscript{37}

\textit{Lidocaine} 0.5\% to 2\% has a short time to onset and medium duration of action. It can be used for peripheral blocks or epidural anesthesia.

\textit{Bupivacaine} 0.1\% to 0.5\% has a longer onset time and duration of action than lidocaine or 2-chloroprocaine but has a greater potential for severe cardiotoxicity than other agents. It can be used for peripheral blocks, spinal anesthesia, and caudal or epidural anesthesia and analgesia.

\textit{Levobupivacaine} is effective for peripheral nerve block and caudal block in children.\textsuperscript{60} It has less cardiac toxicity potential and may be a more attractive alternative to bupivacaine.

\textit{Ropivacaine} 0.2\% to 1\% is supplied as the pure S-enantiomer and has an onset time and duration of action comparable with bupivacaine. It produces less motor blockade and is less toxic than bupivacaine.\textsuperscript{41} It also can be used for peripheral blocks and caudal or epidural anesthesia and analgesia. Unlike most other local anesthetic agents, onset time, duration of action, and systemic absorption are not affected by epinephrine.

\textit{Tetracaine} 1\% is used for spinal anesthesia.\textsuperscript{77}

\textit{Mepivacaine} is approximately equally potent to lidocaine and can safely be used for peripheral nerve blocks.\textsuperscript{20} Mepivacaine can provide a rapid onset of block, with a shorter duration of motor block, that may allow for rapid recovery in the postoperative period.\textsuperscript{69}

\section*{Central Neuraxial Blocks}

\textit{General Principles}

\textbf{Patient Monitoring.} Monitors should be applied and function assured before the block is performed. In particular, the electrocardiogram should be adjusted so that the P wave, QRS complex, and upright T wave can be seen clearly. Baseline systolic blood pressure and heart rates should be noted.

\textbf{Skin Preparation.} Bacterial colonization of epidural and caudal catheters in children occurs at a rate of 6\% to 35\%.\textsuperscript{44, 47, 62} Gram-positive organisms are most common, though gram-negative colonization may also occur, particularly with caudal catheters.\textsuperscript{47} Children under 3 years of age are also most likely to have colonization of caudal catheters.\textsuperscript{47} Despite high rates of colonization, serious epidural infections are exceedingly rare.\textsuperscript{47, 62, 83} Chlorhexidine may be better than povidone iodine for reducing the risk of catheter colonization in children.\textsuperscript{44}

\textbf{Test Dose.} The authors strongly recommend the use of a test dose to decrease the likelihood of intravascular injection. A test dose is not 100\% reliable, however, and graded dosing with careful attention to vital signs is recommended. A test dose should be 0.1 mL/kg of a local anesthetic solution with 5 \mu g/mL of epinephrine to a maximum volume
of 3 mL. An increase in heart rate of 10 beats per minute above baseline occurring within 1 minute of injection is a reasonable predictor of intravascular injection for children anesthetized with sevoflurane. Pretreatment with atropine may improve the accuracy of heart rate changes in detecting intravascular injection for both inhalation agents. An increase in systolic blood pressure of greater than 15 mm Hg within 2 minutes of injection is further confirmation of intravascular injection, although less sensitive and specific than changes in heart rate. A 25% change in the T-wave amplitude (increase or decrease) may be the most reliable predictor of intravascular injection (Fig. 1). All studies have evaluated this parameter by strip recording, however, and accuracy by observation of the monitor alone has not been evaluated. In addition, changes in T-wave amplitude in response to epinephrine vary with age, and this test, therefore, may not be valid in children older than 92 months (7.6 years) of age. Isoproterenol has also been evaluated as an indicator of intravascular injection. Studies are promising, but isoproterenol has not been extensively evaluated for neurotoxic potential; supplies of this medication in the United States are limited because of recent discontinuation of production by several manufacturers.

**Sympathetic Tone.** A clinically significant decrease in blood pressure related to sympathectomy from central neuraxial blocks is rare in children younger than 8 years of age. Volume loading before such blocks, commonly practiced in adults, is unnecessary in this age group. In older patients, the sympathetic block results in a slight (20%–25%) but consistent decrease in blood pressure. Even in adolescents, however, fluids or vasopressors are rarely required to treat the hemodynamic effects of central neuraxial blocks.

**Contraindications.** Contraindications are few and similar to those in adults. These include coagulopathy, infection at the insertion site, true

![Figure 1. Electrocardiographic changes associated with the intravenous injection of bupivacaine and epinephrine 1:200,000. Note the marked increase in the height of the T wave. (From Freid EB, Bailey AG, Valley RD. Electrocardiographic and hemodynamic changes associated with unintentional intravascular injection of bupivacaine with epinephrine in children. Anesthesiology 1993; 79:394–398; with permission.)](image-url)
local anesthetic allergy, and abnormal superficial landmarks or lumbosacral myelomeningocele because of the risk of malposition of the cord or dural sac. Progressive neurologic disease is a relative contraindication primarily because of medico-legal concerns. The safety of central neuraxial techniques in the presence of a ventriculoperitoneal shunt has not been studied. Risks and benefits in these patients should be carefully considered on an individual basis.

“Single-Shot” Caudal Block

The single-dose or “single-shot” caudal technique is the most commonly used neuraxial block for children. Developmental anatomy contributes to the ease of caudal needle placement and, therefore, the popularity of the technique in young children compared with adults, for example, shows that prepubertal children have less presacral fat, making identification of the bony landmarks easier. Additionally, in children, the sacral ligament is noncalcified and the hiatus is wide, further contributing to the ease of caudal needle placement. Caudal block is a useful adjunct to general anesthesia in most procedures performed below the umbilicus. In larger volumes (1–1.25 mL/kg) and in younger children, it has been described for use in upper abdominal and lower thoracic procedures. It is the authors’ experience, however, that analgesia is less reliable for procedures at this higher level. It is less commonly used as the sole anesthetic technique, but has been described as an alternative to spinal or general anesthesia for herniorrhaphy in preterm infants.

Anatomy and Landmarks

The posterior superior iliac spines and the sacral hiatus form an equilateral triangle, the apex of which points inferiorly. The sacral cornua are easily palpated on either side of the sacral hiatus, approximately 0.5 to 1 cm apart (Fig. 2). The sacrum is the most variable bone in the human body, hence the sacral foramina may be misidentified as the sacral hiatus. The proper location is often, but not always, at the beginning of the crease of the buttocks.

Equipment

A variety of needles have been used for single-shot caudal blocks, including 23-gauge to 18-gauge straight needles, 23-gauge to 19-gauge butterfly needles, 22-gauge or 20-gauge styletted block needles, 22-gauge spinal needles, and 22-gauge or 20-gauge intravenous needle catheters. Styletted needles prevent the introduction of a skin plug into the epidural space that may later develop into an epidermal inclusion cyst. Intravenous catheters offer the advantage of confirmation of correct placement if the catheter easily slides off the needle.
**Figure 2.** Sacral anatomy. A, Coronal view of the sacrum showing proper needle placement for performance of a candal epidural block. The needle is advanced at a 45° angle to the skin until the bone is contacted. The angle is then decreased from 15° to 30° and the needle is advanced through the sacrococygeal ligament into the epidural space. B, Coronal view of the sacral anatomy demonstrating potential improper needle location during a candal epidural block. (From Deshpande JK, Tobias JD, eds: The Pediatric Pain Handbook. St. Louis, Mosby; 1996: 100; with permission.)
**Technique**

The patient is positioned in the lateral decubitus position. After identification of the sacral hiatus and sterile skin preparation, the needle is advanced at a 45° angle to the skin. A “pop” or “give” is felt as the sacrococcygeal ligament is passed. In infants under 1 year of age, the dural sac extends to the S4 level. Further needle advancement is not recommended because of the risk of dural puncture. In older children, the angle of the needle can be reduced and advanced slightly into the canal. The needle should be aspirated for blood or cerebrospinal fluid (CSF) and, if negative, a test dose is given. Injection should be easy and feel similar to injection of an epidural catheter in adults. Palpation of the skin overlying the sacrum will help rule out superficial injection. Air injection to check for crepitus is not recommended because of the risk of air embolism.

**Dosing and Duration of Block**

One milliliter per kilogram of bupivacaine 0.125% with epinephrine 1:200,000 reliably produces 4 to 6 hours of analgesia. Higher concentrations have been used, but motor blockade is significantly increased without improving the quality or duration of pain control. Alternatively, ropivacaine 0.2% can be used in a dose of 1 mL/kg. Clonidine 1 to 2 μg/kg appears to prolong bupivacaine block with little additional risk. Two case reports have suggested clonidine may be responsible for apnea when used for caudal blocks in neonates, however. The addition of opioids may increase the potency of the neuraxial block. Fentanyl 1 to 2 μg/kg may also prolong the block, but pruritus and nausea or vomiting are increased. Morphine (30 μg/kg) has also been used by this route, but side effects (nausea or vomiting and pruritus) often occur and the increased risk of respiratory depression precludes its use in outpatients.

**Timing of Block**

Few young children will cooperate with placement of a regional block while awake. Blocks are placed after induction of anesthesia and placement of an intravenous catheter. Prior placement of an intravenous catheter is mandatory for treatment of complications related to accidental spinal or intravascular injection. Blockade before the procedure reduces anesthetic requirements and may have a preemptive analgesic benefit.

**Complications**

Complications are unusual—about 1 per 1000 procedures—and usually minor. Most complications result from misplacement of the needle into superficial soft tissues or sacral foramina, resulting in block failure; intrathecal puncture with subsequent spinal anesthesia; or intravascular
or intrathecal injections, leading to systemic toxicity. Using proper technique, including incremental injection, minimizes these complications. Urinary retention and motor blockade are rare with the recommended solutions.

Continuous Caudal Catheter

Equipment

Several companies manufacture kits for caudal catheter placement. A useful component is a clear plastic drape to better identify landmarks. An 18- or 19-gauge needle (Crawford type) with a 20- or 21-gauge catheter is used in patients of all sizes. Smaller catheters tend to kink either at placement or during postoperative use. A styletted catheter has been reported to increase the successful passage of catheters to the thoracic level (discussed subsequently). After placement, care must be taken to prevent fecal contamination because of the proximity of the anus to the insertion site. Because of this risk, it is prudent to keep them in for no longer than 3 days and to discontinue caudal catheters if the dressing becomes soiled.

Caudal-to-Thoracic Technique

The caudal approach to thoracic epidural anesthesia can be used in children as old as 10 years of age. Success in this age group is related to the less densely packed epidural fat that allows for free cephalad passage of the catheter. Some authors suggest ease of removal of the stylet from a styletted-type catheter, ease of injection, and negative aspiration and test doses predict successful placement, whereas others suggest radiographic confirmation. A case report suggests that nerve stimulation through the catheter (19-gauge epidural catheter, Arrow™ Flextip Plus, Arrow International Inc., Reading) using a low electrical current (1–10mA) can be used to identify correct placement. The level of observed intercostal muscle movement (T9–T10 level) predicted catheter tip placement at the T9–T10 interspace and this was confirmed by radiographic imaging.

Epidural Block

Anatomy and Landmarks

In adults, the line drawn between the two iliac crests passes over the fourth lumbar vertebrae or the L3–L4 interspace. In children, this line may pass closer to the fifth lumbar vertebrae and in neonates it may pass over the L5–S1 interspace. Until 1 year of age, the spinal cord ends at a lower level than in adults (L3 versus L1), as does the dural sac (S4 versus S2). For a lumbar epidural block, it may be safer to select
the L4–L5 or the L5–S1 interspace for infants. Thoracic spine landmarks are the roots of the scapular spines for T3 and the inferior angle of the scapula for T7.

**Technique and Identification of the Epidural Space**

Although the patient can be in the sitting position if awake, the most common position is lateral, with the surgical side down and the hips and knees flexed by 90°. The spine is bent to open the interspinous space and enlarge the interlaminar space. The midline lumbar intervertebral approach is the most common technique of epidural block in children. As with adults, “loss of resistance” (LOR) is used in children for identification of the epidural space. The site of puncture is in the midline, midway between the spinous processes of the selected interspace. The epidural needle is inserted at right angles to the skin until it contacts the interspinous ligament. The introducer needle is then removed, and the syringe used for detecting the epidural space is connected. The epidural needle is then carefully advanced while constant pressure is exerted on the plunger of the syringe. An increased resistance is detected when the needle touches the ligamentum flavum, followed by a sudden LOR as the tip of the needle enters the epidural space.

The epidural space is more superficial in children than adults. Several guidelines for determining epidural depth have been published.⁶, ³⁶, ⁹⁷ None is consistently accurate, though a rough estimate for children between 6 months and 10 years of age is a depth of 1 mm/kg of body weight. Other formulas are depth (cm) = 1 + 0.15 × age (years) and depth (cm) = 0.8 + 0.05 × weight (kg).⁶ The mean depth of epidural space in neonates has been reported as 1 cm (SD 0.2, range 0.4–1.5 cm).³⁶ The best protection against excessive depth and resultant dural puncture is appropriately short needles and extreme care during advancement of the needle. Once the needle is in the epidural space, the absence of blood or CSF reflux is verified before insertion of the catheter. A test dose of the local anesthetic with epinephrine is administered before every bolus injection.

Whether air or saline should be used to detect LOR continues to be debated.⁷⁵, ⁸⁰ Air has a long history of use because of its availability, simplicity, and suitability for identifying the epidural space. Several severe complications have been reported after injection of air into the epidural space, including paraplegia⁶⁷ and multiradicular syndrome in adults⁶³ and air embolism in children.³¹, ⁷⁹, ⁸¹ These complications have led some practitioners to recommend abandoning the air-LOR technique in favor of a saline-LOR technique.⁶⁰, ⁷⁵ In younger patients, some practitioners believe the saline-LOR technique is not as dependable as the air-LOR technique.¹¹ Other possible disadvantages of the saline-LOR technique are dilution of the local anesthetic and difficulty distinguishing a reflux of saline from CSF. Because of the limitations of this technique, some practitioners combine air and saline.⁴, ²⁹ In general, the risk–benefit ratio seems to favor the use of saline in most circumstances.
The most prudent course of action is to always proceed cautiously and avoid injection of large volumes of any test substrate, whether air or saline.

**Dosing**

The recommended volume of anesthetic solution depends on the upper level of analgesia necessary for completion of the surgery. Many dosing schemes have been reported. In children older than 10 years of age, a simple formula calculates the volume \( V \) necessary to block one spinal segment:

\[
V \text{ (in mL)} = \frac{1}{10} \times \text{(age in years)}
\]

In younger children, the weight of the patient should be considered; 0.04 mL/kg/segment provides an initial bolus-dose estimate. Keep in mind the maximum dose recommendations (Table 2). If adequate levels are achieved, redosing after 1 to 2 hours with half the initial volume is reasonable. Alternatively, a continuous infusion can be started immediately after the bolus injection. Recommended solutions and infusion rates are available in standard pediatric anesthesia textbooks. Infants younger than 12 months of age are prone to accumulation with prolonged continuous bupivacaine infusions, so infusion rates should be reduced in this age group.

**Lumbar-to-Thoracic Catheter**

In contrast to caudal-to-thoracic catheter placement, attempts to thread a catheter from the lumbar interspaces to the thoracic level are rarely successful. This is probably related to the more acute angulation of a catheter placed in the lumbar region. If this technique is attempted, radiographic confirmation of correct placement is recommended.

**Epidural Placement During General Anesthesia**

Krane et al have eloquently made the case supporting epidural placement during general anesthesia in an editorial supported by more than fifty pediatric anesthesiologists from all around the world. For children, to avoid movement during performance of a block, sedation or general anesthesia is almost always required. Two concerns regarding

<table>
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<tr>
<th>Table 2. LOCAL ANESTHETIC MAXIMUM DOSING GUIDELINES BY WEIGHT</th>
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<tbody>
<tr>
<td><strong>Local Anesthetic</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Bupivacaine</td>
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<tr>
<td>Chloroprocaine</td>
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<tr>
<td>Lidocaine</td>
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</table>
this practice are reduced reliability of test dose under anesthesia and neurologic damage secondary to the inability of the patient to report pain or paresthesia. Data on thousands of pediatric patients do not support the second concern, and careful attention to technique substantially reduces the possibility of intravascular injection.22, 27, 66

Complications

The potential complications of epidural anesthesia in children are the same as those in adults. As in caudal blocks, accidental intrathecal or intravascular injection may occur. Failure or difficulties may occur because of an inappropriate insertion route, insufficient flexion of the spine, or deformities of the vertebral column. Direct trauma to the spinal cord can occur during thoracic and upper lumbar approaches and may result in the same neurologic sequelae as reported in adults. Fortunately, these sequelae are extremely unusual in children. In the French Language Society of Pediatric Anesthesiologists’ (ADARPEFs) prospective study, no complication was reported following thoracic epidurals, whereas the overall morbidity rate was 0.37% and 0.68% for lumbar and sacral epidurals, respectively.27 The morbidity rate for thoracic epidurals may have been skewed because only experienced anesthesiologists performed that block. As for adults, epidural catheters may be malpositioned, disconnected, or broken. Complete failure of the block usually results from misplacement of the needle or catheter. In a previously functional catheter, the development of new respiratory depression or increasing motor weakness may reflect migration into the subarachnoid space. Unilateral blockade is often caused by migration of the catheter through a spinal foramina. Migration of the catheter into an epidural vein may cause loss of analgesia and increased sedation if opioids are being used. The administration of epidural opioids, particularly morphine, may lead to delayed respiratory depression. All opioids have the potential to cause nausea, or pruritus. The incidence of urinary retention is difficult to determine because it is the practice of many centers to prophylactically place a urinary drainage catheter in these patients.

Catheter Management for Postoperative Pain

Successful use of continuous catheter techniques for postoperative pain requires physicians dedicated to their management and an educated nursing staff comfortable with monitoring and caring for these patients. Preprinted order sheets indicating infusion solutions and dosing, monitoring, patient assessment, and side-effect management increase safety and success. The article on postoperative pain management in this issue provides additional information on dosage and catheter management.
Spinal Anesthesia

In pediatric practice, spinal anesthesia is used mainly for inguinal hernia repair in former preterm infants to reduce the risk of postoperative apnea. Infants born at less than 37 weeks gestational age and less than 60 weeks postconceptional age at the time of surgery are at risk for apnea after general anesthesia. Those presenting with continuing apnea at home or anemia (hematocrit <30%) are at even greater risk. This complication appears to be reduced, though not eliminated, following spinal anesthesia without concomitant sedation. Of note, apnea may even be increased if regional anesthesia is combined with sedation (ketamine, midazolam). Spinal anesthesia is less commonly used in older children in the United States, but several European reports suggest its safety and efficacy in select cases.

Equipment

Short styletted spinal needles, from 22- to 27-gauge, are available for pediatric spinal anesthesia. In former preterm infants, medications are best delivered using 1-mL syringes because of the small volumes required.

Patient Positioning

Lumbar puncture can be performed in the same positions as for lumbar epidural anesthesia. For the former preterm infant, it is easier when the infant is in the sitting position. In the sitting position, the assistant holds the infant so that both arms and legs are bent and the elbows and knees are brought together. This helps to keep the infant in position and maximally opens the intervertebral spaces. Attention must be paid to the position of the head, which must be extended away from the chest to avoid airway obstruction.

Technique

The technique does not differ from that used in adults. In infants, puncture is performed in the midline, at the L4–L5 interspace, to stay below the level of the spinal cord. Some practitioners use local anesthesia at the skin puncture site. The usual depth is several millimeters past that calculated for depth of the epidural space (discussed earlier). After reflux of CSF from the needle, the syringe is quickly attached to minimize CSF loss and the solution is injected in 10 to 20 seconds. Particularly for infants, in whom the total volume injected are very small, some practitioners advocate aspiration of spinal fluid into the syringe at the end of the block and then reinjection to assure that the complete dose is administered. Others intentionally “overfill” the syringe with the volume of the spinal needle. Patients should be carefully returned to the supine position, without elevating the legs, after completion of the block.
**Dosing**

In general, younger and smaller children require larger doses to produce the same level of block, but the duration of the effect is shorter. Dosing recommendations for spinal anesthesia vary and are summarized in Table 3. Guidelines given are designed to reach an upper limit of block between T10 and T7. The safety of hyperbaric lidocaine has recently been questioned in adults because of the high incidence of transient neurologic symptoms (TNS) following its use. The symptoms usually consist of back and buttock pain. Cauda equina syndrome has been reported in adults. The US Food and Drug Administration recommends diluting 5% lidocaine with an equal volume of cerebrospinal fluid before injecting the total dose, but at least one study suggests this does not influence the incidence of TNS. Although reducing the concentration of lidocaine to 2% has been found to provide effective analgesia, the incidence of TNS may be unaffected. In general, for spinal anesthesia in preterm infants, lidocaine is unsuitable because its duration of action is too brief.

**Complications**

Few studies evaluate overall incidence of complications for spinal anesthesia in children. In the ADARPEF’s prospective study, only one complication (intravascular injection) was reported after 506 spinal anesthetics. No headaches were reported. In a retrospective study by the same association, the incidence of complications after spinal anesthesia (n = 705) was 3% and is described as “extension of the block—apnea, seizures.” Recently, a report of spinal anesthesia in 100 children, age 2 to 115 months, found few complications using 0.5% isobaric or hypobaric bupivacaine. Overall, cardiovascular stability was good. A vasopressor was administered to one child to treat hypotension and atropine to another to treat bradycardia. Five children developed a mild, position-dependent headache (24–27-gauge needle). A report of experience with 107 spinal anesthetics in children age 7 to 18 years found that six children required vasopressor and six required atropine to treat bradycardia. Nausea (20 patients) and shivering (16 patients) were also reported. Four children had post-dural puncture headaches (27-gauge needle). High spinal anesthesia has been reported in infants when the legs are raised shortly after placement of the block. Care must be taken to avoid this scenario. A report of inguinal hernia repairs in former preterm infants found 262 of 269 spinal anesthetic placements (97.3%) were successful. Sixteen patients required two attempts; 56 (21.4%) required supplemental anesthesia; 34, intravenous anesthesia; six, general; 12, local; and four, other regional. One hundred fifty-three infants had histories of apnea. Thirteen episodes of apnea were noted in 13 infants (4.9%); all 13 were inpatients undergoing concomitant therapy for apnea (mean gestational age [GA] 28 weeks, postconceptional age at surgery [PCAS], 42.9 weeks). Four of these infants received supplemental...
Table 3. RECOMMENDED DOSES AND APPROXIMATE DURATIONS OF LOCAL ANESTHETICS FOR SPINAL ANESTHESIA IN INFANTS AND CHILDREN

<table>
<thead>
<tr>
<th>Local Anesthetic</th>
<th>0–5 kg</th>
<th>5–15 kg</th>
<th>&gt; 15 kg</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75% hyperbaric bupivacaine</td>
<td>0.5–0.6 mg/kg</td>
<td>0.4 mg/kg</td>
<td>0.3 mg/kg</td>
<td>&gt;70 min</td>
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<tr>
<td></td>
<td>(0.06–0.08 mL/kg)</td>
<td>(0.053 mL/kg)</td>
<td>(0.04 mL/kg)</td>
<td>(similar to 0.5% bupivacaine)</td>
</tr>
<tr>
<td>0.5% hyperbaric or isobaric bupivacaine</td>
<td>0.5–0.6 mg/kg</td>
<td>0.4 mg/kg</td>
<td>0.3 mg/kg</td>
<td>30–180 min</td>
</tr>
<tr>
<td></td>
<td>(0.1–0.12 mL/kg)</td>
<td>(0.08 mL/kg)</td>
<td>(0.06 mL/kg)</td>
<td>(avg 80 min)</td>
</tr>
<tr>
<td>0.5% hyperbaric tetracaine</td>
<td>0.5–0.6 mg/kg</td>
<td>0.4 mg/kg</td>
<td>0.3 mg/kg</td>
<td>35–240 min</td>
</tr>
<tr>
<td></td>
<td>(0.1–0.12 mL/kg)</td>
<td>(0.08 mL/kg)</td>
<td>(0.06 mL/kg)</td>
<td>(avg 90 min)</td>
</tr>
<tr>
<td>5% hyperbaric lidocaine</td>
<td>2.5–3 mg/kg</td>
<td>2 mg/kg</td>
<td>1.5 mg/kg</td>
<td>&lt;60 min</td>
</tr>
<tr>
<td></td>
<td>(0.05–0.06 mL/kg)</td>
<td>(0.04 mL/kg)</td>
<td>(0.03 mL/kg)</td>
<td></td>
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</tbody>
</table>

anesthesia. This apnea rate is significantly lower than the published rate (10%–30%) \((P = .01)\). Thirty-nine of 103 infants who underwent inguinal hernia repair on an outpatient basis had histories of apnea. No postoperative episode of apnea was reported, though patients were not monitored for apnea at home. The mean birth weight of this group was 2091 g (weight range, 710–3693 g); mean GA, 33 weeks (GA range, 25–37 weeks); and mean PCAS, 44.3 weeks (PCAS range, 35.4–59.2 weeks).\(^24\)

Unlike adults, neonates usually tolerate high thoracic spinal anesthesia with minimal changes in heart rate and arterial blood pressure. This may be because the sympatholysis from high thoracic spinal anesthesia is offset by withdrawal of cardiac vagal activity in this age group.\(^70\) Cases of aseptic meningitis after spinal anesthesia in infants have been reported, but a causative relation cannot be firmly established.\(^1\,19\)

### PERIPHERAL NERVE BLOCKS

Peripheral nerve blocks used for surgery and postoperative pain relief are discussed by anatomic regions (Table 4). Very little equipment is needed to perform these blocks—blunt-tip needles and a nerve stimulator capable of providing low-voltage (0.01 mV) electric stimulation. Local anesthetic selection is based on the duration of the surgical procedure and the desired duration of the block. Lidocaine, mepivacaine, bupivacaine, ropivacaine and, more recently, levobupivacaine are used for peripheral nerve blocks. The addition of bicarbonate may enhance the speed of onset of the nerve block and reduce the pain on injection.

<table>
<thead>
<tr>
<th>Region</th>
<th>Nerve to be Blocked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head and neck</td>
<td>Supraorbital and supratrochlear</td>
</tr>
<tr>
<td></td>
<td>Infraorbital nerve</td>
</tr>
<tr>
<td></td>
<td>Greater occipital nerve</td>
</tr>
<tr>
<td></td>
<td>Great auricular nerve</td>
</tr>
<tr>
<td>Chest wall</td>
<td>Intercostal nerve</td>
</tr>
<tr>
<td>Upper extremities</td>
<td>Brachial plexus</td>
</tr>
<tr>
<td></td>
<td>Wrist blocks</td>
</tr>
<tr>
<td></td>
<td>Elbow (radial, ulnar, and median)</td>
</tr>
<tr>
<td></td>
<td>Digital nerve</td>
</tr>
<tr>
<td>Abdomen and genitals</td>
<td>Ilioinguinal nerve, penile</td>
</tr>
<tr>
<td>Lower extremities</td>
<td>Femoral nerve</td>
</tr>
<tr>
<td></td>
<td>Lateral femoral cutaneous</td>
</tr>
<tr>
<td></td>
<td>Sciatic nerve</td>
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<td>Ankle block</td>
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<td>Digital nerve</td>
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Table 4. PERIPHERAL NERVE BLOCKS

This alters the pKa of the solution, making the local anesthetic available in the active cationic form. Caution is required to avoid exceeding the maximum allowable dose of the local anesthetic. The total volume of local anesthetic required for a peripheral nerve block is extrapolated from adult experience.

**Relative Contraindications to Peripheral Blocks**

Though it is rare to encounter opposition to the use of peripheral nerve blocks, certain conditions may call for a judicious avoidance of them. Relative contraindications include:

- Local infection
- Generalized sepsis
- Coagulopathy
- Predisposition to compartment syndrome
- Parental or child dissent

**Nerve Stimulator**

Though not a substitute for anatomic knowledge, a nerve stimulator is useful to localize peripheral motor nerves in anesthetized children. Because paresthesias cannot be elicited in an anesthetized child, the use of a nerve stimulator may decrease the potential for nerve damage. A nerve stimulator capable of delivering low voltage is preferred. The authors prefer stimulation with an insulated needle using a voltage of 0.2 mA with a repetitive single-pole output at a 1-second interval. The area innervated by the nerve is observed for the appropriate muscle contraction. When this has been identified, 1 to 2 mL of local anesthetic agent is injected. Immediate abolishment of muscle movement indicates correct placement of the needle.

**Head and Neck Nerve Blocks**

The trigeminal nerve provides sensory innervation to the scalp and the face. The ophthalmic division of the trigeminal nerve (V₁) supplies the scalp anterior to the coronal suture, and the branches of the cervical nerve (C₂) supply the scalp posterior to the coronal suture.

**Supraorbital and Supratrochlear Nerve. Anatomy and Indication.** These are the terminal branches of the first branch of the V₁. The supraorbital nerve supplies the forehead and the scalp anterior to the coronal suture after it exits the supraorbital foramen. The supratrochlear nerve leaves the orbit between the trochlea and the supraorbital foramen and supplies the forehead (Fig. 3). Blockade of these nerves can be used for surgical excisions of skin lesions on the scalp and for neurosurgical
procedures that involve incisions on the anterior portion of the scalp. The authors have also had success treating patients with chronic headaches with serial blockades of these nerves.

**Technique.** Using a sterile technique, the supraorbital notch is identified, and a 27-gauge needle is inserted perpendicularly. Once resistance is obtained, the needle is drawn back a few millimeters and 1 mL of 0.25% bupivacaine with 1:200,000 epinephrine is injected to block the supraorbital nerve. The needle is then withdrawn gently and directed medially to block the supratrochlear nerve, and an additional 1 mL of 0.25% bupivacaine with 1:200,000 epinephrine is injected.

**Complications.** Pressure is applied to the supraorbital area after the block is performed to avoid periorbital edema and ecchymosis secondary to local anesthetic solution dissecting into the surrounding loose adventitious tissue or from hematoma formation.

**Greater Occipital Nerve Block. Anatomy and Indications.** The greater occipital nerve is a terminal branch of the superficial cervical plexus (dorsal rami of C2). The nerve becomes subcutaneous below the superior nuchal line by passing above the aponeurotic sling just medial to the occipital artery (Fig. 4). Blockade of this nerve provides ipsilateral pain relief for patients undergoing occipital incisions, including craniotomies for posterior fossa tumors and posterior ventriculo-peritoneal
shunts. Blockade can also provide anesthesia for excision of skin lesions on the scalp.84

Technique. The head is turned to the side opposite the side to be blocked. The occipital artery is palpated at the level of the superior nuchal line. Subcutaneous fanning of 2 mL 0.25% bupivacaine with 1:200,000 epinephrine is performed.

Complications. Though complications are rare, it is important to note the proximity to the spinal canal. Particular caution should be exercised in patients who have had surgery to the posterior fossa. Intravascular injection can be avoided by careful aspiration.

Infraorbital Block. Anatomy and Indications. The infraorbital nerve is the terminal branch of the second division of the trigeminal nerve and is purely sensory. It leaves the skull through the foramen rotundum and enters the pterygopalatine fossa. Here it exits the infraorbital foramen, dividing into four branches—the inferior palpebral, the external nasal, the internal nasal, and the superior labial. These branches innervate the lower lid, the lateral inferior portion of the nose and its vestibule, the upper lip, the mucosa along the upper lip, and the vermillion. This block can be used to provide postoperative analgesia for procedures performed to the upper lip and vermillion (e.g., cleft lip repair).74 It can also be used for nasal septal reconstruction, rhinoplasty, and in patients undergoing endoscopic sinus surgery.
Technique. Although two approaches are described (intraoral and extraoral), the authors prefer the intraoral approach. After palpation of the infraorbital foramen, the upper lip is folded back and a 27-gauge needle is advanced to the infraorbital foramen parallel to the maxillary premolar (Fig. 5). By placing a finger at the level of the infraorbital foramen, the cephalad progression of the needle is checked. A volume of 0.5 mL to 1 mL of 0.25% bupivacaine with 1:200,000 epinephrine is injected after careful aspiration.

Complications. Swelling can occur because of loose adventitious tissue around the eyelid. To prevent this, pressure is applied to the area for about 5 minutes after the block is performed. Patients and parents should be informed that the upper lip will be anesthetized after the block.

Great Auricular Nerve. Anatomy and Indications. This nerve supplies the sensory innervation to the mastoid and the external ear. It is a branch of the superficial cervical plexus (C3). The nerve wraps around the posterior border of the belly of the clavicular head of the sternoclei-
domastoid at the level of the cricoid cartilage (C6)\textsuperscript{58} (Fig. 6). Blocking this nerve provides analgesia for patients undergoing otoplasty repair\textsuperscript{16} and tympanomastoid surgery. The authors have found that using this nerve block, can reduce the postoperative morbidity associated with the perioperative use of opioids.

**Technique.** The belly of the clavicular head of the sternocleidomas-toid is identified, and a line drawn laterally at the level of the cricoid dissecting the sternocleidomastoid is marked. This is usually about 5 to 6 cm below the bony external auditory canal. Two to 3 mL of 0.25% bupivacaine with 1:200,000 epinephrine are injected into the area.

**Complications.** Careful attention to the location of the external jugular and carotid can prevent intravascular placement. Superficial needle placement avoids a deep cervical plexus block that can result in Horner’s syndrome. Deep injection can also affect the hemidiaphragm by blocking the phrenic nerve unilaterally or the trapezius by blocking the spinal accessory nerve.

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![Figure 6. Great auricular nerve block. (From Coté CJ, Todres ID, Goudsouzian NG, et al (eds): A Practice of Anesthesia for Infants and Children, 3rd ed. Philadelphia, WB Saunders; 2001, 655; with permission.)](image-url)
Trunk Blocks

Intercostal Nerve Blocks

Anatomy and Indications. The intercostal nerves are derived from the ventral rami of the first through the twelfth thoracic nerves. There are four branches for each intercostal nerve—the gray rami communicans that passes to the sympathetic ganglion; the posterior cutaneous branch, supplying the skin of the paravertebral area; the lateral cutaneous branch, supplying the lateral aspect of the lateral and anterior portions of the chest wall; and the terminal branch, providing sensory fibers to the anterior portions of the chest and abdomen. Intercostal nerve blocks can be used for isolated surgical fields. They are also used to manage the pain of postherpetic neuralgia.

Technique. The authors prefer the anterior approach through the midaxillary line. A 27-gauge needle is placed into the skin over the rib at the level of the anterior axillary line. The skin is gently pulled caudad. This allows the needle to fall in the sulcus below the rib. After careful aspiration, 2 to 3 mL of 0.25% bupivacaine with epinephrine are injected. For a lesion or surgical field that covers several dermatomes, however, the authors’ choice of analgesia is the placement of a thoracic epidural catheter (see previous section on central neuraxial blockade).

Complications. Intravascular injection, local anesthetic toxicity with the use of large volumes of local anesthetic, and pneumothorax from the needle puncturing the pleural cavity have been reported. With the posterior approach, there is a risk for subarachnoid injection because the sheath communicates directly with the subarachnoid space.

Abdomen Blocks

Ilioinguinal and Iliohypogastric Nerve Blocks

Anatomy and Indications. The subcostal nerve (T12) and the ilioinguinal and iliohypogastric nerves (derived from L1) innervate the inguinal area. The ilioinguinal and iliohypogastric nerves pass over the anterior superior iliac spine (ASIS) and, after piercing the internal oblique aponeurosis about 2 to 3 cm medial to the ASIS, travel between the internal and external oblique aponeurosis. Here they lie in close proximity to the spermatic cord and accompany the cord structures to the genitals. This block can be used for hernia repairs and other surgeries in the groin, including orchidopexy. Recent literature contradicts the popular belief that this block, when performed preemptively, may lead to significant preemptive analgesia.

Technique. The ASIS is palpated. A point is marked 1.5 cm below and medial to the ASIS. The cord structures are palpated and a 27-gauge needle is placed into the area. Occasionally, a “pop” may be felt as the sheath is entered. Five to 10 mL of 0.25% bupivacaine with 1:200,000 epinephrine are injected.
Complications. Although rare, there is the possibility of a hematoma developing in the area after injection.

Penile Blocks

Anatomy and Indications. The nerve supply of the penis is from the pudendal nerve and the pelvic plexus. Two dorsal nerves of the penis separate at the level of the symphysis pubis. These are terminal branches of the pudendal nerve. This block can be used for circumcision and other penile procedures when caudal blocks may be contraindicated.

Techniques. Two methods are commonly used—a “ring” block and direct blockade of the dorsal nerves of the penis. For either technique, epinephrine should be avoided in the block solution to prevent ischemia. Care should be taken to avoid intravascular placement. To place a ring block, a ring of 0.25% plain bupivacaine is injected around the base of the penis. To block the dorsal nerves of the penis, a 27-gauge needle is inserted 1 cm above the symphysis pubis. The needle is advanced 1 cm after it pierces the penile fascia. After aspiration, 2 mL of 0.25% bupivacaine without epinephrine are injected slowly. The needle is then withdrawn and directed to the 2 o’clock position. Two to 3 mL of plain bupivacaine are injected. The needle is again withdrawn and then directed to the 10 o’clock position. Two to 3 mL of local anesthetic solution are injected.

Complications. There is a mild risk of compromise to organ blood flow with the ring block. Applying pressure at the base of the penis can minimize hematoma formation after the block.

Upper Extremity Blocks

Brachial Plexus Block

Several approaches to the brachial plexus are described in adults. These include the axillary, the interscalene, the supraclavicular, and the infraclavicular approaches. The axillary approach is the most commonly used technique for brachial plexus block in children.

Anatomy and Indications. The anatomy of the brachial plexus is described in detail in many standard anesthesia textbooks. It arises from the C5, C6, C7, C8, and T1 nerve roots. In children, the axillary sheath, as well as the axillary artery, are easily palpated. Axillary nerve blocks can be used for procedures in the hand and arm that require prolonged pain relief. This can increase blood flow by decreasing the sympathetic tone. It can be used for placement of an Ilizarov device for the arm as well as for reimplantation of severed fingers.

Technique. The arm is abducted to a 90° angle. The artery is palpated in the axilla. The use of a nerve stimulator allows accurate placement of the needle in the neurovascular sheath without trying to elicit
paresthesia. The axillary sheath is divided into fascial compartments for each nerve. These may limit spread of the local anesthetic in the sheath. The transarterial approach involves direct puncture of the axillary artery. The needle is then advanced further into the sheath. Once blood is no longer aspirated, half the total volume of local anesthetic is injected. The needle is then pulled back beyond the artery and the other half of the local anesthetic is injected. The total dose of local anesthetic injected is 1 mL/kg of 0.25% bupivacaine or 1 mL/kg of 0.2% ropivacaine, up to a maximum dose of 40 mL. Regardless of technique, careful aspiration should be carried out before injection to eliminate intravascular local anesthetic injection. An additional cuff of local anesthetic is injected as a subcutaneous cuff to block the intercostobrachial nerve so that tourniquet pain is not experienced.

Another approach is using multiple injections with the aid of a nerve stimulator. The needle is advanced into the facial sheath at a 45° angle to the skin above the pulsation of the axillary artery. When a twitch is elicited in the appropriate muscle group with the nerve stimulator, local anesthetic solution is injected. A ring of local anesthetic should be injected around the upper aspect of the arm. This will block the intercostobrachial nerve, which will provide analgesia for tourniquet-related pain.

Complications. A hematoma may form because of puncture of the axillary artery. This is usually self contained and can be prevented by applying pressure to the area.

Lower Extremity Blocks

Caudal blocks are more commonly used for lower extremity procedures, but when a caudal block is contraindicated, a peripheral block should be considered.

Sciatic Nerve Block

Anatomy and indications. The sciatic nerve arises from the L4, L5, and S1 roots of the sacral plexus. It passes through the pelvis and is superficial at the lower margin of the gluteus maximus muscle. It then descends in the posterior aspect of the thigh, supplying sensory innervation to the entire posterior thigh and the leg and foot below the ankle, except the medial aspect, which is supplied by the femoral nerve. This block can be used for surgery below the knee. In combination with a femoral nerve block, complete analgesia of the leg and foot can be obtained. The authors use this block for unilateral club foot repair and for triple arthrodeses of the foot.

Technique. Although the posterior approach is most commonly used in adult practice, it may be difficult in the anesthetized pediatric
patient. The authors prefer the lateral approach to the popliteal fossa to block the sciatic nerve. This has a longer duration of analgesia in adults.59

Anatomy and Indications. The popliteal fossa is a diamond-shaped area located behind the knee, bordered laterally by the biceps femoris tendon and medially by the semitendinosus and semimembranosus muscles. The sciatic nerve, in adolescents, divides approximately 5 to 6 cm above the crease of the knee into its two major branches, the tibial nerve medially and the common peroneal nerve laterally.

Technique. The lower leg is elevated on a pillow. The biceps femoris tendon is palpated. After sterile preparation, an insulated needle with a nerve stimulator attached is introduced at about 5 cm above the crease of the knee. Using low-voltage (0.2 mV–0.3 mV) electrical stimulation, the needle is slowly introduced anterior to the tendon (Fig. 7). Dorsiflexion or plantar flexion of the foot is seen when the needle is in approximately the right position. On injection, this response is eliminated, suggesting correct placement of the needle. Five milliliters (in infants and toddlers) to 15 mL (in adolescents) of 0.25% bupivacaine with epinephrine 1:200,000 are injected into the space. Careful aspiration is carried out to avoid intravascular injection.

Complications. Intraneural placement can be prevented by using a nerve stimulator. Though rare, intravascular placement should be prevented by careful aspiration.

**Femoral Nerve Block**

**Anatomy and Indications.** The femoral nerve is located immediately lateral to the femoral artery in the inguinal area. This block is useful for surgery on the shaft of the femur. This can be performed on arrival to the hospital to prevent pain caused by transport and other manipulations.

**Techniques.** Because this is a motor nerve, the use of a nerve stimulator is desirable. Look for movement of the knee and the adductors. In adolescents, a volume of 10 to 15 mL of 0.25% bupivacaine with epinephrine 1:200,000 are injected into the fascial sheath. Another technique is to use a blunt needle to enter the femoral sheath. After the second “pop,” the needle will be in the femoral sheath. Following careful aspiration, 10 to 15 mL of local are anesthetic are injected.

**Complications.** Bleeding and hematoma formation from the femoral artery and intraneural placement are the two major complications of this block.

**Lateral Femoral Cutaneous Nerve Block**

**Anatomy and Indications.** This nerve arises from the L2 and L3 roots of the lumbar plexus. It traverses the lateral border of the psoas muscle and passes obliquely under the fascia iliaca to enter the lateral aspect of the thigh. It is a pure sensory nerve, providing sensory fibers to the lateral portion of the thigh. Blockade can be used to provide analgesia to the lateral aspect of the thigh for skin and bone graft procurement and muscle biopsies.

**Technique.** A point 2-cm caudal and medial to the ASIS is located on the side to be blocked. The authors prefer using a blunt needle that is advanced slowly into the sheath. A distinct “pop” is felt as the needle enters the fascia iliaca compartment. In adolescents, 10 to 15 mL of 0.25% bupivacaine with epinephrine 1:200,000 are injected after careful aspiration.

**Complications.** It is rare to see complications from this nerve block. Intraneural injection can cause dysesthesia that can last for a few weeks, however.

**Ankle Block**

**Anatomy and Indications.** The nerves for the ankle are primarily derived from the lumbo-sacral plexus, L4, L5, S1, S2, and S3 roots. Five nerves supply the ankle—tibial, supplying the sole of the foot; deep peroneal, supplying the web between the great toe and the middle toe; superficial peroneal, supplying the dorsum of the foot; saphenous, a branch of the femoral nerve supplying the medial aspect of the foot; and sural, supplying the lateral aspect of the foot.

**Technique.** Because it is not necessary to elicit paresthesias while these nerves are located, an ankle block can be performed in the sedated
patient without the use of a nerve stimulator. A 25-gauge needle is usually used to inject the local anesthetic. In adolescents, a volume of 5 to 10 mL for each of the nerves to be blocked may be necessary.

- **Tibial nerve:** A 27-gauge needle is inserted at the posterior angle of the tibia lateral to the pulsation of the tibial artery until bony contact is made. The needle is then pulled back a few millimeters and 5 to 10 mL of 0.25% plain bupivacaine are injected.
- **Deep peroneal nerve:** This nerve continues midway between the malleoli onto the dorsum of the feet. A 27-gauge needle is inserted between the anterior tibial and the extensor hallucis longus tendons. This is usually lateral to the pulsation of the dorsalis pedis artery. The needle is advanced until the bony surface of the tibia is felt. It is then withdrawn a few millimeters and 3 to 5 mL of 0.25% bupivacaine are injected.
- **Superficial peroneal nerve:** This nerve perforates the deep fascia and runs along the anterior aspect of the dorsum of the foot. A subcutaneous infiltration of 3 to 4 mL of local anesthetic solution between the medial and lateral malleolus can block this nerve.
- **Sural nerve:** This is a cutaneous nerve that arises from the union of a branch of the tibial and the common peroneal nerves. It runs below and lateral to the lateral malleolus. A 27-gauge needle is inserted below the lateral malleolus toward the fibula. Three to 5 mL of plain 0.25% bupivacaine are injected.
- **Saphenous nerve:** This is the terminal sensory branch of the femoral nerve. A skin wheal placed above and medial to the medial malleolus will block the saphenous nerve.

**Digital Nerve Blocks**

**Anatomy and Indications.** Digital nerves supply all fingers and toes. In the hand, the common digital nerves are derived from the median and ulnar nerves and divide in the palm to volar digital nerves that supply the fingers. All digital nerves have accompanying digital arteries. The digital nerves of the foot are derived from the plantar cutaneous branches of the tibial nerve. Digital blocks can be used for providing analgesia for ingrown toenails, laser treatment of warts, traumatic injuries of the nailbed, and for ischemia secondary to Raynaud’s phenomenon related to collagen vascular disease.

**Techniques. Thumb.** With the thumb extended, a 27-gauge needle is inserted into the palmar surface of the hand between the index finger and thumb. The needle is advanced to the junction of the web space and the palmar skin of the hand. One mL of local anesthesia without epinephrine is injected after careful aspiration to prevent intravascular placement.

**Other fingers.** Digital nerves for the other fingers can be blocked by placing a 27-gauge needle into the web about 3 mm proximal to the
junction between the web and the palmar skin; 1 mL of 0.25% bupivacaine without epinephrine is injected into each web space.

**Toes.** These techniques can be difficult to perform because of the thickness of the overlying skin. A dorsolateral approach is preferred, in which the web space is accessed from the dorsum of the foot; 1 mL of local anesthetic without epinephrine is injected into each web space.

**Complications.** Large volumes can cause ischemia through pressure. Vasoconstrictors should be avoided because they may lead to ischemia and necrosis of the digit.

**SUMMARY**

In children, regional anesthetic techniques are safe and effective adjuncts to general anesthesia and for postoperative pain relief. Application of the techniques described in this article will contribute to improved care for pediatric patients undergoing surgical procedures. The judicious choice of local anesthetics, along with the blockades of targeted nerves, decrease the need for supplemental analgesics in the recovery phase.

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