Guidelines for Pediatric Regional Anesthesia

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Guidelines For Pediatric Regional Anesthesia

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Introduction

This syllabus will discuss the salient differences between children and adults as far as the performance of regional anesthesia is concerned. The majority of discussion will be reserved for examination of the controversies surrounding the performance of regional anesthesia in anesthetized subjects who are unable to report the existence of paresthesias, whether this might increase the risk of regional anesthesia, and an overall assessment of the risk of regional anesthesia in children.

The last section of this syllabus is a brief “how to” for various common peripheral and central blocks in children, but this material will not be reviewed in the spoken lecture. It is placed here in this syllabus for your further reading and use.

Assuring Success - What Are the Requirements for Regional Anesthesia in Children?

Anticipation of the problems that commonly arise in performing regional anesthesia for children and formulating a plan for dealing with these problems will assure the success of the anesthesiologist in incorporating this important technique into his or her practice. These problems may be generic to any technique (patient selection, equipment issues, pharmacokinetic differences between children and adults, and problems unique to performing blocks on sedated or anesthetized subjects), or they may be specific to certain techniques (for example anatomical considerations, side effect management related to epidural opiate administration, etc.). The successful application of regional anesthesia techniques for children should be easily attainable in any hospital or outpatient surgery center setting with the following features in mind.

SKILL PERFORMING REGIONAL ANESTHETIC BLOCKS ON ADULTS. The child is not the appropriate subject for mastering regional block skills.

SUPPORTIVE SURGICAL COLLEAGUES. Without the support of your surgeons, who must tolerate somewhat longer induction times, and who will support your efforts when discussing the anticipated procedure with parents, regional anesthesia becomes a contentious issue.

ASSISTANCE IN THE OPERATING ROOM. Depending upon your patient’s airway, your degree of skill and comfort with the pediatric airway, and the nature of the background general anesthetic, you may need skilled assistance administering and monitoring your patient’s general anesthetic while you perform the regional block. This is easily accomplished in the teaching hospital setting, or in practices in which CRNA’s and anesthesiologists start cases as a team, but is less easily accomplished (but not impossible!) in settings in which anesthesiologists practice alone.

PROPER EQUIPMENT. Most adult block kits and needles are not appropriate for children. Several manufacturers are now marketing regional block kits and needles specifically designed for the pediatric patient. The most important feature is to have needles that are short; the gauge of the needle need not be reduced for pediatric applications.

NURSING POLICIES AND PROCEDURES. Many PACU’s still require the return of motor function before discharge, and/or require PACU stays of a certain minimum duration. Among the advantages of regional anesthesia in children is the ability to discharge from a Phase I PACU within 15-30 minutes, and to discharge home within one hour. We routinely move children out of the Phase I environment when awake regardless of the duration of time that has elapsed since administration of an anesthetic; indeed, with regional blocks in combination with propofol administration it is often feasible to bypass the Phase I PACU altogether! There need not be any
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requirement for voiding prior to discharge home. (Coad and Hain 1989; Fisher Q A. et al. 1993; Shyr M H. et al. 1990) We also routinely discharge children with residual motor and sensory blockade home (Burns et al. 1990; Coad and Hain 1989) in the care of parents or guardians provided that certain requirements have been met: (1) a qualitative judgment has been made about the capability of the parents to understand and follow instructions, (2) the acceptance of the parents of the additional responsibility associated with early discharge, and (3) discharge teaching regarding protection of weak and numb body parts.

Successful application of epidural analgesia in children requires the organization of a pain management service, appropriate nursing protocols and procedures, and the hospital support to provide electronic monitoring of children (e.g. pulse oximetry and perhaps ECG) at other than an ICU setting.

Assuring Success - What are the Differences between Children and Adults?

Recognition and recall of these 4 differences will assure successful regional blocks:

ANATOMY. Target nerves are smaller, closer to other (vascular) anatomic structures, and are closer to the skin. The ability to predict the depth at which the needle will encounter the epidural space, subarachnoid space, nerve sheath, etc., will greatly enhance one’s success rate. This is discussed in more detail below. The caudal extent of the spinal cord and dural sac extends approximately two interspaces lower in the newborn and infant than in the older child and adult. Finally, the contents of the epidural space in the child are more gelatinous and less fibrous than in the adult, which both favors the spread of local anesthetics and allows the passage of epidural catheters to a greater distance in the space.

PHYSIOLOGY. Clinically significant changes in blood pressure related to neuraxial sympathectomy are quite unusual in children less than 8 years of age. This obviates the need for volume loading prior to performing subarachnoid or epidural blocks in young children. The reason for this blood pressure stability has not been defined, but may be related to the reduced resting sympathetic tone in children compared to adults, or a greater ability to compensate for a fall in SVR.

PHARMACOLOGY. Both pharmacokinetic changes (e.g. peak plasma levels of local anesthetics and metabolism of local anesthetics) and pharmacodynamic changes (e.g. dose-response relationship and toxicity) exist for children and adults and determine the safe maximum doses that may be administered.

Generally, the volume of distribution of local anesthetics is greater in children than adults, resulting in lower peak plasma levels. (Murat et al. 1988) This means that on a mg/kg basis, larger doses are tolerated in children and are associated with peak plasma levels well below the toxic threshold. Doses of bupivacaine of up to 3mg/kg, and lidocaine up to 10mg/kg are associated with peak plasma levels of less than 2µg/kg, which is well below the toxic plasma level. (Bruguerolle B. et al. 1990; Mobley K A. et al. 1991; Stow P J. et al. 1988)

However in newborn infants less than 6 months of age, serum protein binding of local anesthetics is approximately half of that of older children and adults, and hepatic metabolism is similarly depressed. (Stow P J. et al. 1988) This will result in both higher peak plasma levels and a greater free (unbound) fraction of local anesthetic in the blood, allowing toxicity to occur at lower blood levels than normal. The maximum dose of amide local anesthetics should therefore be reduced by 50% in this age group.
### Table 1. Recommended Local Anesthetic Doses

<table>
<thead>
<tr>
<th>Block</th>
<th>Lidocaine 2% + Tetracaine 0.1%</th>
<th>Bupivacaine 0.25%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Levo-Bupivacaine, 0.25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ropivacaine 0.2%</td>
</tr>
<tr>
<td>Brachial Plexus</td>
<td>0.25 - 0.5 cc/kg</td>
<td>0.25 - 0.5 cc/kg</td>
</tr>
<tr>
<td>Femoral</td>
<td>0.25 - 0.5 cc/kg</td>
<td>0.25 - 0.5 cc/kg</td>
</tr>
<tr>
<td>Sciatic</td>
<td>0.25 - 0.5 cc/kg</td>
<td>0.25 - 0.5 cc/kg</td>
</tr>
<tr>
<td>Lumbar Epid</td>
<td></td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Caudal (to T10 level)</td>
<td></td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Caudal (to T6 level)</td>
<td></td>
<td>1.0 cc/kg</td>
</tr>
<tr>
<td>Penile Block</td>
<td></td>
<td>2 cc</td>
</tr>
<tr>
<td>Ilio-inguinal</td>
<td></td>
<td>5 cc</td>
</tr>
</tbody>
</table>

### Psychology

As the reader begins to read this section, the thought probably running through the mind is that this is the most obvious and the least important section of this syllabus. "Of course children behave differently than adults." However, the truth is that it is the difference in behavior that give rise to the greatest controversies in pediatric regional anesthesia.

Because, as is self evident, rarely children will allow the performance of a regional block without deep sedation or general anesthesia, two problems are created: (1) the inability to recognize paresthesias, and (2) the effect of general anesthetic agents on the ability of a test dose to identify accidental intravascular injection of local anesthetic.

Several blocks do not require a paresthesia to identify location of the nerve (axillary block, femoral block, ilio-inguinal block, penile block, popliteal nerve block). Interscalene and sciatic nerve block do, however, (Dalens B. et al. 1990) and therefore require the use of a nerve stimulator. In the ambulatory surgery setting I therefore would not choose to use these blocks unless specifically indicated for the type of surgery performed (e.g. shoulder surgery).

An area of considerable controversy is the performance of blocks under general anesthesia, during which a paresthesia indicates something may have gone awry, but cannot be reported. Some experts in this field believe that the inability to recognize a paresthesia will increase a patient’s risk of experiencing a nerve injury because the anesthesiologist will persist in the performance of the block absent a report of paresthesia. However, while conventional wisdom and experience suggest that nerve injury may be prevented by discontinuing a block in the presence of a paresthesia, it is far from certain that this is indeed the case. In fact, it might be cogently argued that the safety of regional techniques may in some ways be enhanced by general anesthesia, by virtue of providing a still subject who may be optimally positioned by assistants. Let us examine the evidence that the inability to elicit a paresthesia will increase the risk of regional anesthesia:
Paresthesias are an early warning before permanent neurologic injury occurs. Spinal nerve roots both within the epidural space and within the subarachnoid space are mobile (in the absence of scarring), and move away from an advancing needle. This probably accounts for the rarity of permanent neurologic disability in spite of the relatively common occurrence of paresthesia during the performance of epidural or subarachnoid anesthesia. However if it were not the case that nerves were mobile, contusion or laceration of a spinal nerve by an epidural needle would frequently result, producing both severe pain as well as permanent injury. Yet, neurologic injury is less common after regional anesthesia than after general anesthesia (Kroll et al. 1990).

Paresthesia or pain will alert the anesthesiologist that the subarachnoid space has been entered, and that the needle is encountering the spinal cord. The dura mater is usually punctured without producing sensation, as anesthesiologists frequently observe. The presence of CSF is generally the sign that alerts the anesthesiologist that the subarachnoid space has been entered, not sensation or paresthesia on the part of the patient. As is the case in the epidural space, subarachnoid spinal nerve roots would be expected to move away from an advancing needle unless tethered by scar formation, arachnoiditis, etc. Furthermore, the spinal cord is enveloped in the pia mater, which does not contain sensory nerve endings, nor are there sensory neurons within the spinal cord itself that would warn the anesthesiologist that intramedullary needle placement had occurred before the injection of air or local anesthetic was attempted. Evidence for this comes from neurosurgeons inducing spinal cord lesions or tractotomies for management of chronic pain, who report that no pain is induced in the awake patient when the advancing needle is inserted into the spinal cord, and that pain does not occur until a lesion is created by radiofrequency energy or freezing (Coffey 1992).

According to some, the standard of care dictates that all epidurals above the termination of the spinal cord are to be placed in awake patients. The standard of care in medicine is ultimately determined by the common practice of physicians, and safe, common sense. The readers of this should know that it has been an accepted practice and therefore the standard of care for many years amongst pediatric anesthesiologists to place caudal, lumbar and thoracic epidural catheters in anesthetized children, and this standard of care and the collective published and unpublished experience of our subspecialty withstands the rare singular report of a complication in an adult. While this controversy will continue to be debated by proponents of pediatric regional anesthesia and those who believe that regional nerve blocks must be performed on awake subjects, the considerable experience in pediatric anesthesia is that this practice is safe and beneficial to the patient (Krane et al. 1998).

The effect of halogenated inhalation agents on the development of tachycardia following intravascular injection of an epinephrine containing test dose is also controversial. Desparmet et al. (Desparmet et al. 1990) found that many false negative test doses occurred with children breathing 1 MAC halothane, while pretreatment with atropine improved the accuracy of the test dose but did not eliminate false negatives. Recently the effect on the accuracy of test dosing with epinephrine of inhalation of sevoflurane was studied. Tanaka, et al. (Tanaka and Nishikawa 1998) found that 1.0 MAC of sevoflurane in 60% N2O did not reduce the ability to recognize an intravenous injection of lidocaine with epinephrine; the sensitivity of a threshold of 20 bpm increase in heart rate was 100%. The effects of isoflurane and desflurane are similar, (Tanaka et al. 1995; Tanaka et al. 1995) but the effects of intravenous anesthetics are untested. It seems prudent based upon Desparmet's and Tanaka's work to administer 10µg/kg of atropine prior to the test dose if children are anesthetized with halothane, and also to fractionate the total local anesthetic dose and to administer it over 2-3 minutes for all children administered local anesthetics while anesthetized with general anesthetics. Atropine may not be necessary during sevoflurane inhalation, but will improve the sensitivity of detecting an intravascular injection. The use of other markers of an intravascular injection, such as isoprotrotenol, has been tested, but probably holds no value over epinephrine. (Desparmet et al. 1991; Tanaka 1996; Tanaka 1997; Tanaka and Nishikawa 1998)
Unlike some other experts in this field, I do not advocate abandoning the test dose because the majority of times it will indeed detect inadvertent intravascular injection even in the anesthetized child.

**General Principles**

Any and all blocks may be performed in children with the appropriate indication. The following describes the salient differences in performing blocks between children and adults–

- The targets are smaller and closer to other neurovascular structures. The caudal extent of the spinal cord and dural sac extend 2–3 interspaces lower in the infant than child/adult. The iliac crests are at the level of L4 spinous process.
- Neuraxial blocks rarely produce hypotension children <10 yrs, therefore crystalloid volume loading should not be performed.
- Peripheral nerve blocks provide longer lasting analgesia than central nerve blocks, and are associated with a lower rate of complications.
- The maximum dose of amide local anesthetics is somewhat higher, but the block duration is somewhat shorter than in adults.
- However in infants <2 mo, the maximum amide i.a. dose should be reduced by 50% to compensate for decreased serum protein binding by plasma alpha-1-glycoprotein.
- Test doses are as important in children as adults, but the presence of general anesthesia decreases their sensitivity. For example, during halothane administration IV epinephrine may increase blood pressure and reduce heart rate, rather than produce a tachycardia during a test dose. Prior administration of atropine 0.01 mg/kg increases the reliability of test doses during halothane anesthesia. During inhalation of sevoflurane, however, the sensitivity of test dosing with 0.01 mg/kg of epinephrine is 100% using a 10 beat per minute increase in heart rate as the definition of a positive test dose. Atropine is not needed to achieve this sensitivity. There are no data regarding test dosing during enflurane, or desflurane inhalation.
- The total dose should be administered in fractions over a few minutes in case a false negative test dose has occurred.
- Blocks usually require a GA or deep sedation.
- Extremity blocks require up to 30 minutes to become established; perform the block ASAP after induction to allow time for the block to set up.
- Peripheral nerve blocks are amenable to catheter techniques to assure long lasting postoperative analgesia. An infusion of 0.25% bupivacaine or levo-bupivacaine, or 0.2% ropivacaine, at 0.1 ml/kg/hr is an appropriate rate.

**Using a Nerve Stimulator:**

- Not all nerve stimulator are appropriate for needle use. The drug company give-aways are USUALLY NOT. Only nerve stimulators with digital amperage readout capable of delivering 0.2–2mA of current are safe to use.
- It is not necessary to use insulated needles, but it is better to use them if they are available.
- The negative (anode) terminal from the stimulator is attached to the needle (remember: “N to N”).
- The positive terminal is attached to an ECG patch near the block site.
- The needle is positioned near the nerve while an assistant observes for muscle contractions in the distal extremity. You are close enough to the nerve when:
- Contractions are recognized with <0.7mA current, or when injection of 1cc of local anesthetic ablates the contraction.
Table 2. Common Surgical Procedures and Appropriate Regional Nerve Blocks

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Appropriate Block</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORIF elbow</strong></td>
<td>Brachial plexus</td>
<td>Provides needed vasodilatation when there is vascular compromise from the fracture. Makes postoperative evaluation of neurological function and integrity of ulnar/median nerves impossible.</td>
</tr>
<tr>
<td><strong>Syndactyly repair</strong></td>
<td>Brachial plexus</td>
<td>Axillary approach provides more successful distal block</td>
</tr>
<tr>
<td><strong>Pectus repair; Anterior Spine Fusion</strong></td>
<td>Thoracic epidural</td>
<td>The thoracic epidural space may be cannulated directly or by threading a caudal catheter proximally.</td>
</tr>
<tr>
<td><strong>Thoracotomy; Correction of coarctation or PDA</strong></td>
<td>Thoracic epidural Paravertebral block</td>
<td>The lumbar epidural space may be cannulated directly or by threading a caudal catheter proximally.</td>
</tr>
<tr>
<td><strong>Abdominal surgery</strong></td>
<td>Lumbar epidural</td>
<td>The lumbar epidural space may be cannulated directly or by threading a caudal catheter proximally.</td>
</tr>
<tr>
<td><strong>Gastrostomy</strong></td>
<td>Rectus sheath block Paravertebral block</td>
<td>Shortest duration postoperative analgesia after caudal block; ilioinguinal block may distort surgical tissues in infants and smaller children</td>
</tr>
<tr>
<td><strong>Appendectomy</strong></td>
<td>Rectus sheath block Paravertebral block</td>
<td>Shortest duration postoperative analgesia after caudal block; ilioinguinal block may distort surgical tissues in infants and smaller children</td>
</tr>
<tr>
<td><strong>Herniorrhaphy, hydrocelectomy, orchiopexy</strong></td>
<td>Caudal block Paravertebral block Rectus sheath block Ilioinguinal block</td>
<td>Shortest duration postoperative analgesia after caudal block; ilioinguinal block may distort surgical tissues in infants and smaller children</td>
</tr>
<tr>
<td><strong>Hip arthroplasty/osteotomy</strong></td>
<td>Lumbar epidural</td>
<td>Shortest duration postoperative analgesia after caudal block; ilioinguinal block may distort surgical tissues in infants and smaller children</td>
</tr>
<tr>
<td><strong>Femoral osteotomy; femoral fracture repair</strong></td>
<td>Lumbar epidural Paravertebral block Femoral nerve block Fascia iliaca block</td>
<td>Shortest duration postoperative analgesia after caudal block; ilioinguinal block may distort surgical tissues in infants and smaller children</td>
</tr>
<tr>
<td><strong>Arthroscopic knee surgery</strong></td>
<td>Fascia iliaca block</td>
<td>Compartment syndrome is a significant risk after tibial fractures or surgery; complete anesthesia of the foreleg will obscure pain as a symptom of a compartment syndrome, and necessitates frequent and excellent nursing observation to assure circulation to the foot distal to the cast.</td>
</tr>
<tr>
<td><strong>Tibial osteotomy</strong></td>
<td>Lumbar epidural Caudal block Sciatic+femoral block Popliteal+saphenous block</td>
<td>Shortest duration postoperative analgesia after caudal block; ilioinguinal block may distort surgical tissues in infants and smaller children</td>
</tr>
<tr>
<td><strong>Ankle arthroplasty Club foot repair</strong></td>
<td>Caudal block Sciatic+femoral block Popliteal+saphenous block</td>
<td>Compartment syndrome is a significant risk after tibial fractures or surgery; complete anesthesia of the foreleg will obscure pain as a symptom of a compartment syndrome, and necessitates frequent and excellent nursing observation to assure circulation to the foot distal to the cast.</td>
</tr>
</tbody>
</table>
COMMON BLOCKS PERFORMED IN CHILDREN

NEURAXIAL BLOCKS

Caudal Block:

A. Indications: Surgery below diaphragm
B. Contraindications:
   1. Sacral deformities
   2. Perianal surgery
   3. Same day surgery in patients >6 years, 30kg, etc.
   4. Bacteremia
C. Equipment:
   1. Single shot: Appropriate needle
      a. 23G butterfly (orange)
      b. 20-22G angiocath
   2. Catheter:
      a. 20G epidural catheter
      b. 18G angiocath
      c. Sterile towels
D. Technique: With patient in decubitus or semi prone position with knees drawn toward chest, palpate the posterior superior iliac spines, and visualize an equilateral triangle with the posterior superior iliac spines as the upper two corners.

Figure 1. Surface landmarks for the caudal block.
Figure 2. The boney structures underlying the surface landmarks of the caudal block.

The lower apex of the triangle identifies the sacral ligament between the sacral cornua. The most common mistake is to insert the needle too caudad, in the region of the coccyx; the space is usually more cephalad than you think. Note at the right how the correct entry point is well above the intergluteal folds. Insert the needle at 45° to the skin in the midline. A distance "give" or "pop" will be felt as the needle passes the sacral ligament into the caudal space.

Figure 3. Threading a caudal catheter.

Advance only 1–2mm further and then either pass the catheter or inject the drug after an appropriate test dose. A catheter may be passed into the thoracic epidural space in small children, if the catheter meets no resistance whatsoever during insertion. The following is a video of this technique.
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E. Drug Selection/Dose:
1. T10 level: Bupivacaine 0.25%, ± epinephrine, 0.25 cc/kg
   L-bupivacaine 0.25%, ± epinephrine, 0.25 cc/kg
   Ropivacaine 0.2%, 0.25 cc/kg
   Lidocaine, 0.25cc/kg
2. T6 level: as above, 1–1.2 cc/kg
3. Maximum dose: Bupivacaine 3 mg/kg, Lidocaine 10 mg/kg
4. Analgesics: See Epidural (Lumbar and Thoracic) below.

Epidural (Lumbar and Thoracic)

A. Indications: Surgery below clavicles.
B. Contraindications: Spine deformity, bacteremia; inexperience of the anesthesiologist
C. Equipment: Pediatric epidural tray–
   1. 18G 5cm Tuohy needle.
   2. 20G epidural catheter
D. Technique:

Position patient in lateral decubitus position with knees to chest. Sterile prep and drape. Tuohy needle with glass syringe containing 3cc N.S. is inserted in interspace.

The lumbar space is usually encountered at 2.2–2.5 cm, accurately predicted by the formula:

\[
\text{EpiduralSpaceDepth(\text{mm})} \approx \text{18} + \text{1.5} \times \text{age(yrs)}
\]

The depth of the thoracic space cannot be easily predicted because it depends upon the approach (paramedian vs. midline) and the needle's angle of entry. Generally in the midline with an entry angle of about 45 degrees, it will be 0.5-1 cm shallower than the equation above predicts for the lumbar space.

Be aware the softer more elastic tissues of the back may give you a false LOR before the ligamentum flavum is pierced, and the more saline you inject into the soft tissues of the back the harder it is to do the block. After the space is identified the catheter is passed an appropriate length.

E. Drug Selection/Dose:
1. Lumbar: Bupivacaine 0.25%, ± epinephrine, 0.5 cc/kg
   L-bupivacaine 0.25%, ± epinephrine, 0.5 cc/kg
   Ropivacaine 0.2%, 0.5 cc/kg
   Lidocaine, 0.5cc/kg
2. Thoracic: same solutions, 0.3 cc/kg
3. Maximum dose: Bupivacaine 3 mg/kg, Lidocaine 10 mg/kg
4. Analgesics:
   a. Preservative free morphine: 30-50 µg/kg
   b. Hydromorphone 5-10 µg/kg
   c. Fentanyl 0.25-0.5 µg/kg
   d. Clonidine 0.5-1 µg/kg
   e. Ketamine 0.3 mg/kg
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**Paravertebral Block:**

A. **Indications:** To provide unilateral local anesthesia following trauma or surgery of the chest, flank, or abdomen, between the C6 and L1 dermatomes..

B. **Contraindications:** Spine deformity (relative contraindication), bacteremia (for placement of a catheter), etc.

C. **Equipment:** 2.5 - 5.0 cm block or Tuohy needle. Epidural catheter if desired.

D. **Technique:** With the patient in the lateral decubitus position, with the block side uppermost, the spinous processes of the desired dermatomal levels are marked with a skin marker. Needle insertion is performed 1.5cm (for infants) - 2.5cm (for adolescents) lateral to the midline of the spinous process, level with the superior aspect of the spinous process. The needle is advanced until the transverse process is encountered, then it is withdrawn to the skin. It is then reinserted in a cephalad direction so that it walks off the transverse process superiorly. As the paravertebral space is entered, there is usually a loss of resistance to needle advancement, and at that point saline or local anesthetic may be injected without resistance. If resistance to injection is encountered, the needle tip lies within a ligament and must be advanced another 2-3mm.

Local anesthetic, 2-4ml, is injected at each spinal level. If a continuous catheter technique is employed, the same technique above is used, inserting the Tuohy needle at the center of the dermatomes that should be anesthetized, and injecting a total of 0.25-0.5ml/kg at one site. A continuous infusion of 0.1ml/kg/hr may then be delivered through the catheter.

E. **Drug Selection:**
   - Rapid onset + long duration: Mixture of 2% lidocaine + 0.5% bupivacaine/levobupivacaine
   - Continuous infusion: 1% lidocaine or 0.25% bupivacaine/levobupivacaine

F. **Complications:**
   - Pneumothorax (excessive needle advancement)
   - Epidural anesthesia
   - Subarachnoid block

**Subarachnoid (spinal) Block:**

A. **Indications:** Generally only performed in ex-preemies undergoing herniorrhaphy, circumcision, etc., in whom general anesthesia and/or sedatives are to be avoided, and yet muscle relaxation is needed.

B. **Contraindications:** Spine deformity, bacteremia, etc.
Figure 4. With the patient held in the lateral decubitus position, or sitting bent over, the appropriate interspace is selected (L4/5 or L3/4). Note at right how the neck is not held in flexion so that airway occlusion does not occur.

C. Equipment: Pedi spinal tray with 3cm 26G needle.

D. Technique: A local skin wheal with bicarbonated lidocaine is injected. After the infant settles down, the spinal needle is slowly advanced in the interspace until CSF returns freely.

While one might not expect CSF to flow freely from a 25G needle, the

Figure 5. 25G spinal needle showing free flow of CSF.
the short length of the needle allows this to happen (Figure 5).

The desired dose is quickly injected and the needle is withdrawn. Do not allow the scrub nurse to elevate the feet to place the grounding pad on the back. After performing the block, place an IV in the foot, measure blood pressures in the leg.

Restrain the limbs with soft restraints. Give the infant a pacifier dipped in sugar water from the coffee lounge.

E. Drug Selection/Dose: Tetracaine with epi, 0.5–1 mg/kg.
Mix crystalline tetracaine with sterile water to a concentration of 1%, then dilute with an equal volume of D10W to a concentration of 0.5% (5mg/cc). The dose to be administered will need to be drawn up in a TB syringe. When injecting, administer an extra 0.1–0.2cc to compensate for needle dead space.

**UPPER EXTREMITY BLOCKS**

**Brachial Plexus Blocks:**

We see many patients having hand surgery for repair of congenital deformities, finger reimplantation, burn treatment, etc. Blocks of the upper extremity provide excellent postoperative analgesia, protect delicate repairs from patient movement, and in the case of vascular repairs, reduce arterial spasm.

**Axillary Approach (At level of trunks; blocks C5–T1)**

A. Indications: Surgery on the hand and arm.
B. Contraindications: Generally, injuries or surgery that carry a significant risk of neurovascular injury and neuropraxia should not be managed with nerve blocks in order to facilitate a complete peripheral nerve examination by the surgeon following surgery. In that way, a discovered nerve injury may be returned to the operating room for early repair. Typical examples of this in pediatrics are supracondylar and condylar fractures of the elbow, which are often associated with ulnar nerve injuries.
C. Equipment: A nerve stimulator capable of delivering currents <1 mA may be used. Butterfly needles (23G-orange and 25G-red) are suitable block needles, or a 1.5” 25G spinal needle or (insulated) beaded block needle with a T-piece attached. 20cc syringe. Sterile towels.

D. Technique: There are two techniques that work best in my experience. Without a nerve stimulator: Pin the axillary artery against the humerus with your nondominant hand; the needle is inserted through a skin wheal over the axillary artery, directing the needle tip just inferiorly to the axillary pulse (inferior trunk® ulnar nerve). When the sheath is entered (slight “give” on the needle) half of the dose is injected. The needle is then withdrawn to just under the skin and is redirected just superior to the pulse, and the remainder of the dose is injected (superior trunk® median/musculocutaneous nerves). In the second technique, the nerve bundles are identified by nerve stimultor, and 1/2 of the dose is injected at each nerve. When the output of the stimulator is ~0.5–0.7mA the needle tip is near enough to reliably anesthetize the target. If in either technique the artery is accidentally punctured, continue to advance the needle through the artery while continuously aspirating. When blood can no longer be withdrawn, inject half the dose. Then withdraw the needle while aspirating, and again when aspiration is negative above the artery, inject the remaining dose. Maintain pressure on the artery for 2 minutes to prevent hematoma formation.

To ablate all tourniquet pain you must also anesthetize the intercostobrachial nerve which runs subcutaneously in the axilla. Reserve 3-5cc of l.a. solution used for your block, and inject it subcut. 2-5cm caudally from your previous needle entry site over the axillary pulse.

E. Drug Selection/Dose:
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For long duration:
Bupivacaine 0.25%, ± epinephrine, 0.25 - 0.5cc/kg
L-bupivacaine 0.25%, ± epinephrine, 0.25 - 0.5cc/kg
Ropivacaine 0.2%

For fast onset and medium duration:
Lidocaine 2% + crystalline tetracaine 5mg/10cc lidocaine ± epinephrine, 0.25 - 0.5cc/kg.

Interscalene Approach (At level of roots; blocks C4–T1, especially C4–C7)

A. Indications: Surgery on the shoulder and upper extremity.
B. Contraindications: See axillary approach.
C. Equipment: See axillary approach. A nerve stimulator must be used.
D. Technique: Turn head slightly to the opposite side, with the neck in slight extension. Identify landmarks: cricoid cartilage, lateral border of SCM muscle, groove between scalene muscles just posterior to the SCM border.
E. Insert needle over interscalene groove at level of cricoid (C6), keeping needle perpendicular to skin at all planes. If bone is encountered redirect laterally. When hand contraction is seen with 0.5–0.6mA of stimulating current, confirm negative aspiration and inject a test dose, then the remainder of the dose. Injection at too shallow a depth will produce a Horner's syndrome and phrenic nerve anesthesia. Needle entry too cephalad in direction can enter intervertebral foramen and produce spinal block, hypotension, etc.
F. Phrenic nerve block, recurrent laryngeal nerve block, and/or Horner's syndrome are common.
G. Drug Selection/Dose: See axillary approach.

Dalens Method (At level of roots; blocks C4–T1, especially C4–C7)

A. Indications: Surgery on the shoulder and upper extremity.
B. Contraindications: See axillary approach.
C. Equipment: See axillary approach. A nerve stimulator must be used.
D. Technique: Turn head slightly to the opposite side, with a rolled towel under the shoulders. Identify landmarks: cricoid cartilage, lateral border of SCM muscle, Chassagnac's tubercle (at level of cricoid at lateral border of SCM).
E. Draw line from midclavicle to Chassagnac's tubercle. Trisect the line.
F. Insert needle at junction of lower and middle third of line, with needle perpendicular to the bed directed due posteriorly, using a nerve stimulator to identify the roots of the brachial plexus.
G. Phrenic nerve block, recurrent laryngeal nerve block, and/or Horner's syndrome are common.

Supraventricular Approach:

Usually not used in children because of the higher rise of the cupola of the lung and the greater subsequent risk of pneumothorax.
LOWER EXTREMITY BLOCKS:

The major advantages of selective lower extremity blocks over lumbar or caudal epidural blocks are their increased duration of effect (10–12hr vs. 2-4hr), and the fact that patients will still be able to weight bear on at least one leg after the block, which facilitates their transfer in and out of bed, in and out of the family car, etc. Therefore, these blocks may be safely performed on outpatients, while neuraxial blocks should probably not be performed on outpatients who are not babes in arms, and whom the parents cannot easily carry in and out of the car, home, etc. Furthermore, many children over 5 or 6 years of age are distressed by the numbness and paralysis following neuraxial blocks in spite of best efforts to prepare them for this sensation preoperatively.

Femoral Nerve Block (L2–L4):

A. Indications: Anterior branch: surgery of anterior-lateral thigh, femur fractures, quadriceps muscle biopsy, etc; posterior branch gives rise to saphenous nerve: surgery on the medial part of lower leg, and medial aspect of ankle. Note the medial knee is innervated by the obturator nerve.

B. Contraindications: Local adenopathy or skin sepsis.

C. Equipment: A nerve stimulator capable of delivering currents <1 mA may be used. Butterfly needles (23G-orange and 25G-red) are suitable block needles, or a 2.5” 25G spinal needle or (insulated) beaded block needle with a T-piece attached. 20cc syringe. Sterile towels.

D. Technique: The femoral arterial pulse is identified below the inguinal ligament, and the needle is inserted just lateral to the pulse. If a nerve stimulator is used, the needle is positioned to obtain quadriceps contractures at ~0.5–0.6mA. If not, the needle should be close enough to the artery to pulsate when disconnected from a syringe. 75% of the dose is injected at the approximate depth of the arterial pulse and while moving the needle from that point to the subcutaneous tissues. One-fourth of the dose is reserved for a subcutaneous fan injection from a point 1cm medial and inferior from the anterior superior iliac spine in order to anesthetize the lateral femoral cutaneous nerve.

E. Drug Selection/Dose:
   1. For long duration:
      - Bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
      - L-bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
      - Ropivacaine 0.2%
   2. For fast onset and medium duration:
      - Lidocaine 2% + crystalline tetracaine 5mg/10cc lidocaine ± epinephrine, 0.5cc/kg.

Fascia Iliaca Block (An alternative to a femoral nerve block; L2–L4):

A. Indications: See femoral nerve block. This block anesthetizes the obturator nerve, lateral femoral cutaneous nerve, and femoral nerve with one single injection (see Anesth Analg 1989;69:705-13 for original description of this block).

B. Contraindications: Local adenopathy or skin sepsis.

C. Equipment: 2.5” 25G spinal needle or block needle with a T-piece attached. 20cc syringe. Sterile towels.

D. Technique: The inguinal ligament is mentally trisected in its length from the pubis to the anterior superior iliac spine, and the needle is inserted
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To place the needle for the femoral nerve block, insert the needle 0.5–1cm below the juncture of the middle and lateral thirds of the ligament, directing the needle 90° to the skin. A fascial plane will be punctured and a loss of resistance to injection will occur as the needle crosses the fascia latta, then the needle is further advanced until a second LOR occurs as the fascia iliaca is pierced; then, while exerting pressure just caudal to the needle site, the dose is injected. The needle is withdrawn, and the groin "massaged" to encourage further proximal spread of l.a

![Femoral Art Fascia Iliaca Injection](image)

**Figure 7.** Surface anatomy of the groin of a child, with the landmarks for the fascia iliaca block illustrated.

E. Drug Selection/Dose:
1. For long duration:
   - Bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
   - L-bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
   - Ropivacaine 0.2%
2. For fast onset and medium duration:
   - Lidocaine 2% + crystalline tetracaine 5mg/10cc + epinephrine, 0.7cc/kg
3. 1:1 mixture of 0.5% bupivacaine+1% lidocaine, 0.7 cc/kg
4. If combined with a sciatic block, keep total bupivacaine dose to <3.2mg/kg by using 1/4–3/8% bupivacaine for each block

**Sciatic Nerve Block (L4–S3):**

A. Indications: Surgery of lateral side of lower leg, tibia/fibula, lateral aspect of ankle, and entire foot. In addition to the territory covered by the popliteal fossa block, a conventional sciatic nerve block anesthetizes the posterior aspect of the thigh.
B. Contraindications: Local skin sepsis.
C. Equipment: A nerve stimulator capable of delivering currents <1 mA should be used. 3.5" 25G spinal needle or insulated block needle with a T-piece attached. 20cc syringe. Sterile towels.
D. Technique: The patient is placed in the lateral decubitus position with the operative extremity on top, leg slightly flexed at hip and knee. A line is drawn from the posterior superior iliac spine (PSIS) to the greater...
trochanter of the femur; flex the hip so the axis of the femur lines up with this line. From the midpoint of this line draw a second perpendicular line caudally 3 cm in length. Insert the block needle at the end of the second line perpendicular to the skin until it contacts bone (ischial spine), then walk the needle off the bone toward the PSIS. Position the needle tip to achieve maximum contraction of a muscle while stimulating with 0.5–0.6mA. The anticipated depth of the sciatic nerve may be predicted from the following formula in children of average weight (compensate for the overweight or slight child appropriately):

**E. Drug Selection/Dose:**

a. **For long duration:**
   - Bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
   - L-bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
   - Ropivacaine 0.2%

b. **For fast onset and medium duration:**
   - Lidocaine 2% + crystalline tetracaine 5mg/10cc lidocaine ± epinephrine, 0.5cc/kg.

c. **If combined with a femoral block/fascia iliaca block, keep total bupivacaine dose to <3.2mg/kg by using 3/8% bupivacaine for each block.**

**Popliteal Nerve Block (Sciatic Nerve behind the knee, L4–S3):**

A. **Indications:** Surgery of lateral side of lower leg, tibia/fibula, lateral aspect of ankle, and entire foot.

B. **Contraindications:** Local skin sepsis.

C. **Equipment:** A nerve stimulator capable of delivering currents <1 mA may be used. 2.5” 25G spinal needle or (insulated) beaded block needle with a T-piece attached. 20cc syringe. Sterile towels.

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**Figure 8.** The popliteal fossa block anatomy. The popliteal nerve runs slightly lateral to the middle of the triangle defined by the popliteal crease and the two edges of the biceps femoris muscles (hamstrings).
D. Technique: With the patient in the decubitus or prone position, and the knee straight, the bifurcation of the biceps femoris muscle, the "hamstrings" is identified. This forms the apex of the popliteal fossa. The arterial pulse is identified, if possible, in the fossa. The popliteal nerve lies in a fat filled space lateral to the arterial pulsation. The local anesthetic may be blindly injected lateral to the pulse, or a nerve stimulator may be used to identify the nerve more accurately. Either way the block will be effective, because there are no septations or sheaths in the space.

E. Drug Selection/Dose:
1. For long duration:
   - Bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
   - L-bupivacaine 0.25%, ± epinephrine, 0.5cc/kg
   - Ropivacaine 0.2%
2. For fast onset and medium duration:
   - Lidocaine 2% + crystalline tetracaine 5mg/10cc lidocaine ± epinephrine, 0.5cc/kg.
3. If combined with a sciatic block, keep total bupivacaine dose to <3.2mg/kg by using 3/8% bupivacaine for each block.

Saphenous Nerve Block:

A. Indications: Surgery of the medial calf or medial ankle.
B. Contraindications: local skin sepsis.
C. Equipment: syringe and needle.
D. The saphenous nerve is a branch of the femoral nerve, and is a pure sensory nerve, therefore a nerve stimulator is not used. It ennervates the medial calf and medial ankle.
E. The saphenous nerve lies under the sartorius muscle, which runs from the anterior superior crest of the ilium to the medial condyle of the femur.
F. It may be blocked in 3 ways:
   1. At the level of the medial condyle, enter the sartorius muscle using a local anesthetic filled syringe and a 23 gauge needle, pushing gently on the plunger of the syringe. After the needle exits the muscle, there will be a subtle loss of resistance to injection. The anesthetic is then deposited in this space after negative aspiration.
   2. Draw a line from the tibial tubercle to medially to the medial calf. Inject a band of subcutaneous local anesthetic underneath this line.
   3. At the medial border of the sartorius muscle, half-way along its length, a nerve stimulator needle is introduced in a posterior direction. Here the nerve runs with the vastus medialis nerve that ennervates the quadriceps muscle. When muscle twitches are seen with a stimulating current of <0.5 mA, inject the local anesthetic.
   4. Technique #1 has the greatest success rate.
G. Drug Selection/Dose:
   1. For long duration:
      - Bupivacaine 0.25%, ± epinephrine, 0.25cc/kg
      - L-bupivacaine 0.25%, ± epinephrine, 0.25cc/kg
      - Ropivacaine 0.2%, 0.25cc/kg
   2. For fast onset and medium duration:
      - Lidocaine 2% + crystalline tetracaine 5mg/10cc lidocaine ± epinephrine, 0.25cc/kg.
3. If combined with a sciatic block, keep total bupivacaine dose to <3.2mg/kg by using 3/8% bupivacaine for each block.

**PERIPHERAL NERVE BLOCKS OF THE TRUNK:**

**Ilio-Inguinal/Ilio-Hypogastric Nerve Block:**

A. Indications: Inguinal herniorrhaphy, hyrdocelectomy, orchidopexy. They do not provide anesthesia of the peritoneum, therefore a deep anesthetic plane is required until peritoneal manipulation by the surgeon is complete and wound closure has begun.

B. Contraindications:
   1. Local skin sepsis
   2. Should not be used preoperatively in small infants (e.g. <6 months) preoperatively because of distortion of nearby surgical tissues.

C. Equipment:
   1. Single shot: Appropriate needle
      a. 25G butterfly (red)
      b. 25-27G needle

D. Technique:
   1. Identify the anterior superior iliac prominence
   2. Insert a 23 - 27G needle 1cm medial to the prominence, aiming toward the wing of the ilium at a 45° angle.
   3. 2 very subtle "pops" will be felt as the aponeuroses of the external and internal oblique muscles is punctured. Inject after the second pop.
   4. If these are not appreciated, contact the ilium with the needle, withdraw 2mm, and inject.
   5. Remove the needle, and reinsert in the same site, injecting a "fan" subcutaneously in a 45° arc directed toward the inguinal ligamen.

E. Drug Selection/Dose:
   1. Bupivacaine 0.25%, ± epinephrine, 2-5 cc
   2. L-bupivacaine 0.25%, ± epinephrine
   3. Ropivacaine 0.2%

**Rectus Sheath Nerve Block**

A. Indications: Inguinal herniorrhaphy, hyrdocelectomy, orchidopexy. Bilateral for ventral herniorrhaphy and umbilical herniorrhaphy. This does not provide anesthesia of the peritoneum, therefore a deep anesthetic plane is required until peritoneal manipulation by the surgeon is complete and wound closure has begun.

B. Contraindications: Local skin sepsis

C. Equipment:
   1. Single shot: Appropriate needle
      a. 25G butterfly (red)
      b. 25-27G needle

D. Technique:
   1. Identify the lateral margin of the rectus sheath.
   2. Insert a 23 - 27G needle 1cm at the level of the umbilicus at a 45° angle toward the midline, using loss of resistance technique to identify when the needle has penetrated the rectus sheath.
3. A very subtle “pop” will be felt. Inject the local anesthetic after negative aspiration.

E. Drug Selection/Dose:
   1. Bupivacaine 0.25%, 2-5 cc
   2. L-bupivacaine 0.25%,
   3. Ropicacaine 0.2%
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References


