REGIONAL ANESTHESIA FOR THE PEDIATRIC OUTPATIENT

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I. What is The Rationale for Using Regional Anesthesia?

Regional anesthesia adds to the complexity and anesthesia time in anesthetizing children, and also requires more time obtaining informed consent from the parents. Is this investment in time and effort worth the trouble in a busy ambulatory setting? Yes: the time investment up front is made up on the back end in several ways, including more rapid and smoother emergence from anesthesia and therefore quicker egress from the operating room, faster recovery times and discharge home from the hospital or surgery center, and greater personal and patient/parent satisfaction:

A. REDUCED GENERAL ANESTHESIA REQUIREMENT: For many regional blocks the dose and depth of general anesthetic agents may be significantly reduced. This in turn yields several advantages, including (1) a less frequent need for instrumentation of the airway with attendant cost savings for endotracheal tubes and the labor of cleaning laryngoscopes, (2) faster wake-up times in the operating room awaiting extubation, and later in the recovery room awaiting street readiness, (3) smoother pain-free emergence, (3) and potentially diminished risk associated with deeper planes of general anesthesia.

B. OPTIMAL POSTOPERATIVE ANALGESIA: There is, of course, no more effective manner in producing a pain-free state than by eliminating nociception with local anesthetic nerve blocks. This in turn reduces the requirement for parenteral opiates with attendant opiate related side effects, most especially a reduction in nausea and vomiting. There is an enormous sense of personal satisfaction in delivering an awake and comfortable child to the recovery room, and the recovery room environment becomes quiet and peaceful without the thrashing and screaming of a child who emerges from general anesthesia with inadequately treated pain. The parents of a pain-free child are generally more satisfied with their hospital experience, and the child's emotional trauma is reduced.

II. What are the Requirements for Regional Anesthesia in Children?

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.

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

B. 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.

C. 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.

D. EQUIPMENT. 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.

E. FLEXIBLE PACU POLICIES AND PROCEDURES. Many PACU 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 requirement for voiding prior to discharge home. We also routinely discharge children with residual motor and sensory blockade home 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.

III. What are the Differences between Children and Adults?

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

A. 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.

B. 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
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.

C. 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. This means that on an 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 2pg/kg, which is well below the toxic plasma level.

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. 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.

D. PSYCHOLOGY. It is self evident that rarely will children allow the performance of a regional block without deep sedation or general anesthesia. This creates two problems: (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, 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).

The effect of halogenated inhalation agents on the development of tachycardia following intravascular injection of an epinephrine containing test dose is controversial. Desparmet et al. 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. The effects of isoflurane and desflurane are unstudied, as are the effects of intravenous anesthetics. It seems prudent based upon Desparmel's work to administer 10pg/kg of atropine prior to the test dose if children are anesthetized with halothane, but 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. 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.

### Table 1  Anesthetic Solutions and Doses

<table>
<thead>
<tr>
<th>Block</th>
<th>1% Lidocaine + 0.1% Tetracaine</th>
<th>0.25% Bupivacaine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachial Plexus</td>
<td>0.5 cc/kg</td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Femoral</td>
<td>0.5 cc/kg</td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Sciatic</td>
<td>0.5 cc/kg</td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Lumbar Epid</td>
<td>0.5 cc/kg</td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Caudal (T10)</td>
<td></td>
<td>0.5 cc/kg</td>
</tr>
<tr>
<td>Caudal (T6)</td>
<td></td>
<td>1.0 cc/kg</td>
</tr>
<tr>
<td>Penile Block</td>
<td>2 cc</td>
<td></td>
</tr>
<tr>
<td>Ilioinguinal</td>
<td>5 cc</td>
<td></td>
</tr>
</tbody>
</table>

I. What are the Most Useful Blocks for Ambulatory Surgery?

A. UPPER EXTREMITY BLOCKS:

Axillary Block

**Indications:** Surgery on arm and hand.

**Contraindications:** Supracondylar fractures, epicondylar fractures, or other fractures associated with ulnar nerve injuries, because of the need for peripheral nerve examination by the orthopedist in the postop period; local skin sepsis or rash.

**Drugs/Doses:** See Table 1. For a rapid onset and long duration block, 10mg of tetracaine crystals may be dissolved in each 10ml 1% lidocaine. If rapid onset is not needed then 0.25% bupivacaine will provide 6-12hr of anesthesia.

**Technique:** The brachial plexus is very superficial in children, in fact it's virtually subcutaneous. The brachial pulse can be easily palpated in the axilla. A 25G butterfly needle or 23G block needle is inserted adjacent to the brachial pulse and half the anesthetic dose is injected. The needle is then withdrawn to the skin and readvanced to the other side of the pulse, and the remainder of the anesthetic is injected. Often a distinct pop is felt as the sheath is entered the second time, having been distended by the first injection. If the artery is accidentally punctured, proceed through it and inject half the anesthetic dose behind the axillary artery.
B. LOWER EXTREMITY BLOCKS:

Femoral Block

Indications: Muscle biopsy, femoral osteotomy, femoral fracture, etc. Contraindications: Local skin sepsis or rash.

Drugs/Doses: See Table 1. For a rapid onset and long duration block, 10mg of tetracaine crystals may be dissolved in 1% lidocaine. If rapid onset is not needed then 0.25% bupivacaine will provide 6-12hr of anesthesia.

Technique: The femoral pulse is palpated. Using a 25 or 23G needle, the anesthetic dose is injected laterally adjacent to the pulse. A nerve stimulator will aid in approximating the needle next to the nerve but is not required. Dalens described an alternative technique termed the fascia iliaca block, in which the needle is introduced 1cm below the junction of the middle and lateral third of the inguinal ligament, and is advanced until a 'pop' is perceived as the fascia iliaca is pierced. This will also anesthetize in the obturator distribution.

Popliteal Block of the Sciatic Nerve

Indications: Surgery on the foreleg, ankle, and foot. The web-space between the first and second toes is supplied the deep peroneal nerve, a branch of the femoral nerve. If surgery will involve this web-space a supplemental injection of the deep peroneal nerve at the ankle is required.

Contraindications: Tibial fractures, tibial osteotomies, because of the subsequent inability to recognize the pain associated with a compartment syndrome; local skin sepsis or rash. Drugs/Doses: See Table 1

Technique: With the patient in the prone or lateral position, the knee is extended and the popliteal pulse is palpated high in the popliteal fossa at the bifurcation of the biceps femoris muscle (hamstrings). A needle is introduced into the fatty popliteal fossa lateral to the aneural pulse, and the local anesthetic dose is injected. A nerve stimulator will aid in accurate needle placement, but as there are not nerve sheaths in this space, precision is not required; as long as the anesthetic is deposited in an adequate volume in the space, the nerve will be anesthetized.

C. Ilioinguinal/Iliohypogastric Nerve Block:

Indications: Inguinal herniorrhaphy, orchiopexy.

Contraindications: Best avoided in children <15kg because the anesthetic infiltrates into the surgical wound area, annoying the surgeon; local skin sepsis or rash.

Drugs/Doses: See Table 1. For a rapid onset and long duration block, 10mg of tetracaine crystals may be dissolved in 1% lidocaine. If rapid onset is not needed then 0.25% bupivacaine will provide 6-12hr of anesthesia.

Technique: Identify the anterior superior iliac spine (ASIS). Ilioinguinal nerve: Insert a block needle or 23G butterfly needle 1-2cm medial to the ASIS, directed 45' laterally toward the ASIS. A slight 'pop' may be detected. If so, inject half the anesthetic there. If not, contact the wing of the ileum with the needle, withdraw it 5mm, and inject half the anesthetic there and on the way out with the needle. Iliohypogastric nerve: using the same injection site at the skin, inject a subcutaneous fan of anesthetic laterally and inferiorly using the remainder of the dose.

D. Penile Nerve Block:

Indications: Circumcision, hypospadias repair.

Contraindications: Local skin sepsis or rash.

Drugs/Doses: See Table 1

Technique: Use only epinephrine-free solutions! Retract the penis towards the feet, and insert the needle just below the symphisis pubis into the shaft of the penis, with the needle 90' to the skin. You will feel the needle enter the penis as Buck's fascia is pierced. Inject half the dose on each side of the midline at 11:00 and at 1:00. Inject a final 1 cc subcutaneously on the dorsal (under) side of the penis.

E. Neuraxial Blocks:

Caudal Epidural Block:

Indications: Surgery below the diaphragm.

Contraindications: Aberrant sacral anatomy. Local skin sepsis or rash

Drugs/Doses: See Table 1. The optimum concentration of bupivacaine has been addressed by several authors. In general, it seems that concentrations <0.25% do not consistently produce less motor block, but are associated with less analgesia.

Technique: Place the child prone or in the lateral position, with the hips slightly flexed. Identify the two posterior superior iliac spines, and use them to define an equilateral triangle pointing south. The third corner of the triangle will identify the sacral hiatus. Note the hiatus and cornuae are nearly always well above the intergluteal folds. A 23G block needle, a 22G or 20G IV catheter, or a 23G butterfly is then inserted at 45' to the skin, and a distinct 'pop' and 'give' will be felt as the sacroccocygeal ligament is punctured. A 22G epidural catheter may be inserted for longer cases via a 20G IV catheter. Advance the needle only another mm or two. After confirming negative aspiration of CSF and a negative test dose, the total dose of anesthetic is fractionally and slowly injected. There should be minimal resistance to injection; resistance indicates incorrect needle placement.
Lumbar Epidural Block:
Indications: See caudal block.
Contraindications: Anomalies of spine anatomy. Local skin sepsis or rash
Drugs/Doses: See Table 1
Technique: This block is easier to perform on children than on adults but it is necessary to use a pediatric 5cm Tuohy needle. The only difference in technique for the child is anticipation of the correct depth of needle placement, which may be predicted from the following formula adapted from the work of Dohl:

\[ \text{Depth(mm)} = 18 + 1.5 \times \text{Age} \]

In other words, in children from 2-8 years of age the depth is between 2-3cm.

References


