rich2/zaf-ane/zaf-ane/zaf10408/zaf3355d07z | xppws | S=1 | 3/19/08 | 12:06 | Art: 000020 | Input-XXX

Integrating Regional Anesthesia into Postoperative Pain Management in Children: An Intensive Review

Santhanam Suresh, MD, FAAP

The use of regional anesthesia in children and adolescents has seen resurgence in the past decade due to innovative methods described as well as newer technology that can facilitate easy placement of blocks. An explosion of material available on the web as well as standard textbooks incorporating DVD technology to demonstrate the placement of these blocks have resulted in a wider exposure of anesthesiologists to pediatric blocks. This review course will discuss the use of common blocks in pediatrics with greater emphasis on dosing as well as technique. Teaching regional anesthesia for use in children is still lacking and greater effort should be made to add regional anesthesia techniques as part of the required curriculum in children in training programs. The controversy about the use of regional techniques in children under anesthesia is not much of an issue although there have been multiple reports with complications associated with regional techniques in adults under general anesthesia.[1] This case report was followed by vigorous discussions in the pediatric anesthesia circles followed by an editorial that accompanied the article in *Regional Anesthesia and Pain Medicine*.[2] Other new data showing the efficacy of monitoring injection pressures may have significant implications in pediatric anesthesia.[3] A large prospective database from the French language speaking areas demonstrated a very low incidence of regional anesthesia related complications in children.[4] Although the field of regional anesthesia has recently exploded with ultrasound guided blocks, the use of this technique is not so common yet in regional techniques for children.[5]

EQUIPMENT AND TECHNOLOGY

Nerve stimulation is still commonly used for regional techniques in children. The stimulation techniques used are very similar to adult nerve stimulation. There is one area that may be more commonly used in children and this includes the use of surface mapping in children. Using higher amperage, (usually about 7 mA), the skin over the area of the nerve can be adequately stimulated to produce the desired response to nerve stimulation.[6] This is often used in the absence of ultrasound equipment for localization of the nerves. This prevents repeated needle entries prior to nerve localization. Nerve stimulation can be used for caudal blocks as well as epidural catheter placement using the Tsui technique. This can facilitate the placement of the catheter into higher dermatomal level with greater accuracy.[7,8] The introduction of ultrasonography (US) into clinical practice in pediatrics has greatly enhanced the performance of regional anesthesia in children.[9] The availability of US machines in most medical centers and the knowledge gained from the published material should enhance the use of US in clinical practice. Regional techniques including the use of epidural analgesia can improve the use performance of these blocks. The use of US guidance can also reduce the volume of local anesthetic solution needed for these blocks and hence may pose an excellent risk benefit ratio particularly for children.[10]

LOCAL ANESTHESIA SOLUTION

Bupivacaine is commonly used local anesthetic solution in pediatric practice in North America. The pharmacokinetics of bupivacaine has been adequately studied in children.[11] Dosing guidelines for local anesthetic are strictly followed using a mg/kg basis rather than a total volume dose.[12,13] The use of ropivacaine and levobupivacaine in Europe and Asia seems to have a better safety profile compared to bupivacaine although the risk of toxicity with IV injection remains.[14]

CENTRAL NEURAXIAL BLOCKS

Caudal Blocks

The most common block used in children is a caudal block.[15] This is uniformly taught at most training programs in North America and Europe. The technique is simple and requires very little equipment other than a needle and local anesthetic solution. After palpation of the sacral hiatus, the needle is advanced until a "pop" is felt. This denotes the placement of the needle in the caudal epidural space. A gentle loss of resistance can be felt as the caudal space is entered. Local anesthetic solution is injected in a graduated manner to a total volume of 1 mL/kg. This provides postoperative analgesia for most surgeries below the umbilicus for up to 5 hours with local anesthetic solution alone. The addition of additives to the caudal solution does not uniformly seem to improve the

Table 1. Dose of bupivacaine in the epidural space (13)

Age	Bolus dose	Continuous infusion
Infants	2 mg/kg	0.2 mg/kg/h
Children	3 mg/kg	0.3 mg/kg/h
Older children	4 mg/kg	0.4 mg/kg/h

duration of analgesia in infants and children.[16] It is imperative to monitor the ECG to look for any "peaked T-waves" as a sign of intravascular placement if epinephrine is used in the local anesthetic solution.[17] Newer techniques including the use of stimulating technique as described by Tsui[8] or more recently an ultrasound-guidance technique[18] may lead to accurate localization of the caudal space.

EPIDURAL CATHETERS

This technology for use in pediatrics has existed for more than a couple of decades. The limiting factor to their routine use has been the availability of smaller needles and catheters for use in children. Loss of resistance with saline is preferred in neonates and infants due to the potential of introducing a large bolus of air causing air embolism.[19] Stimulation techniques[7] as well as ultrasound guidance[18] has been recently introduced for placement of epidural catheters in children. This may provide a more accurate method for catheter placement. Dosing of local anesthetic for continuous infusion has to be carefully titrated based on body weight and age. A rule of thumb for local anesthetic dosing is the 4, 3, 2 rule (Table 1).[20]

T1

A dedicated pain treatment service with adequate and frequent follow up of patients is required to facilitate the use of regional anesthesia techniques in children. It is important to stress the importance of moving patients on their sides so that they do not develop heel sores following regional anesthesia. Thoracic epidural analgesia can be placed successfully in children.[21] Patient controlled epidural analgesia can be very rewarding especially in older children and adolescents for managing postoperative pain and is a routine part of our treatment modality for children over 6 years of age or those with the cognitive ability to discern pain.[22]

PERIPHERAL NERVE BLOCKS

A variety of peripheral nerve blocks are utilized in children (Table 1). The use of peripheral blocks in routine practice is increased due to the power of the Internet, the greater exposure to hands-on teaching workshops (NYSORA, ASA, IARS, ASRA), and the resources available for patients and families to check the potential possibilities for pain control. We offer a variety of regional techniques in our practice. A sampling of the variety of nerve blocks will be elucidated in the following paragraphs. A full detailed review of these blocks is found in standard textbooks (*Modern Regional Anesthesia*, Hadzic A, 2006).

Head and Neck Blocks

A variety of different blocks are performed in children for various surgical procedures. The sensory supply to the face is supplied by the terminal branches of the trigeminal nerve, (V1, V2, and V3). These supply the entire frontal face and some of the temporal aspects of the face and scalp. The occipital nerve and the superficial cervical plexus supply the neck and the posterior portion of the ear.

Supraorbital Nerve

The V1 branch of the trigeminal nerve provides the sensory supply to the anterior portion of the scalp, anterior to the coronal suture. The nerve exits the skull through the supraorbital foramen. Blockade of the nerve is easy as it exits the supraorbital foramen and can be easily performed using 0.5 mL to 1 mL of local anesthetic solution injected subcutaneously at the level of the supraorbital foramen. We utilize this block for frontal craniotomies, scalp lesion excisions, and for minor surgical procedures on the anterior portion of the scalp.[23,24]

Infraorbital Nerve

This is the terminal part of the maxillary division of the trigeminal nerve that exits the infraorbital foramen at the inferior border of the orbital rim.[25,26] The nerve can be easily blocked using an intraoral approach (our preference), or an extraoral approach. This is useful for patients who have surgery for cleft lips[27] or endoscopic sinus surgery.[26,28] After eversion of the upper lip, a 27-G needle is inserted into the oral cavity at the subsulcal plane and after careful aspiration 0.5 mL of local anesthetic solution is injected into the area of the infraorbital nerve. This provides adequate analgesia for postoperative pain control.

N of Arnold

This is the auricular branch of the vagus. The nerve is located behind the tragus and is easy to block for myringotomy tube placement. We have just completed a randomized controlled trial comparing the use of this block to IV injection of fentanyl and demonstrated equianalgesic response to pain in the postoperative period.

Superficial Cervical Plexus

The C2-C4 branches of the cervical plexus form the superficial cervical plexus. This winds around the sternocleidomastoid and has 4 branches, the great auricular, which supplies the post-auricular area; the transverse cervical that supplies the anterior cervical area and the thyroid; the supraclavicular that supplies the sensory supply to the shoulder; and the lesser occipital, which along with the greater occipital supply the posterior occiput. The nerves can be easily blocked in the neck using a subcutaneous injection at the level of the cricoid and at the posterior border of the sternocelidomastoid. The injection is superficial and should create a wheal at the site of injection. We use this block routinely for patients undergoing tympanomastoid surgery[29] and for thyroid surgery[30] and vocal cord surgery.[31]

Occipital Nerve Block

The occipital nerve, a branch of the cervical root, is noted on either side of the midline juxta to the occipital artery. After palpation of the occipital artery, the nerve is blocked with 1 mL of local anesthetic solution injected on either side of the occipital protruberance. This is useful for posterior fossa craniotomies as well as in patients with occipital neuralgia.

UPPER EXTREMITY BLOCKS

The brachial plexus is blocked for surgery involving the upper extremity.[32] I will discuss mainly the indications for the variety of approaches to the brachial plexus in children

- *Interscalene*: This is very rarely performed in children. However this block can be easily performed with greater safety in children using ultrasound guidance.
- *Supraclavicular block*: The supraclavicular block is more often used in children and can be easily performed with the aid of ultrasound guidance. This is very useful for patients who require fracture reductions.[33]
- *Infraclavicular*: This technique is often used in our practice for children who require long-term catheter placement.
- *Axillary block*: The axillary approach used to be the most commonly used technique in children.[34] However with the advent of US-guided blocks, other approaches to the brachial plexus are commonly used now. However, in our practice we find that the performance of the axillary block under US guidance has led to specifically blocking nerves for various surgical procedures based on their nerve distribution.

LOWER EXTREMITY BLOCKS

Lower extremity blocks in children are mainly involving the femoral and sciatic nerve blocks.

- *Femoral nerve*: The femoral nerve is perhaps the most common nerve blocked in children. The femoral nerve, a branch of the lumbar plexus can be easily blocked in the femoral crease below the inguinal ligament. Surface mapping can be easily carried out at this area.[6] The indications for femoral nerve blocks include lower extremity surgery including fracture reductions.[35,36] US guidance can be used for provision of this block with ease.[5] We also use the femoral approach for placement of catheters for children undergoing knee athroplasty or ACL repair. More recently, we discharge patients home on these catheters after surgery.
- *Lateral femoral cutaneous nerve block*: This can be used for patients who are undergoing muscle biopsies[37] as well as in combination with a femoral nerve blocks for pin removal and plate removal from the lateral aspect of the femur.
- *Sciatic nerve block*: This is commonly used in children for foot surgery. We have resorted to the use of peripheral block techniques and have shied away from central neuraxial blocks if the surgery involves one extremity. This results in lower incidence of nausea and vomiting and urinary retention.[38] A posterior popteal fossa approach is preferred to the lateral approach in children. More recently a subgluteal approach has been used in children for placement of catheters. The use of US guidance has decreased the incidence of complications while improving the ability to place catheters.[39]

TRUNCAL BLOCKS

The use of truncal blocks in children is more frequent than in the adult population. Although there is limited research in the utilization of these blocks, we feel that the use of truncal blocks in the routine postoperative care of children may far exceed the use of other blocks in routine practice.

- *Ilioinguinal nerve blocks*: The ilioinguinal and iliohypogastric nerves are most commonly performed in children undergoing hernia repair. The nerves are located in the facial plane between the internal oblique and the transverse abdominus muscle. They are derived from T-10 to T-12 thoracic nerve roots. The usual technique of utilizing a "pop" method has been replaced with US guidance, which affords easy visibility of the nerve and can be used for localizing the ilioinguinal and iliohypogastric nerves.[40] Newer pharmacodynamic studies have also reduced the need for large volumes of local anesthetic solution for these blocks.[10]
- *Rectus sheath blocks*: The rectus sheath is a compartment that is enveloped between the rectus abdominus muscle and the posterior rectus sheath. The thoracic intercostals nerves T-7 to T-9 run in this space to supply the sensory fibers to the anterior abdominal wall especially around the umbilicus. This can be used effectively for providing analgesia to the umbilicus. A newer US-guided imaging technique is used for localizing the exact position of this space and can facilitate easy placement of this block.[41]

Table 2. Local Anesthetic Volume for Common Blocks

Block	Volume	Indication
Supraorbital	0.5 mL	Scalp surgery
Infraorbital	0.5 mL to 1 mL	Cleft lip repair
N of Arnold	0.2 mL	Myringotomy tube
Greater palatine nerve	0.5 mL	Palate surgery
Brachial plexus	0.2 mL/kg	Upper extremity surgery
Femoral nerve	0.1 to 0.2 mL/kg	Femur surgery/ ACL
Sciatic nerve	0.2 mL/kg	Foot surgery
Rectus sheath	0.1 mL/kg	Umbilical hernia repair
Ilioinguinal nerve block	0.1 mL/kg	Hernia repair

PERIPHERAL NERVE BLOCK CATHETERS

The use of peripheral nerve catheters has recently been introduced in pediatric practice.[39] The use of perineural catheters along with methods to secure them will be discussed in this workshop. Commonly used perineural catheters in children include sciatic, femoral and infraclavicular catheters.

CONCLUSION

Regional anesthesia in children can be effectively carried out with proper guidance and application. The major advantage with the use of regional anesthesia in children is the avoidance if the use of opioids for postoperative pain control. A formal teaching program to facilitate the demonstration and teaching of these blocks is needed to improve the utilization of T2 regional anesthesia in children.

REFERENCES

1. Bromage PR, Benumof JL. Paraplegia following intracord injection during attempted epidural anesthesia under general anesthesia. Reg Anesth Pain Med 1998;23:104–7
2. Krane EJ, Dalens BJ, Murat I, Murrell D. The safety of epidurals placed during general anesthesia. Reg Anesth Pain Med 1998;23:433–8
3. Kapur E, Vuckovic I, Dilberovic F. Neurologic and histologic outcome after intraneural injections of lidocaine in canine sciatic nerves. Acta Anaesthesiol Scand 2007;51:101–7
4. Giaufre E, Dalens B, Gombert A. Epidemiology and morbidity of regional anesthesia in children: a one-year prospective survey of the French-Language Society of Pediatric Anesthesiologists. Anesth Analg 1996;83:904–12
5. Marhofer P, Chan VW. Ultrasound-guided regional anesthesia: current concepts and future trends. Anesth Analg 2007;104: 1265–9
6. Bosenberg AT, Raw R, Boezaart AP. Surface mapping of peripheral nerves in children with a nerve stimulator. Paediatr Anaesth 2002;12:398–403
7. Tsui BC, Guenther C, Emery D, Finucane B. Determining epidural catheter location using nerve stimulation with radiological confirmation. Reg Anesth Pain Med 2000;25:306–9
8. Tsui BC, Tarkkila P, Gupta S, Kearney R. Confirmation of caudal needle placement using nerve stimulation. Anesthesiology 1999;91:374–8
9. Marhofer P, Greher M, Kapral S. Ultrasound guidance in regional anaesthesia. Br J Anaesth 2005;94:7–17
10. Willschke H, Bosenberg A. Marhofer P. Ultrasonographic-guided ilioinguinal/iliohypogastric nerve block in pediatric anesthesia: what is the optimal volume? Anesth Analg 2006;102:1680–4
11. Ecoffey C, Desparmet J, Maury M. Bupivacaine in children: pharmacokinetics following caudal anesthesia. Anesthesiology 1985;63:447–8
12. Berde CB. Toxicity of local anesthetics in infants and children. J Pediatr 1993;122(Pt 2):S14–20
13. Berde CB. Convulsions associated with pediatric regional anesthesia. Anesth Analg 1992;75:164–6
14. Petitjeans F, Mion G, Puidupin M. Tachycardia and convulsions induced by accidental intravascular ropivacaine injection during sciatic block. Acta Anaesthesiol Scand 2002;46:616–7
15. Suresh S, Wheeler M. Practical pediatric regional anesthesia. Anesthesiol Clin North Am 2002;20:83–113
16. Wheeler M, Patel A, Suresh S. The addition of clonidine 2 microg.kg-1 does not enhance the postoperative analgesia of a caudal block using 0.125% bupivacaine and epinephrine 1:200,000 in children: a prospective, double-blind, randomized study. Paediatr Anaesth 2005;15:476–83
17. Freid EB, Bailey AG, Valley RD. Electrocardiographic and hemodynamic changes associated with unintentional intravascular injection of bupivacaine with epinephrine in infants. Anesthesiology 1993;79:394–8
18. Willschke H, Bosenberg A. Marhofer P. Epidural catheter placement in neonates: sonoanatomy and feasibility of ultrasonographic guidance in term and preterm neonates. Reg Anesth Pain Med 2007;32:34–40
19. Schwartz N, Eisenkraft JB. Probable venous air embolism during epidural placement in an infant. Anesth Analg 1993;76:1136–8
20. Berde C. Epidural analgesia in children [editorial; comment] [see comment]. Can J Anaesth 1994;41:555–60
21. Suresh S. Thoracic epidural catheter placement in children: are we there yet? Reg Anesth Pain Med 2004;29:83–5
22. Birmingham PK, Wheeler M, Suresh S. Patient-controlled epidural analgesia in children: can they do it? Anesth Analg 2003;96:686–91
23. Suresh S, Bellig G. Regional anesthesia in a very low-birth-weight neonate for a neurosurgical procedure. Reg Anesth Pain Med. 2004;29:58–9
24. Suresh S, Wagner AM. Scalp excisions: getting "ahead" of pain. Pediatr Dermatol 2001;18:74–6
25. Suresh S, Voronov P, Curran J. Infraorbital nerve block in children: a computerized tomographic measurement of the location of the infraorbital foramen. Reg Anesth Pain Med 2006;31:211–4
26. Higashizawa T, Koga Y. Effect of infraorbital nerve block under general anesthesia on consumption of isoflurane and postoperative pain in endoscopic endonasal maxillary sinus surgery. J Anesth 2001;15:136–8
27. Bosenberg AT, Kimble FW. Infraorbital nerve block in neonates for cleft lip repair: anatomical study and clinical application. Br J Anaesth 1995;74:506–8
28. Suresh S, Patel AS, Dunham ME. A randomized double-blind controlled trial of infraorbital nerve block versus intravenous morphine sulfate for children undergoing endoscopic sinus surgery: Are postoperative outcomes different? Anesthesiology 2002;97
29. Suresh S, Barcelona SL, Young NM. Postoperative pain relief in children undergoing tympanomastoid surgery: is a regional block better than opioids? Anesth Analg 2002;94:859–62
30. Aunac S, Carlier M, Singelyn F, De Kock M. The analgesic efficacy of bilateral combined superficial and deep cervical plexus block administered before thyroid surgery under general anesthesia. Anesth Analg 2002;95:746–50
31. McAdam D, Muro K, Suresh S. The use of infraorbital nerve block for postoperative pain control after transsphenoidal hypophysectomy. Reg Anesth Pain Med 2005;30:572–3
32. Tobias JD. Brachial plexus anaesthesia in children. Paediatr Anaesth 2001;11:265–75
33. Dalens B, Vanneuville G, Tanguy A. A new parascalene approach to the brachial plexus in children: comparison with the supraclavicular approach. Anesth Analg 1987;66:1264–71
34. Fleischmann E, Marhofer P, Greher M. Brachial plexus anaesthesia in children: lateral infraclavicular vs axillary approach. Paediatr Anaesth 2003;13:103–8
35. Denton JS, Manning MP. Femoral nerve block for femoral shaft fractures in children: brief report. J Bone Joint Surg Br 1988;70:84

36. Johnson CM. Continuous femoral nerve blockade for analgesia in children with femoral fractures. Anaesth Intensive Care 1994;22:281–3
37. Maccani RM, Wedel DJ, Melton A, Gronert GA. Femoral and lateral femoral cutaneous nerve block for muscle biopsies in children. Paediatr Anaesth 1995;5:223–7
38. Dadure C, Bringuier S, Nicolas F. Continuous epidural block versus continuous popliteal nerve block for postoperative pain relief after major podiatric surgery in children: a prospective, comparative randomized study. Anesth Analg 2006;102: 744–9
39. Ganesh A, Rose JB, Wells L. Continuous peripheral nerve blockade for inpatient and outpatient postoperative analgesia in children. Anesth Analg 2007;105:1234–42
40. Willschke H, Marhofer P, Bosenberg A. Ultrasonography for ilioinguinal/iliohypogastric nerve blocks in children. Br J Anaesth 2005;95:226–30
41. Willschke H, Bosenberg A, Marhofer P. Ultrasonography-guided rectus sheath block in paediatric anaesthesia: a new approach to an old technique. Br J Anaesth 2006;97:244–9

AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES **1**