Chapter 1

Introduction

Stephen Mannion

Introduction

Welcome to *Ultrasound-Guided Regional Anesthesia in Children*. If you are reading this book you will have both an interest in pediatrics and the use of regional anesthesia in caring for children.

Pediatric practice, regardless of its subspecialty status, is often viewed as the "Cinderella" of medicine, with innovations and clinical care usually following on from developments in adult practice.

A simple PubMed® search of the terms "children" and "regional anesthesia" reveals 227 results compared to 2069 for "regional anesthesia" on its own.[1] There is a lack of data upon which to base pediatric regional anesthesia practice and a substantial time lag behind changes that occur in adult practice.

Bernard Dalens attempted to address some of these knowledge deficits in his reference textbook *Pediatric Regional Anesthesia*, the first edition of which was released in 1989 (Dalens, 1989). Currently there is a lack of books available on regional anesthesia in children. The majority of anesthesiologists have to refer to general regional anesthesia resources where pediatric regional anesthesia is represented only by a subsection.

Benefits

Anesthesiologists specializing in pediatrics are well aware of the benefits that regional anesthesia techniques bring to the care of children (Russell et al., 2013). The main benefits of regional anesthesia in children are improved post-operative analgesia and a reduction in the use of opioids, with a concomitant reduction in associated adverse effects, such as nausea and vomiting, excessive sedation, and respiratory compromise (Bosenberg, 2013) (Table 1.1).

Table 1.1 Benefits of regional anesthesia in children

Reduced pain scores
Reduced opioid consumption
Decreased post-operative nausea and vomiting (PONV)
Reduced minimum alveolar concentration
Reduced use of muscle relaxants
Reduced emergence delirium
Greater hemodynamic stability
Reduced immunosuppression
Greater suppression of metabolic response
Less post-operative respiratory support after major surgery
Earlier return of gut function and feeding
Reduced intensive care unit stay
Shorter hospital stay

Recent concerns regarding the possible adverse effects of drugs used in general anesthesia on neurodevelopment, and in particular on cognitive and behavioral outcomes in later life, have prompted discussion of the benefits of regional anesthesia techniques as the sole anesthetic for children undergoing surgery (Lei et al., 2014).

The use of regional anesthesia in perioperative care and as part of the management of pain in children is common, with peripheral nerve blocks now accounting for two-thirds of all neural blocks performed as compared to 20 years ago when they made up just one-third (Ecoffey et al., 2010).

[1] PubMed® search results. Available at http://www.ncbi.nlm.nih.gov/pubmed/?term=children+%22regional+anaesthesia%22 (Accessed October 21, 2014).

Challenges

The practice of regional anesthesia in children is not without its challenges.

Unlike in adults, in the vast majority of children (95%), regional anesthesia is performed with the child under general anesthesia (Polaner et al., 2012). This practice appears to be safe in children and may well be unavoidable in many children so as to prevent movement.

Success rates of neural blockade in children are often difficult to determine because of the concurrent use of general anesthesia, as well as the difficulties in eliciting specific information on sensory or motor blockade in young children. Traditional landmark-based techniques have variable success rates, even when combined with nerve stimulation (Ponde and Diwan, 2009).

These factors mean that it is important to ensure reliable, high rates of successful neural blockade if we are considering regional anesthesia in children.

One of the major concerns in caring for children is safety. There are unique elements in performing regional anesthesia in children compared to adults. Children are not a heterogeneous group and present at a wide range of ages, from preterm babies to 15-year-old adolescents. These various ages present a spectrum of physiologic, anatomic, and pharmacologic parameters relevant to the practice of regional anesthesia (Steward and Lerman, 2001).

Small differences in local anesthetic (LA) dosage or volume injected may have significant adverse effects. Regional anesthetic techniques that would allow for a reduction in both, should, therefore, offer a safer method.

Ultrasound

The use of ultrasonography in regional anesthesia is a recent development. In South Africa, la Grange and colleagues described the first use of Doppler ultrasound to perform a supraclavicular block (la Grange et al., 1978). It took until 1994 for what might be considered the routine practice of ultrasound for regional anesthesia – that is the use of ultrasound to view the nerve, needle, and LA – to be first published by Kapral and colleagues (Kapral et al., 1994). Ten years later the same group published the first randomized trial of the use of ultrasound to perform regional anesthesia in children (Marhofer et al., 2004), which followed on from a case report a year earlier on ultrasound-guided sciatic nerve block (Gray et al., 2003).

The use of ultrasound has revolutionized the practice of regional anesthesia, as demonstrated by year-on-year increases in the number of publications in the field (Figure 1.1). This "ultrasound revolution" includes the performance of regional anesthesia in children (Boretsky, 2014).

Many of the challenges associated with the performance of regional anesthesia in children may be significantly ameliorated by the application of ultrasound, due to visualization of critical structures, reduced LA volumes, improved success rates, and reduced rate of vascular puncture.

Need

This book addresses the need to encourage the use, and improve the performance, of regional anesthesia using ultrasound in children.

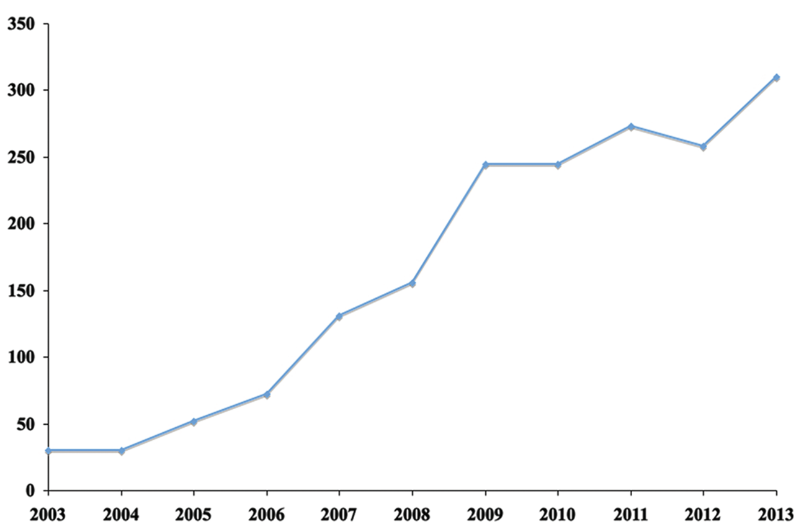

Figure 1.1 Graph of PubMed® search results for terms "ultrasound," "nerve," and "block" from 2003 to 2013.

There are few resources available, either in print and online, that specifically focus on the use of ultrasound in pediatric regional anesthesia practice.

This book has been conceived with the practicing anesthesiologist in mind. The editors determined that a practical, user-friendly book would be an excellent tool to encourage and improve the use of ultrasound in pediatric regional anesthesia. They have assembled an international group of authors who have written this up-to-date guide on specific ultrasound-guided blocks.

Other users, such as emergency doctors, pain specialists, nurse anesthetists, and medical students, may also find this book useful.

Practical

This book consists of two parts. The first part contains five chapters dedicated to the principles and practice of ultrasound use for regional anesthesia in children.

These chapters address in detail the challenges and issues described previously and include the performance of regional anesthesia in children, the pharmacology of LAs in children, the "nuts and bolts" of ultrasonography, managing safety and complications, and providing a description of the relevant clinical anatomy to allow interpretation of the sonoanatomy for each nerve block. These chapters should be read before performing any block, as the principles and practices necessary for safe regional anesthesia in children are described in detail and are not repeated in the "block" chapters.

The second part consists of 15 chapters, each describing the performance of a nerve block using ultrasound. Each "block" chapter will introduce the nerve block and describe its clinical uses and the current literature on the use of ultrasound for that block. The chapter will provide a practical "how-to-do" section on performing that block, including relevant sonoanatomy, patient and probe position, needle placement, and block performance. The reader should note that static ultrasound images are not fully representative of scanning in practice. The dynamic imaging obtained by subtle tilting and translation of the probe results in better resolution images in real-time. Therefore, the sonoanatomy has been labeled to assist with anatomic identification, and where necessary for quality purposes, a needle pathway has been highlighted as for some blocks the needle images were faint, poor, or unclear. Finally a section on clinical tips is provided, where applicable, from the clinical experiences of the authors.

Each chapter has a suggested reading list including references from the text as well as resources that provide further information for interested readers.

Some readers may be disappointed by the apparent omission of certain nerve blocks. Examples of techniques where ultrasound guidance can be used include penile and psoas compartment blocks. The non-inclusion of a particular block does not diminish its clinical usefulness; we have chosen the nerve blocks for this book based on their clinical application, common usage, and/or innovative nature.

Conclusion

The safe and effective practice of regional anesthesia in children requires in-depth knowledge and supervised training. This book in isolation will not make you an expert in pediatric ultrasound-guided regional anesthesia. It will, we hope, assist you in developing and expanding your skills and knowledge base and facilitate the application of regional anesthesia to your everyday pediatric practice.

Acknowledgements

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Suggested reading

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Chapter 2

Performance of regional anesthesia in children

Arjunan Ganesh and Wallis T. Muhly

Introduction

The use of regional anesthesia for post-operative analgesia in children has gained popularity over time. While the caudal block is still the most commonly performed regional anesthetic technique in children, the performance of peripheral nerve blocks is growing. Advances in ultrasound technology have certainly contributed to the increase in the use of regional anesthetic techniques in children. The ability to view the anatomy and the use of real-time needle guidance has increased the confidence among anesthesiologists to perform a variety of regional anesthetic procedures in anesthetized children.

A successful regional anesthetic block requires adequate distribution of local anesthetic (LA) around the target neural structures (Marhofer et al., 2005). The ability to visualize the spread of LA adjacent to the neural structures has improved the success of regional anesthetic techniques. In addition, variations in anatomy can be recognized with the use of ultrasound, which in turn has the potential to increase the safety and success of regional anesthetic techniques.

This chapter describes the key principles necessary for performing safe and effective ultrasound-guided regional anesthesia in children – a number of the topics are considerably expanded on in subsequent chapters.

Anatomy and physiology

Chapter 6 describes the relevant anatomy for the blocks described in this book – below is a brief outline of the key anatomic differences between children and adults.

With regard to peripheral nerve blocks anatomic differences between children and adults may not be significant, although the smaller size of infants and children (structures are more superficial compared to adults) allow the use of higher frequency ultrasound probes resulting in a higher resolution image. However, one needs to appreciate the differences with neuraxial blockade. In a study using ultrasound guidance for epidural placement in children, the median value for the termination of the spinal cord was noted to be L2, but was as low as L3/L4 in some neonates (Willschke et al., 2007). Also, the dural sac in infants extends up to the S3 level. This is in contrast to adults where the spinal cord ends at the level of L1 and the dural sac at S1. Practitioners need to keep this in mind when performing neuraxial blockade in order to avoid injury to the spinal cord or an unintentional intrathecal injection. However, in infants under six months old, the posterior elements of the spinal canal are incompletely ossified allowing an acoustic window for sonographic imaging. With increasing age, the value of ultrasound imaging decreases as ossification increases and the depth of the epidural space and spinal cord increases (Willschke et al., 2006). The authors in this study also determined the paramedian longitudinal and the intervertebral axial planes offer the best views, but the size of these ultrasound windows also decreases with age.

Spinal anesthesia, more commonly used as the sole anesthetic technique in neonates for procedures below the T10 level, may reduce the incidence of post-operative apnea in this population. Larger doses of LA are needed in infants for reasons that include larger cerebrospinal fluid (CSF) volume in relation to body weight (4 ml/kg vs. 2 ml/kg in adults), greater height-to-body weight ratio in infants and a larger surface area of the spinal cord. It is also rare to see profound hypotension with spinal anesthesia in infants and young children (Dohi et al., 1979; Dohi and Seino, 1986), which could be due to an immature sympathetic nervous system and smaller blood volume in the lower extremities of a small child.

Ultrasound-Guided Regional Anesthesia in Children, ed. Mannion et al. Published by Cambridge University Press.

Regional anesthesia under general anesthesia

The decision to perform regional anesthesia in anesthetized or heavily sedated patients is controversial and made in the absence of reliable scientific evidence (Bernards et al., 2008). In this article, the authors have acknowledged that when awake, infants and young children may be unable to communicate symptoms of potential nerve injury or intravascular injection of LA, and also uncontrolled movement in this age group may increase the risk of injury. Therefore, they have recommended that performance of neuraxial and peripheral nerve blocks in anesthetized or heavily sedated children may be carried out when benefits outweigh the risks. However, reports of permanent spinal cord injury in four patients in whom interscalene blocks were placed under general anesthesia (Benumof, 2000) had prompted the authors (Bernards et al., 2008) to recommend against performing interscalene blocks under general anesthesia in children.

Several prospective databases have attempted to define the additional risk, if any, when regional anesthesia is performed under general anesthesia in children (Giaufre et al., 1996; Polaner et al., 2012; Taenzer et al., 2014a, 2014b). In their study (Polaner et al., 2012), the authors reported that 95% of regional anesthetic procedures in children were performed under general anesthesia with a very low rate of complications. Two years later (Taenzer et al., 2014b), using additional information from the database, the authors concluded that performance of regional anesthetic procedures under general anesthesia did not increase the risk of complications when compared to procedures performed in awake/sedated children. In fact, the authors noticed a tendency towards a lower rate of complications when regional anesthesia was performed under general anesthesia. However, there were limitations to this study including a lack of a matched comparison based on age groups and blocks. Another recent study from the Pediatric Regional Anesthesia Network (PRAN) group (Taenzer et al., 2014a) evaluated the safety of interscalene blocks in children and adolescents under general anesthesia. They concluded that placement of interscalene blocks under general anesthesia in children is no less safe than placement in awake adults as far as post-operative neurologic symptoms or LA systemic toxicity (LAST), and questioned the American Society of Regional Anesthesia and Pain Medicine (ASRA) advisory against performing interscalene blocks under general anesthesia in pediatric patients.

The use of ultrasound guidance for peripheral nerve blocks may help improve the safety of procedures performed under general anesthesia. The ability to localize the tip of the needle and monitor the spread of LA along with advances in ultrasound technology may improve the safety of peripheral nerve blocks, particularly the interscalene block.

The present consensus among almost all pediatric regional anesthesia enthusiasts is that it is safe to perform peripheral nerve and neuraxial blockade under general anesthesia, which is based primarily on large case series (Giaufre et al., 1996; Krane et al., 1998; Llewellyn and Moriarty, 2007; Berde and Greco, 2012; Polaner et al., 2012).

Pharmacology

In most cases, pediatric regional anesthesia is performed as an adjunct to general anesthesia during the intraoperative period and primarily for post-operative analgesia. As such, lower concentrations of LA can be used in pediatric peripheral nerve blockade. Ropivacaine is more popular than bupivacaine both for bolus injections in all patients, and particularly in infants for epidural infusions (Feldman et al., 1989; Dony et al., 2000; Bosenberg et al., 2005). Several adjuvants including clonidine, opioids, dexamethasone, epinephrine, dexmedetomidine, and others have been used with varying results. The use of ultrasound can decrease the minimal effective volume of LA required (Marhofer et al., 1998; Casati et al., 2007), and could, thus, increase safety. Finally, the immediate availability of Intralipid®, when performing regional anesthetic procedures, has become a standard of care (Weinberg, 2010; Neal et al., 2012). Please refer to Chapters 3 and 4 for detailed description of pharmacology and management of LA toxicity.

Informed consent

Consent requires five conditions to make it acceptable: (1) the patient must be competent; (2) information must be disclosed; (3) the patient must understand the information; (4) the consent must be voluntary; and (5) the patient gives authorization (Ecoffey and Dalens, 2003). The issue of competency, which is better defined in adults, is still quite complicated in children. In most countries, a child is considered to be an adult at the age of 18 years, although some jurisdictions allow children 16 years and older to consent to a medical or dental procedure.

However, in children who have attained a certain level of maturity and are able to make reasonable choices regarding their care, it may be prudent to respect their wishes. This may particularly be true when regional anesthesia is considered as part of the anesthetic plan. As an example, there are children who, because of previous experience, may refuse continuous epidural analgesia because of the need to maintain an indwelling Foley catheter while the epidural catheter is in place. There may be children or adolescents who choose to forgo continuous perineural infusion techniques because of being uncomfortable with the concept of being attached to nerve catheters and infusion devices. Interestingly, we have even encountered patients who did not like the feeling of a numb extremity and requested premature removal of their perineural catheter. Enthusiastic anesthesiologists need to respect the wishes of children and parents who refuse any form of regional anesthesia, even when they believe that it will offer superior pain relief, as other analgesic alternatives may be adequate and more acceptable to the family.

There is an increasing drive and directive by federal agencies to increase the participation of children in research. The informed consent process for research in children usually involves proxy consent from the parents and obtaining assent from the children who attain a certain age and maturity. The criteria for obtaining assent vary from one institution to another. Because children and adolescents will increasingly be recruited to be research subjects, it is imperative that investigators better understand, from both the child's and parents' perspective, (1) how decisions are made about research enrolment, and (2) how current practices of informed consent/assent can be improved to foster respect for children and to protect child subjects from research risks (Broome et al., 2003).

Use of ultrasound

The use of ultrasound for peripheral nerve blocks will soon become the gold standard for peripheral nerve blocks. Several studies have shown the benefits of ultrasound guidance that includes faster onset time, higher success rate, and decreased minimal effective volume (Marhofer et al., 1998; Casati et al., 2007). Ultrasound guidance should be a clear choice in performance of blocks involving fascial planes, namely transversus abdominis plane, ilioinguinal (Willschke et al., 2005), and rectus sheath blocks, where the other alternative is to rely on pops and clicks (Griffin and Nicholls, 2010). However, there is a learning curve involved in the use of ultrasound. Although many anesthesiology training programs offer training in performance of ultrasound-guided blocks, the experience is not uniform. Also, very few programs offer a structured training program in the use of ultrasound guidance. Despite these issues, the use of ultrasound guidance is increasing in clinical practice as the technology is improving and the costs are decreasing. In the PRAN study (Polaner et al., 2012), about 82% of upper extremity, 70% of lower extremity, and most truncal blocks were performed with ultrasound guidance. The use of ultrasound for neuraxial blockade, though reported (Willschke et al., 2006, 2007), requires further study before broad recommendations can be made.

The cost of an ultrasound machine is often a hurdle in acquiring this technology in various departments. In a study comparing infraclavicular block using nerve stimulator and ultrasound guidance, it was demonstrated that it was cost efficient with ultrasound guidance (Sandhu et al., 2004). In addition, ultrasound guidance is also increasingly being used for central line placement, arterial line placement, and in cases of difficult intravenous access. Please refer to Chapter 5 for a thorough discussion of the use of ultrasound in pediatric regional anesthesia.

Equipment

The primary equipment in ultrasound-guided regional anesthesia is the ultrasound machine. The selection of machine in each institution may be determined by the practitioners' personal preferences, features in the machine, cost, and institutional contracts with manufacturers who provide other devices (Figure 2.1). However, the following capabilities are recommended: (1) easy to use, in order for practitioners of varying abilities to use; (2) portable; (3) a selection of linear, curvilinear, and phased array probes; (4) color-flow Doppler; (5) image- and video-capture facilities for documentation and training; and (6) a suitable warranty (Griffin and Nicholls, 2010).

A variety of needles, stimulating and non-stimulating, and echogenic needles that are coated or scored are available for use (Figure 2.2). In centers where only ultrasound guidance is used, stimulating needles are not necessary. However, many practitioners still use a combination of nerve stimulation and ultrasound guidance. There also are echogenic catheters available for placement. At this moment there is no clear evidence to show the benefit of echogenic needles and catheters. A variety of nerve stimulators are available if one uses a concurrent nerve stimulation technique.

Long-sleeve probe covers are recommended when perineural catheters are placed. For single injection blocks one can just seal the probe tips with sterile adhesives (Figure 2.3).

Figure 2.1 A selection of ultrasound machines used for regional anesthesia.

Block set up

All patients should have the standard monitors that include pulse oximetry, electrocardiogram (ECG), and blood pressure in addition to a functioning intravenous (IV) line prior to the placement of a block. As most regional anesthetic procedures in children are performed under general anesthesia, one should remember to avoid neuromuscular blockade if nerve stimulation is to be used for performance of the block. The ability to use neuromuscular blockade is an advantage when performing blocks with ultrasound guidance only. Also, when performing the blocks under general anesthesia, there should be assistance available to monitor the patient. The second person may also help with optimizing the ultrasound image, operating the nerve stimulator when used, and injection of the LA. It is also important to pay attention to ergonomics, like raising the table to the desired height and lining up the ultrasound machine, the needle direction, and the line of vision to obtain best results.

Drugs needed for resuscitation, such as epinephrine and Intralipid®, should be readily available to address LAST if it occurs. When blocks are performed in awake/sedated patients, equipment for airway support should be available along with benzodiazepines to treat seizures.

Asepsis

Recent guidelines on the prevention of regional anesthesia-related infection have recommended the

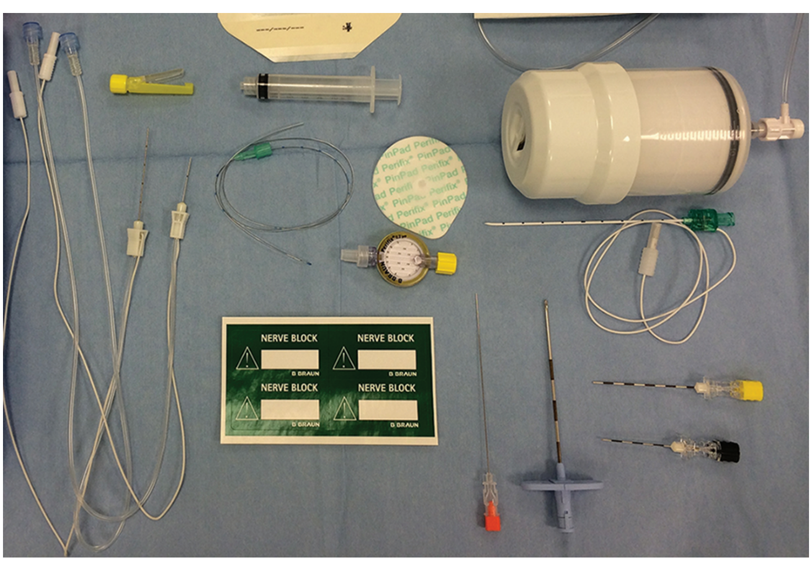

Figure 2.2 A variety of needles can be used for ultrasound-guided regional anesthesia. A nerve stimulator can be used concurrently with many block needles if required. A catheter should be labeled with a suitable label, e.g. "nerve block," and can be connected with an elastomeric pump such as the one shown. Needles shown from left to right are: 50 mm and 25 mm 21-gauge stimulating needles; 27-gauge spinal pencil point needle (orange); 18-gauge Touhy-type needle (blue); 20-gauge Touhy-type catheter through needle (green); and pediatric caudal needles – 20-gauge (yellow) and 22-gauge (black).

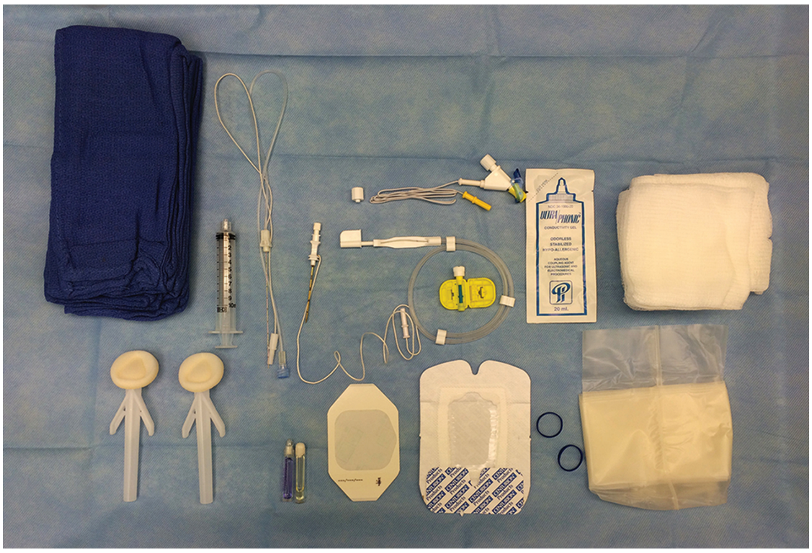

Figure 2.3 Sterile set-up for an ultrasound-guided peripheral nerve block with catheter placement – includes sterile skin disinfectant, drape, sterile gel and probe cover, and catheter skin adhesive and clear dressing.

use of chlorhexidine in alcohol solutions for all blocks including neuraxial (ASRA 2006; ASA 2010; AAGBI 2014). However, there is ongoing controversy in this area, which is beyond the scope of this chapter. In summary, skin preparation for peripheral nerve blocks can be done using either iodine or chlorhexidine solutions mixed with alcohol. In the case of neuraxial blocks, concerns that chlorhexidine is a neural toxic and that it has been implicated in cases of chemical arachnoiditis in adults have resulted in vigorous debate regarding its use for neuraxial blocks. The most recently published national guidelines (UK and Ireland) recommend chlorhexidine in 70% isopropyl alcohol but at a reduced concentration of 0.5%.

When perineural catheters are placed it is advisable to drape the field just like for a surgical procedure (Figure 2.3). The incidence of infection following placement of perineural catheters in children is less than 1% (Ganesh et al., 2007; Polaner et al., 2012; Gurnaney et al., 2014) and for neuraxial blockade, about 1.1% (Polaner et al., 2012) and less than 1% (Llewellyn and Moriarty, 2007). In most studies there was a clear correlation between the duration of the indwelling catheter and the risk of infection. The incidence of serious infective complications like epidural abscess and meningitis was very low.

Safety and complications

The safety of regional anesthesia in children has been well established (Giaufre et al., 1996; Krane et al., 1998; Llewellyn and Moriarty, 2007; Polaner et al., 2012; Krane and Polaner, 2014; Taenzer et al., 2014b). The incidence of neurologic complications is extremely low and infective complications are mostly confined to local skin infections. There were no cases of deep-seated abscesses in the PRAN study (Polaner et al., 2012) and only 2 cases (out of 10 633 epidurals) in the Pediatric Epidural Audit (Llewellyn and Moriarty, 2007).

A prospective study of 1010 ultrasound-guided blocks found neurologic symptoms in 8.2% of patients after 10 days, 3.7% after 1 month, and 0.6% after 6 months (Fredrickson and Kilfoyle, 2009), which is similar to the overall incidence of complications following peripheral nerve blocks (Auroy et al., 2002). Chapter 4 deals with complications in greater detail. There are no large pediatric studies to evaluate the safety of ultrasound-guided regional anesthesia in children. The incidence of adverse events following peripheral nerve blockade is so low that it is going to be very difficult to demonstrate a superior safety profile with the use of ultrasound guidance. However, the improved success rate and the requirement for lower volumes with the use of ultrasound guidance should result in the increasing use of ultrasound for peripheral nerve blockade.

Interestingly, there has been renewed interest in regional anesthesia as the sole anesthetic technique in children. The effects of general anesthesia drugs on neurodevelopment, particularly on behavioral and cognitive function, has recently added to this debate

(Lei et al. 2014). Spinal anesthesia previously performed in neonates or for children at increased risk of apnea, can be safely and effectively performed in older children as well. A pediatric series of 1132 spinal anesthetics for lower abdominal and orthopedic surgeries, in children aged 6 months to 14 years, has been published without a major complication (Puncuh et al. 2004).

Contraindications to regional anesthesia

Contraindications to regional anesthesia in children are very similar to those in adults. Parent or patient refusal, infection at the site, and LA allergy are absolute contraindications. Coagulopathy due to disorders of coagulation, use of anticoagulants, and systemic disorders like overt sepsis are usually absolute contraindications for neuraxial blockade. However, peripheral nerve blockade may be performed with caution in some of these patients (Sripada et al., 2009), but they should be closely monitored for complications with early intervention when indicated (Rodriguez et al., 2011). Imaging with ultrasound prior to neuraxial procedures in infants, particularly those with atypical dimples that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (that include hemangiomas, hairy patches, etc.), may help detect cases of spinal dysraphism and thereby prevent catastrophic consequences (Kriss and Desai, 1998). Relative contraindications include progressive neurologic diseases and the presence of ventriculo-peritoneal shunts (Ecoffey, 2012).

Post-operative care

Whenever feasible all patients who have had a regional anesthetic procedure performed in the operating room need to be evaluated in the recovery room to evaluate the efficacy of the block. This is important as most regional anesthetic techniques in children are performed under general anesthesia and success of the block can only be truly determined in the post-operative period. Supplement analgesia should be ordered for those who have insufficient coverage from the block or when the block is a failure. Pain assessment should be carried out in the recovery room and at least every 4 hours thereafter. Clear instructions need to be given to protect the insensate areas resulting from the block. If there is a possibility of motor blockade, particularly in the lower extremities, adequate weight-bearing instructions need to be provided. In case of continuous peripheral nerve and neuraxial blockade, the catheter site needs to be evaluated at least once a day to look for signs of infection/dislodgement.

When patients are discharged home with indwelling perineural catheters, verbal and written education should be provided about the continuous infusion device system, techniques to remove the catheter, recognition of potential complications (symptoms of LA systemic toxicity), catheter dislodgement, and inadequate pain control. Families should also receive emergency contact information for the pain service. Patients should be cautioned to avoid weight bearing on the extremities that are weak and also to protect insensate areas from injury (e.g. from heat, cold, pressure, and other trauma) (Ganesh et al., 2007; Gurnaney et al., 2014).

Conclusions

Regional anesthesia in children is gaining in popularity. The availability of safety data from several multicenter prospective and retrospective studies has helped pediatric anesthesiologists approach regional anesthesia with renewed interest. The advances in ultrasound technology and its availability have accelerated this resurgence. More data should be available in the future to understand the full impact of the use of ultrasound guidance in pediatric regional anesthesia.

Suggested reading

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Bosenberg AT, Thomas J, Cronje L, et al. (2005) Pharmacokinetics and efficacy of ropivacaine for continuous epidural infusion in