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Pediatric regional anesthesia is best performed with the child asleep

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Over the last 20 years a renaissance of pediatric regional anesthesia has occurred. Although regional anesthesia is rarely employed as the sole means of providing surgical anesthesia for pediatric patients, it is increasingly used in combination with general anesthesia to reduce the amount of general anesthetics administered, attenuate the stress response of surgery, facilitate a rapid emergence from general anesthesia, and most importantly to provide incomparable postoperative analgesia.

Many of the principles of safe pediatric regional anesthesia practice are adopted from those developed for adult patients. However, children are not small adults and several principles have been modified so that children can enjoy the benefits of regional anesthesia. Most notably, regional anesthesia is routinely performed with the adult patient awake or lightly sedated so that they can report symptoms during the block. A report of paresthesias during the placement of the block needle or during the injection of local anesthetic heralds the close proximity of the needle to neural structures or an intraneural injection prompting an immediate cessation of the block and avoidance of nerve injury. The fully conscious adult can also report symptoms of ringing in the ears or a metallic taste indicating an inadvertent intravascular injection. However, the performance of regional blocks can be associated with significant discomfort which is to be avoided in children and can result in severe anxiety, an inability to cooperate, and sudden, unpredictable movement. Finally, children are not able to understand the concept of paresthesia nor can they reliably differentiate between pain and pressure at the site of the block and paresthesia. Thus the performance of regional anesthesia in awake children can be difficult and dangerous, and the information obtained from a conscious child during the block may be unreliable or misleading. Consequently, as has been recently expressed in an editorial, many pediatric anesthesiologists believe that regional anesthesia must be performed in sedated or anesthetized children[1]. This belief is based on mounting clinical data involving pediatric patients and the collective experience and judgement of pediatric anesthesiologists from around the world.

Two major risks concerning the placement of regional blocks during general anesthesia in children are often cited by critics of this practice. The first is an increased risk for local anesthetic toxicity including seizures and cardiovascular collapse since the increase in heart rate in response to an intravascular injection of a test dose containing epinephrine is attenuated by general anesthetics. The second is the risk of permanent neurological injury since anesthetized or deeply sedated children can not report paresthesias during performance of a regional block. In fact there is no data to suggest that performing regional blocks in awake children reduces these complications. Many Pediatric anesthesiologists believe that complications such as neural injury, soft tissue injuries, dural puncture, and block failure would be increased by routinely performing regional anesthesia in awake children. A brief discussion of these two risks follows.

The risk of systemic toxicity secondary to inadvertent intravascular injection of local anesthetics is low. In the largest study of morbidity associated with pediatric regional anesthesia 6/24,409 (0.024%) patients had an intravascular injection of local anesthetics and 4 of these 6 patients experienced systemic toxicity; 2 patients had seizures and 2 patients had transient cardiac arrhythmias[2]. There were no deaths or cardiac arrests in this report. The Pediatric Perioperative Cardiac Arrest registry was formed in 1994 to evaluate the causes of cardiac arrest in children during the perioperative period[3]. In the first 4 years, among 63 participating institutions in the United States, 289 cardiac arrests were reported during an estimated 1,089,200 anesthetics. It is not known how many of these patients received a regional anesthetic but 5 of the 289 cardiac arrests were the result of inadvertent intravascular injection of local anesthetic medication and all 5 patients were successfully resuscitated. In a report of closed malpractice claims, 1/238 pediatric cases involved a cardiac

arrest secondary to inadvertent intravascular injection of local anesthetics[4]. In a recent report of 103,600 regional anesthetics in adult patients, the incidence of seizures was no different than that reported in children despite the fact that the blocks were performed while the adults were awake[5]. Also, in this report death and neurological complications were higher in adults.

It is well known that the direct intravenous administration of epinephrine failed to cause an increase in heart rate > 10 BPM in 39% of halothane-anesthetized children[6]. Failure to detect an intravascular test dose may contribute to an increased incidence of cardiac arrest or seizures during regional anesthesia performed in anesthetized *vs* awake children. In one series of 750 caudal anesthetics, 47 patients had evidence of vascular penetration and 3 patients experienced an intravascular injection of a test dose[7]. Vascular penetration was more common and intravascular injection of test dose only occurred when an IM needle (as compared to a short-beveled needle) was used to perform the block. In another series of 742 caudal, lumbar, and thoracic epidurals, intravascular placement of the block needle or catheter was detected in 42 patients[8]. Detection was by immediate aspiration of blood in only 6/42 patients. An increase in heart rate > 10 BPM in response to a test dose was observed in only 30 patients and in 5 patients the heart rate increased < 10 BPM. Changes in t-wave morphology (particularly an increase in amplitude) or in heart rhythm occurred in the majority of subjects. Other reports too confirm that changes in t-wave morphology, S-T segment changes, hypertension, and/or bradycardia, and not an increase in heart rate > 10 BPM, are the most reliable indicators of an intravascular test dose injection during caudal anesthesia[9-12]. The surest way to prevent inadvertent vascular injection and local anesthetic toxicity in anesthetized children is to combine several measures including the use of short-beveled needles and aspiration for blood prior to and after the administration of a test dose of local anesthetic with epinephrine (0.25 – 0.5 μg/kg); constant EKG surveillance of ST-T wave morphology, heart rate, and rhythm; the measurement of blood pressure in response to a test dose; and the slow administration of the total dose of local anesthetic in small increments. When these principles are adhered to, the intravascular injection of local anesthetics can be detected and systemic toxicity from local anesthetics can be kept acceptably low.

Although there are numerous case reports of neurological injuries related to caudal, lumbar, and thoracic epidural blockade in children, the incidence of these injuries appears to be quite low. In the French Language Society of pediatric Anesthesiologists' study there were 2/24,409 (0.008%) patients who had temporary S1 paresthesias following lumbar epidurals placed during general anesthesia[2]. Most of these patients received single shot caudal or lumbar blocks (n = 12,111 and 1370, respectively) but epidural catheters were placed via the caudal (n = 126), sacral (n = 236), lumbar (n = 655), and thoracic (n = 135) routes. There were no permanent nerve injuries. This study also included 4,090 peripheral nerve blocks. Although many of these blocks were penile (n = 2134), other blocks performed included Axillary (n = 608), Supraclavicular (n = 277), Femoral (n = 185), Sciatic (n = 152), and Intercostal (n = 39). The vast majority of these peripheral blocks were placed during general anesthesia with the aid of a nerve stimulator and no neurological complications were reported in any of these children. Our own experience at the Children's Hospital of Philadelphia indicates that epidural analgesia is safe in anesthetized children. Between 12/1/2001 and 11/30/2003, there were 676 epidural catheters (29% thoracic, 34% lumbar, and 37% caudal) placed during general anesthesia in 366 males and 310 females aged 1 day – 54 years old (mean 7.6 years), weighing 1.28 – 121 kg (mean 28.7 kg), and receiving epidural infusions for 1 – 40 days (mean 3.91 days). No adverse events were reported in 59% of patients and miscellanaeous adverse events such as vomiting and pruritus were reported in 35%. Adverse events requiring evaluation to rule out a neurological complication occurred in 6% of our patients and included: motor block (n = 10), Horner's syndrome (n = 5), superficial inflammation (n = 5), muscle spasms (n = 4), headache (n = 3), mental status changes (n = 3), dysesthesia (n = 2), dural puncture headache (n = 1), and hysterical paralysis (n = 1). The only true neurological complications were the patients who experienced dysesthesias (n = 2). One of these patients underwent the resection of a lower extremity malignancy and it was concluded that the dysesthesia was due to the surgical nerve injury. The other patient was a 6 year old child had severe burning pain on the sole of her right foot which was related to the thoracic epidural catheter resting against a sacral nerve root as the symptoms immediately disappeared when the catheter was pulled back by 5 cm.

It is not clear that performing regional anesthesia is safer in awake *versus* anesthetized adults as no controlled, prospective trials exist. Spinal cord injury has been reported in an awake adult who moved suddenly during thoracic epidural placement[30]. Furthermore, there is substantial evidence that epidurals can be placed safely in anesthetized adults[31,32].

Thoracic epidural analgesia is perhaps the one regional block regularly performed at my own institution that carries the greatest risk for neurological injury. I would like to discuss thoracic epidural anesthesia in more detail. TEA has gained tremendous popularity and is now routinely practiced by many anesthesiologists around the world[2,13-17]. Nevertheless, studies comparing the benefits of epidural analgesia with conventional systemic analgesia in pediatric patients are few[18,19]. Further investigations are required to demonstrate the superiority of TEA over conventional systemic

analgesia as well as other forms of regional analgesia in various clinical scenarios. Also, in spite of the increasing experience with pediatric TEA, little is known about the absolute risks of this procedure, especially with regard to spinal cord injuries resulting in temporary or permanent neurological deficits. In the largest and only prospective study of morbidity associated with pediatric regional anesthesia, 135 thoracic epidurals were performed and none of these children experienced a complication[2]. In the other reports too, no serious complications were reported[13-17,20,21]. However, it can't be concluded that TEA is without risk of spinal cord injury based on the few existing reports since the total number of children receiving TEA in these reports remains small and spinal cord injuries are expected to occur infrequently, similar to the rate of occurrence in adults[5]. Though rare, these complications can be devastating. At the present time our knowledge of spinal cord injuries associated with thoracic (and lumbar) epidural analgesia in children is limited to a few case reports. Spinal cord hematoma, transient paresthesias, paraplegia, and injury to sacral parasympathetic nerves due to an intraspinal hematoma have all been reported in association with lumbar epidural analgesia[2,16,22-24]. Epidural abscess, transient neurological symptoms, epidural hematoma and spinal cord injury are the only neurologic complications reported in association with thoracic epidural anesthesia in children[25-28]. Kasai et al[27] report on the case of a child with temporary bilateral lower extremity neurologic deficits and pain associated with spinal cord injury after a single-shot thoracic epidural block performed during general anesthesia for emergency appendectomy. This case report is important because it reminds us that there are serious risks associated with TEA in children and that we must carefully weigh the risks and benefits of this procedure in any child considered to be a candidate for TEA. In the absence of clinical data demonstrating the risks and benefits of TEA, adherence to the recommendations of experts and the exercise of sound clinical judgement are mandatory.

In conclusion, regional anesthesia can and should be performed in pediatric patients. The majority of children require sedation or general anesthesia to safely, comfortably, and satisfactorily perform the block. Skill in performing the blocks is acquired with experience initially under the supervision of an individual with expertise in pediatric regional anesthesia. Since regional anesthesia is primarily done for postoperative analgesia and not surgical anesthesia, it is rarely indispensable. Thus careful patient selection for regional anesthesia is required by considering the proposed surgery, the patient's medical conditions, alternative analgesic techniques, the skill of the anesthesiologist, and the abilities of the personnel responsible for the child's postoperative care. Serious complications can occur but do so rarely when the anesthesiologist adheres to these principles.

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