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Clinical experience

Update on regional anaesthesia in children

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INTRODUCTION

Over the last 20 years, regional anaesthesia (RA) has become widely used for anaesthesia and post-operative analgesia in children, and now also includes acute and chronic pain management, including trauma and other medical procedures. Although the value and scientific basis of RA are accepted, some aspects remain unclear. From outdated 19th century concepts, RA was often considered an alternative to general anaesthesia. Combining the two techniques was thought to be dangerous since it could increase or even multiply the respective side effects. The use of »blind« techniques was considered hazardous or unreliable even though knowledge of some anatomy and use of simple apparatus allows safe and precise location of nerve trunks and anatomical spaces. In the last 5 years, the further experience has improved safety, especially in the very young with new pharmacological data, and efficacy with more continuous techniques and ultrasonography guidance in performing the blocks.

Providing the benefit is not easy as there are too few controlled studies from limited number of centres with sufficiently large numbers to allow evidence-based decision making *(1)*. Enthusiasts however, continue to influence the progress of RA and have initiated its use in controversial areas, such as cardiac surgery, while others have taken RA outside the operating room for management of painful non-surgical conditions.

New local anaesthetics and adjuvants

Ropivacaine is one of the new local anaesthetics. This long-acting local anaesthetic causes less cardiovascular changes than bupivacaine. Indeed, the outcome of these inadvertent intravascular administrations was favourable. Levobupivacaine may represent an alternative – this is a pure enantomer (similar to ropivacaine) with the same beneficial properties as ropivacaine *(2, 3)*. Levobupivacaine is an effective agent for caudal anaesthesia in children at a recommended dose of 2.5 mg/kg. The rapidity of onset was suitable for establishment of surgical anaesthesia and postoperative analgesia was achieved in more than 97.5% of patients. It appears to be of equivalent potency to racemic bupivacaine in children requiring lower abdominal surgery *(4)*. Ropivacaine and levobupivacaine are effective for peripheral nerve, caudal and lumbar/thoracic epidural blocks. It produces less motor blockade than bupivacaine after caudal administration *(4, 5)*. In addition, isobaric 5 mg/ml ropivacaine intrathecal anaesthesia has been successfully reported in 1 to 17-year old children *(6)*.

Pharmacokinetic data have recently been provided by a study on continuous epidural infusions. Epidural infusions (0.2–0.4 mg/kg/h ropivacaine) provided satisfactory pain relief in neonates and infants of less than one year. As plasma concentrations of unbound ropivacaine were not influenced by the duration of the infusion, ropivacaine can be safely used for postoperative epidural infusion for 48–72 h *(7)*. Levels of unbound ropivacaine were higher in the neonates than in the infants, but were below threshold concentrations for central nervous system toxicity in adults (0.35 mg/l or greater).

Many adjuvants have been used, but it has been recently reported that clonidine offers clear advantages in central blocks. Using a dose-ranging design in children undergoing elective inguinal hernia repair, the addition of 2 µg/kg clonidine to a caudal block with 0.125% bupivacaine, increased the duration of postoperative analgesia without any respiratory or hemodynamic side effects *(8)*. No advantages have been found by adding clonidine in ilioinguinal/iliohypogastric nerve block *(9)*.

Clonidine 1–2 µg/kg and ketamine 0.5–1 mg/kg *(10)* increase the duration of analgesia from approximately 5–10 h when combined with bupivacaine 0.1–0.25% or ropivacaine 0.08–0.2%. The combination of S + ketamine and clonidine has been reported to provide satisfactory analgesia for up to 20 h. Both agents at the higher dosage levels are associated with a greater risk of sedation, apnea (particularly neonates and infants) or nausea. Concerns over the safety of ketamine and spinal cord toxicity remain unanswered. Fentanyl, on the contrary, does not prolong the duration of analgesia when added to »single shot« caudal, but significantly increases the incidence of nausea and vomiting.

Other agents, such as buprenorphine, tramadol, neostigmine *(11),* and midazolam *(12),* have their advocates but all are associated with an unacceptably high incidence of nausea and vomiting with minimal added benefit.

New techniques and equipment

Paediatric anaesthesiologists have long had to make do with equipment which is more suited to adults. Fortunately, the demand for appropriately sized equipment for use in children has gradually been met. Anaesthesiologists tend to be fascinated by gadgets and technical advancement. This is born out by new techniques that have been introduced to facilitate more accurate placement of needles or catheters. This includes:

1. The use of ultrasound technology to guide a needle or catheter whilst »visualising« the underlying anatomy *(13)*.
2. Direct stimulation of the nerve roots via a reinforced catheter.
3. Continuous electrographic monitoring via a specially devised catheter (Tsui test) *(14)* facilitates accurate placement of an epidural catheter introduced via the sacral hiatus.
4. Acoustic enhancement of the »pop« used to identify tissue planes by means of the »acoustic puncture assist device« *(15)* have been used to identify entry into the epidural space.
5. Surface nerve mapping by transcutaneous electrical stimulation of the motor component of superficial peripheral nerves to facilitate accurate location of these nerves in children of different ages or those with abnormal anatomy *(16)*.

Ultrasound in performing peripheral blocks

The use of ultrasound as an aid for accurate placement of local anaesthetics is gaining in popularity for regional anaesthesia over conventional landmark-based techniques and neurostimulation *(17, 18)*. The development of a high-resolution portable ultrasound has made the use of ultrasound for RA possible. Ultrasonography allows noninvasive real-time imaging of the relevant anatomical structures while the needle is placed under direct vision *(19)*. Ultrasonography-guided block techniques are superior to blind techniques relying on suitable sensations, which may be unreliable even in experienced hands. Lower limb surgery commonly requires the use of multiple nerve blocks. Thus, a central block is often chosen as each peripheral block has a potential for failure and the local anaesthetic dose available is limited. The use of ultrasonography allows the volume of local anaesthetic per block to be decreased by 30–50%, making it easy to remain within the maximum dose when performing multiple blocks while still achieving success.

Many blocks have been recently studied with ultrasonography. For peripheral nerve blocks, paraumbilical block and ilioinguinal block have been revised by the use of ultrasonography. The bilateral placement of levobupivacaine 0.25% 0.1 ml/kg in the space between the posterior aspect of the rectus sheets and the rectus abdominis muscul under real-time ultrasonographic guidance provides sufficient analgesia for umbilical hernia repair *(20)*. The unpredictable depth of the posterior rectus sheets in children is a good argument for the use of ultrasonography in this regional anaesthetic technique. Local anaesthetic volumes for ilioinguinal block have been reevaluated; indeed, ultrasonographic guidance for ilioinguinal/iliohypogastric nerve blocks in children allowed a reduction of the volume of local anaesthetic to 0.075 ml/kg *(21)*.

Continuous peripheral nerve blocks

Continuous peripheral nerve blocks represent new aspects of regional anaesthesia in children. These blocks are even safer than central ones, but few studies describe this technique in children, except recently for infraclavicular block *(22)* and sciatic block *(23, 24)*. The indications to place a catheter for continuous peripheral blocks are severe pain, long intraoperative time requiring redosing and pain control necessary for many days. A recent study has reported the efficacy of continuous peripheral nerve blocks with elastomeric disposable pumps associated with initial Bier blocks for the treatment of recurrent complex regional pain syndrome in children

(25). All the studies published so far underline the efficacy and safety of analgesia via a peripheral catheter, and no complications or side effects linked to the long-term infusion have been described, with only a few accidental removals and some drug leakage *(26)*. They are at least as efficient as epidural analgesia, and produce fewer side effects *(23)*. Sometimes a combination of peripheral blocks as a continuous sciatic block with a single-shot three-in-one block for tourniquet pain and light general anaesthesia provides good intraoperative conditions for leg and foot surgery and adequate postoperative pain relief. Finally, continuous regional anaesthesia should be the first choice of the anaesthesiologist involved in the treatment of paediatric postoperative limb pain.

Ultrasound in performing continuous epidural blockade

Continuous epidural blockade remains the cornerstone of paediatric RA. The risk of catastrophic trauma to the spinal cord when inserting direct thoracic and high lumbar epidural needles in anaesthetised or heavily sedated paediatric patients is, however, a concern. To reduce this risk, research has focused on low lumbar or caudal blocks (i.e. avoiding the spinal cord) and threading catheters from distal puncture sites in a cephaled direction. With conventional epidural techniques, including loss-of-resistance for localisation of the needle, optimal catheter tip placement is, however, difficult to assess. Novel approaches include electrical epidural stimulation for physiological confirmation and segmental localisation of epidural catheters *(27),* and mainly ultrasound guidance for assessing related neuroanatomy and real--time observation of the needle puncture and, potentially, catheter advancement *(28, 29)*. Ultrasonography is a useful aid to verify epidural placement of local anaesthetic agents and epidural catheters in children. Advantages include reduction in bone contacts, faster epidural placement, and direct visualisation of neuroaxial structures and the spread of local anaesthetic inside the epidural space.

The Tsui technique employs a styletted catheter connected to a nerve stimulator *(28)*. Recognition of myotomal-level stimulation relates to catheter tip level and in expert hands it has an 89% success rate. The test can, however, only be used in the absence of muscle relaxants and epidural local anaesthetics. On the other hand, despite the fact that a recent survey has shown that the loss-of-resistance technique to normal saline is the preferred method for identification of the epidural space in children of all age groups *(29, 31),* a study comparing ultrasonography guidance with the traditional loss-of – resistance technique for epidural anaesthesia has shown a reduction in bone contacts, faster epidural placement, and direct visualisation of neuroaxial structures, depth from the skin and spread of local anaesthetics inside the epidural space. In addition, it has been shown that ultrasonography can locate the caudal catheter tip itself or infer its position by injecting a saline bolus and observing the ventral displacement of the posterior dura *(30, 32)*.

Despite its increasing popularity, however, ultrasound guidance requires additional training and good manual skills. Appropriate education in ultrasonographically guided regional anaesthetic techniques is one of the major limitations of the method. Currently, there is a severe lack of specialists in the field and only a very few centres worldwide have introduced the technique into their daily clinical practice. The first step in education should be intensive theoretical training in anatomy and in the physics underlying ultrasonography. The second step is intensive ultrasonographic training. Wherever an ultrasound machine is available, this training can be performed. Specialised workshops including theory, practical needle guidance techniques and intensive discussion of all topics in the field are useful during the initial education process.

Controversial areas

a) Neuroaxial blockade for perioperative analgesia in cardiac surgery

Although RA is widely used for anaesthesia in many branches of paediatric surgery, in cardiac surgery it has not enjoyed the same popularity because of the potential risks**.** There are few randomised controlled studies that have directly compared the effects of intravenous analgesia with neuroaxial blockade in children undergoing cardiac surgery. The potential advantages of RA are: attenuation of the physiological stress response, more profound analgesia, improved pulmonary function with early extubation, improved metabolic status and shorter stay in the intensive care unit *(33)*. The disadvantages are the risk of spinal cord damage, bleeding, and the potentially disastrous neurological complications. There are many unanswered questions. These include the true risk of epidural haematoma, the safe time period from placement of neuroaxial block to full anticoagulation for cardiopulmonary bypass, or whether surgery should be postponed in the event of »bloody tap« or placement difficulty *(34)*.

b) Neuroaxial blockade for high risk former preterm infants

Postoperative apnea is a well recognised threat to preterm and ex preterm infants undergoing surgery. The best anaesthetic technique remains a source of debate. Awake spinal, and more recently awake caudal, have been advocated to reduce the incidence of apnea *(35, 37)* but both are technically difficult to perform in infants that are not anaesthetised. For this reason most are still performed blocks under general anaesthesia without deleterious consequences. When light general anaesthesia using sevoflurane or desflurane is combined with caudal block, postoperative apnea is rare. Although awake regional has been found to be superior in most studies, with appropriate neonatal care and monitoring, apnea can be easily recognised and treated.

c) Spinal anaesthesia as an equal alternative to general anaesthesia in ASA I and II patients

In most cases, spinal anaesthesia (SA) has been used instead of general anaesthesia when specific underlying patient factors are thought to increase the risks. Although the use of SA in ASA I and II patients is still under utilised, accumulated experience suggests that it may also be viewed as an equal alternative in those groups of patients. To date, the majority of experience has been during lower abdominal surgery in the former, preterm neonate or infant *(35, 36, 37)*. There has also been an increased use of spinal anaesthesia for other surgical procedures including lower extremity orthopaedic procedures *(38)* as well as specific surgical procedures above the umbilicus and in patients outside of the neonatal period. Some authorities have reported their experience with SA for major surgical procedures including repair of gastroschisis, meningomyelocele repair, and scoliosis surgery. One of the most important reviews for use of SA in children younger than one year is the so-called Vermont Infant Registry *(39)*. In this registry 1554 patients have been studied according to the type of surgery, success rate and complications. The study verifies the infrequent incidence of complications associated with SA in infants. Spinal anaesthesia can be preformated safely, efficiently, and with expectation to a high degree of success. SA should be strongly considered as an alternative to general anaesthesia for lower abdominal and lower extremity surgery in infants. We confirm a similar conclusion, although for older children according our experiences *(40, 41)*.

The majority of the reports describe a single shot technique thereby limiting application to procedures lasting 90 min. In addition, SA has been combined with general anaesthesia as a means of limiting the intraoperative use of opoids, blunting the surgical stress, and perhaps allowing for earlier tracheal extubation.

CONCLUSION

Studies have demonstrated a diminished stress response, fewer episodes of hypoxia, greater cardiovascular stability, faster return of gastrointestinal function, a reduced need for postoperative ventilation and a shorter stay in intensive care of children who have had surgery performed under regional anaesthesia.

But really new aspects of regional anaesthesia in children during the last couple of years are the use of continuous peripheral nerve blocks and ultrasonography guidance to perform the blocks. Our training should be modified in order to introduce these new aspects into our daily clinical practice.

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