Epidural analgesia for children

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Epidural analgesia is now firmly established in paediatric anaesthetic practice and its popularity continues to grow. Despite the lack of controlled studies in children, the combination of excellent pain relief associated with minimal side-effects provides high patient satisfaction when compared with other methods of analgesia. Consideration should be given to the use of epidural analgesia as part of the multimodal approach to acute and chronic pain management in children. The more commonly used local anaesthetic agents and central neuraxial techniques are described in this article.

Local anaesthetic agents

Pharmacokinetic considerations

There are several pharmacokinetic considerations when considering epidural analgesia in children:

(i) The larger volume of distribution of local anaesthetics in children reduces peak plasma concentrations after a single bolus dose. However, the risk of drug accumulation after a continuous infusion is increased.

(ii) Liver and kidney functions are immature until 3 months of age. Drug metabolism and clearance are reduced during this time. The infusion rate in infants should be reduced after 24 h to prevent accumulation.

(iii) The relatively large cardiac output in children increases the uptake of local anaesthetic agents from neuraxial spaces, producing higher initial plasma concentrations and decreased duration of action.

(iv) Lower concentrations of plasma proteins for drug binding in neonates, particularly α1-acid glycoprotein, increase the amount of free local anaesthetic available for potential toxicity.

(v) The blood-brain barrier is more permeable to local anaesthetics in infants.

Drugs and dosage

The single S+-isomers, ropivacaine and levobupivacaine, are the drugs of choice in paediatric practice. The reduced cardiac and central nervous system toxicity, and less motor blockade, suggest that these agents may be more beneficial, particularly in infants and neonates. The maximum suggested dosage for racemic bupivacaine (0.2 mg kg\(^{-1}\) h\(^{-1}\) for infants and neonates, 0.4 mg kg\(^{-1}\) h\(^{-1}\) for older children) has led to improved safety of continuous epidural infusions. Recent pharmacokinetic studies also support these guidelines for levobupivacaine (Table 1). Little or no accumulation occurs when ropivacaine 0.2% is infused epidurally for up to 72 h in children >3 months. Plasma concentrations in neonates were also found to be within safe limits. The vasoconstrictive properties of ropivacaine may delay its systemic absorption from the epidural space when compared with bupivacaine. Pharmacokinetic studies using levobupivacaine are currently limited to <24 h or single shot caudals.

Test dose

As the majority of these blocks are performed under general anaesthesia, test doses have a limited role. The early signs of toxicity (e.g. sedation and twitching) are often masked. The first signs of toxicity in children are convulsions, arrhythmias and respiratory or cardiac arrest. The addition of epinephrine in the test dose to detect i.v. injection produces inconsistent changes in heart rate, although atropine at induction of anaesthesia may improve the sensitivity of this test. Monitoring

Table 1 Local anaesthetic infusion rates for epidural blocks in children

<table>
<thead>
<tr>
<th>Drug</th>
<th>Age (months)</th>
<th>Maintenance dose (mg kg(^{-1}))</th>
<th>Duration (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levobupivacaine</td>
<td>0–6</td>
<td>0.2–0.25</td>
<td>36–48</td>
</tr>
<tr>
<td></td>
<td>&gt;6</td>
<td>0.25–0.5</td>
<td>72</td>
</tr>
<tr>
<td>Ropivacaine</td>
<td>0–6</td>
<td>0.2</td>
<td>36–48</td>
</tr>
<tr>
<td></td>
<td>&gt;6</td>
<td>0.4</td>
<td>72</td>
</tr>
</tbody>
</table>

Key points

Epidural analgesia is useful as part of a multimodal approach to acute and chronic pain management in children.

The single S+-isomers, ropivacaine and levobupivacaine, are the drugs of choice in paediatric practice.

In infants below 6 months, epidural additives should not be used because concerns about spinal cord toxicity and the risk of apnoea remain unanswered.

An imaginary line drawn between the two superior iliac crests (intercristal line) is below the lower level of the spinal cord at any age.

Thoracic epidural placement in young children should be performed by clinicians experienced in the technique in this patient group.

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ECG changes (i.e. >25% change in T wave or ST segment size irrespective of the lead chosen) is considered by some to be more specific and more reliable. Therefore, it is suggested that slow incremental injections of local anaesthetic after negative aspiration, with continuous ECG monitoring remains the safest practice.

Additives

Any drug used as an adjunct must be preservative-free as they may cause local nerve damage. Their purpose is to prolong the duration of analgesia, or to improve the quality of the blocks by reducing unwanted side-effects.

Clonidine is an α2-adrenoceptor agonist, used previously as an anti-hypertensive and sedative in children. Clonidine stimulates the descending norepinephrine medullospinal pathway, which inhibits the release of nociceptive neurotransmitters in the dorsal horn of the spinal cord. Ketamine is an NMDA receptor antagonist that binds to the subset of the glutamate receptor. These receptors are found at both the CNS and spinal cord level. At spinal cord level, it decreases the activity of dorsal horn neurons involved in the nociceptive pathway. Clonidine 1–2 μg kg⁻¹ and ketamine 0.5–1 mg kg⁻¹ increase the duration of analgesia by ~5–10 h when combined with bupivacaine 0.1–0.25% or ropivacaine 0.08–0.2%. The combination of S+ ketamine and clonidine is reported to provide satisfactory analgesia for up to 20 h. Both agents, at a higher dose, are associated with a greater risk of sedation, apnoea (particularly neonates and infants) or nausea. Morphine 50 μg kg⁻¹, or diamorphine 30 μg kg⁻¹, may increase the duration of analgesia by up to 24 h. However, they commonly produce unpleasant side-effects (e.g. nausea and pruritus) and have a theoretical risk of late onset respiratory depression. The potential risk of these additives seems unjustified for relatively minor day case surgery. However, fentanyl does not prolong the duration of analgesia but significantly increases the incidence of nausea and vomiting. In infants <6 months, these additives should not be used because concerns over spinal cord toxicity and the risk of apnoea remain unanswered.

General considerations

Epidural analgesia is used frequently in children; the caudal technique is relatively simple to perform and appropriately sized equipment for other approaches is readily available. More than 2500 continuous epidural blocks are performed each year in the UK. Continuous epidural analgesia should only be used in wards or units where the technique is used frequently to ensure expertise and safety. Epidural blockade in children produces much less haemodynamic disturbance than in adults. The combination of a lower circulatory volume in the legs and splanchnic system, and a relatively vasodilated systemic vasculature, is responsible for a reduced incidence of local anaesthetic-induced hypotension in children <8 yr. Contraindications to paediatric epidural blockade are similar to those for adults i.e. patient or parental refusal, coagulation abnormalities, raised intracranial pressure, sepsis, local infection, congenital vertebral anomalies and allergy to local anaesthetics.

Anatomy

There are several anatomical considerations:

(i) The spinal cord and dural sac terminate at lower vertebral levels in neonates and infants aged up to 12 months compared with older children and adults (Table 2).

(ii) An imaginary line drawn between the two superior iliac crests (intercristal line) is below the lower level of the spinal cord at any age; siting blocks at this level reduces the incidence of damage to the spinal cord.

(iii) The sacrum does not fuse posteriorly until the late teens; therefore, sacral epidural blocks are possible.

(iv) The sacral hiatus results from failure of fusion of the posterior arches of the fifth (occasionally fourth and third) sacral vertebrae; it is covered by the sacrococcygeal membrane. The sacral hiatus is relatively larger and higher in neonates. Sacral anomalies are found in ~5% of children.

(v) The epidural space contains less fat and fibrous tissue; therefore it is easier to insert catheters to higher levels from lower approaches.

New techniques and indications for epidural block

Several new techniques and indications for epidural block are emerging:

(i) Ultrasound technology to guide a needle or catheter whilst viewing the underlying anatomy.

(ii) Continuous electrographic monitoring via a specially devised catheter (Tsui test). This facilitates accurate placement of an epidural catheter introduced via the sacral hiatus.

(iii) Neuraxial blockade for perioperative analgesia in cardiac surgery. This is perhaps the most controversial application of epidural analgesia. Previously, congenital heart disease and anticoagulation were considered contraindications to neuraxial blockade. Although the number of cases published to date remains small, no major complications (e.g. epidural haematoma) have been reported. Advantages of this technique are said to include better cardiovascular stability, reduced need for postoperative ventilatory support and shorter ICU stay.
Caudal epidural analgesia

Caudal blockade is the commonest regional technique used in children. It produces dense perioperative analgesia and, when combined with simple analgesics, it provides excellent analgesia with minimal side-effects, making it suitable for day-stay surgery. The technique is relatively simple and safe. Catheters can be inserted easily via this route to extend the duration or height of the block.

Indications

Caudal blocks have been shown to reliably block dermatomes below the level of the umbilicus (T10-S5) in children <20 kg (~6 yr of age). It is therefore suitable for all types of surgery below the umbilicus in these children (e.g. inguinal herniotomy, orchidopexy and hypospadias repair). In older children, only sacral dermatomes are reliably blocked.9 Peripheral nerve (e.g. ilioinguinal) or compartment (e.g. rectus sheath) blocks may be more beneficial in these children.

Technique

All regional blocks should be performed using an aseptic technique. The most reliable method of identifying the sacral hiatus appears to be by identifying the posterior superior iliac spines. The thumb and middle fingers of the ope rator’s hand are placed on the posterior superior iliac spines and the index finger is then used to complete an equilateral triangle, thus identifying the sacral cornua and hiatus. A 20 or 22 G i.v. cannula is most commonly used for this block because: (i) the needle acts as an obturator and prevents seeding of skin into the epidural space; (ii) a more definite give is produced on passing through the sacrococcygeal membrane and the advancement of the cannula over the needle helps to confirm correct placement; (iii) the soft cannula is less likely to puncture a vessel or dura and, because of its size, it is more likely to confirm i.v. or subarachnoid placement; (iv) any resistance encountered during injection of the local anaesthetic indicates incorrect placement; and (v) the cannula allows the placement of an epidural catheter, if desired.

Drugs and doses

The recommended doses of local anaesthetic for caudal blocks are summarized in Table 3. It should be noted that the concentration of block obtained with these doses may vary significantly between individuals. A single bolus dose should not exceed 20 ml of 0.25% levobupivacaine. Using larger doses increases the incidence of side-effects and usually indicates an inappropriate choice of block.

Complications

Caudal blockade is remarkably safe. Serious or catastrophic complications are rare e.g. inadvertent i.v. injection (1:10 000), epidural haematoma or abscess (1:80 000).10 Minor complications are more common and include leg weakness and urinary retention (4–8%), and proprioceptive loss leading to an unsteady gait (close supervision is required when first walking). The failure rate is 2–10% (abnormal anatomy, inexperienced operator or inappropriate choice of block).

Lumbar epidural analgesia

Lumbar epidural analgesia has become increasingly popular in recent years. Clinical studies have demonstrated fewer episodes of hypoxaemia, greater cardiovascular stability, faster return of gastrointestinal function, a reduced need for postoperative ventilation and a shorter stay in intensive care in children who have had surgery performed under regional anaesthesia.11

Technique

This procedure can only be performed safely in children under general anaesthesia. Currently, there are three sizes of Tuohy needles suitable for children: 18 G (standard 10 cm); 18 G (short 8 cm) marked at 0.5 cm intervals; and 19 G (short 8 cm) for infants <5 kg. Smaller gauge and shorter needles are used because they are easier to handle and the smaller bevel is more appropriate for the narrower epidural space. With a midline approach, the depth of the epidural space from the surface is ~1 mm kg−1 with a minimal distance of 10 mm in children aged 6 months to 10 yr. The ligamentum flavum is softer in children and a change of resistance is used to determine needle entry into the epidural space. Loss of resistance to saline is the technique of choice for all approaches. The aim is to place the tip of the catheter as close as possible to the spinal level of the nerves innervating the dermatomes involved in the surgery. This enables the use of a lower dose of local anaesthetic, thus reducing the potential for side-effects and local anaesthetic toxicity.

Drugs and dosages

The maximum safe rates of local anaesthetic infusion for epidural block are given in Table 1.

Complications

The incidences of serious (<1:10 000) or major (< 1:100 000) complications after lumbar epidural analgesia in children are less than that in adults.12 The reasons for this are a matter of conjecture, but one explanation may be that experienced anaesthetists perform these blocks. Complications include:

(i) Failure or inadequate block (5%).
(ii) Technical problems and premature discontinuation (11–17%), e.g. leakage, occlusion or disconnection.
(iii) The incidence of a dural tap is 0.1–0.5% for an experienced operator, although this is higher in neonates.
(iv) The incidence of urinary retention is unknown; it is more frequent in adolescents.
(v) Opioid additives increase the incidence of side-effects such as nausea, vomiting and pruritus.
(vi) Post dural puncture headache is rare in young children but commoner in adolescents. The management is identical to that of adults.
(vii) Epidural abscess formation is very rare. Severe back pain, with or without fever, is the most consistent finding with an epidural abscess; an urgent MRI scan is required.

Thoracic epidural analgesia

Thoracic epidural placement in infants and young children should be restricted to those experienced in the technique. The procedure should be abandoned if difficulties are encountered. Imaging studies have shown that, in children 2–10 yr of age, the mean distance of the spinal cord from the dura at T9–10 vertebral level is 4.3 mm. In these patients, the thoracic vertebrae spines are almost horizontal, which allows a midline approach to the thoracic epidural space. A paramedian approach is often required in adolescents.

In neonates and infants, catheters can be easily and consistently threaded to higher segmental levels from lower approaches. Therefore, insertion at a lumbar level is often possible and safer in infants compared with a direct thoracic approach.

Conclusion

With proper patient selection, based on a careful risk/benefit analysis, epidural analgesia is extremely effective in children. The block chosen should be tailored to the anticipated postoperative pain, surgical procedure and the child’s underlying condition. Experienced operators should perform continuous epidural blocks only in institutions where appropriate equipment, staff and monitoring are available.

References


Please see multiple choice questions 13–16.