Local and regional anaesthesia in infants
NS Morton FRCA FRCPCH

Local or regional analgesia is the platform of multimodal analgesia for all paediatric patients, whatever their age, undergoing surgery or painful procedures, unless there is a specific contraindication. Local and regional analgesia provides dense intraoperative analgesia that continues into the postoperative period. Lower amounts of volatile anaesthetic agents are needed and an opioid-sparing effect is produced. For the pre-term neonate, some procedures can be performed under spinal or epidural analgesia alone, which may improve outcome and reduce postoperative respiratory morbidity. Regional anaesthesia acts synergistically with non-steroidal anti-inflammatory drugs (NSAIDs) to produce good analgesia with minimum side-effects, so for most day-case surgery, opioids may be avoided completely. Single-dose techniques are most often employed; however, pain control may be continued with repeated application of topical local anaesthesia or repeated doses, or continuous infusions of local anaesthesia applied topically, near peripheral nerves or nerve plexuses or via the extradural space if required.

Safety considerations in neonates and infants

Doses of local anaesthetics

Initial doses of local anaesthetics should be reduced in neonates by around 50% from the equivalent adult dose per kg body weight and should be given slowly in increments (fractionation). Maintenance infusion rates should also be reduced by about 50% from those in older children and adults. It is good practice to limit the duration of epidural infusions to about 36 h and to consider reducing the infusion rate by about one-third after 24 h as there is evidence of accumulation of free circulating local anaesthetic, even with these low rates of infusion (Table 1).

Pharmacokinetics and pharmacodynamics of local anaesthetics

The young infant is at increased risk of amide local anaesthetic toxicity. The usual early warning signs and symptoms are not exhibited, and the first sign of toxicity may be a grand mal convulsion, apnoea or arrhythmia. The risk of convulsions is increased in the presence of hypoxaemia, hypothermia, acidosis and hypercarbia. In an acid environment, local anaesthetic dissociates from plasma proteins increasing the unbound fraction. Raised cerebral blood flow will increase delivery of local anaesthetic to the brain. The blood–brain barrier is not well developed in the neonate. Decreased plasma protein binding and reduced hepatic clearance result in increased free drug availability.

During continuous infusion techniques, the free concentration of all amide local anaesthetics continues to rise after the first 6 h and may approach clinically significant toxic concentrations in some infants after 36–48 h. Infants with right-to-left cardiac shunts may be more likely to suffer local anaesthetic toxicity because the first-pass clearance of the lung may be bypassed. Toxicity relates to both the absolute and the rate of rise of plasma concentration of local anaesthetic. Concurrent administration of general anaesthetics or sedatives (especially benzodiazepines) counteracts CNS toxicity.

Treatment should include cessation of administration, measures to ensure a clear airway, artificial ventilation with oxygen 100% and external cardiac massage if necessary.

### Table 1 Local anaesthetic doses in neonates and infants

<table>
<thead>
<tr>
<th>Drug</th>
<th>Age (months)</th>
<th>Initial dose (mg kg⁻¹)</th>
<th>Maintenance dose (mg kg⁻¹ h⁻¹)</th>
<th>Maximum dose per 4 h (mg kg⁻¹)</th>
<th>Duration (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levo-/bupivacaine</td>
<td>0–6</td>
<td>0.5–1.0</td>
<td>0.2–0.25</td>
<td>1.0</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>&gt;6</td>
<td>1–2</td>
<td>0.25–0.5</td>
<td>0.8</td>
<td>2</td>
</tr>
<tr>
<td>Ropivacaine</td>
<td>0–6</td>
<td>0.5–1.5</td>
<td>0.2</td>
<td>0.8</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>&gt;6</td>
<td>1–3</td>
<td>0.4</td>
<td>1.6</td>
<td></td>
</tr>
</tbody>
</table>
Anticonvulsants such as benzodiazepines or thiopental should be titrated to effect (remembering that these may also cause apnoea) and fluids, pressor agents (e.g. dobutamine) and anti-dysrhythmic drugs (e.g. bretylium) given if required. Clonidine may also have a role. For the unresponsive case, extracorporeal life support should also be considered using veno-arterial bypass to support the myocardium until it recovers.

Technical issues

Most local anaesthetic techniques are performed on the anaesthetized infant. Anatomical relationships and landmarks may be different and absolute distances are very small. For example, the distance from skin to epidural space in infants >6 months is ~1 mm kg⁻¹. The intercristal line is at L5/S1 (L4 in adults), the termination of the spinal cord is at L3 (L1/2 in adults) and the termination of the dura is S3/4 (S2 in adults). The technique for accessing the epidural space must be adapted to avoid inadvertent dural puncture or spinal cord damage in infants. The younger the patient, the lower the approach is a sound general principle. Most practitioners do not use a nerve stimulator when performing blocks in infants but it can be a very useful teaching aid.

Care must also be exercised in positioning of small infants for blocks. For example, lack of head control may lead to airway obstruction when the baby is held in the sitting position for a subarachnoid block; flexion of head, neck and legs in the lateral position for a caudal epidural or subarachnoid block may lead to airway obstruction and diaphragmatic splinting.

Small diameter needles and catheters are used in infants and this makes recognition of intravascular and subarachnoid placement difficult. Small catheters are difficult to feed and are more likely to kink, disconnect, dislodge and occlude. The driving pressure on infusion devices may be very high when continuous infusions are delivered via very fine catheters and occlusion alarm limits often need to be reset well above 100 mm Hg to avoid false occlusion alarms.

Care of the infant with a block

Lack of sensation presents the potential risk of injuries from incorrect positioning of a limb, pressure sores, burns from warming devices, tight plaster casts or ischaemia of muscle compartments. Moreover, the pain free infant may move around more and may try to dislodge catheters, cannulae and monitors. Nursing staff may have to adjust their care for such lively postoperative cases and sedation may be required. Low-dose oral diazepam syrup 0.1 mg kg⁻¹ every 6 h or very low-dose benzodiazepine infusion is highly effective and safe, provided the infant is monitored at high dependency level or above (e.g. midazolam infusion 0.025 mg kg⁻¹ h⁻¹).

Techniques in the conscious infant

Topical local anaesthesia

Topical cutaneous local anaesthesia is used before venepuncture, venous cannulation and for removal of small superficial lesions. EMLA cream is an eutectic mixture of local anaesthetics containing lidocaine and prilocaine. When applied under an occlusive dressing it has an onset time of 60–90 min. In order to reduce the risk of methaemoglobinemia, the maximum recommended dose in infants is 1 g. The duration of analgesia after removal of the cream is 30–60 min. Amethocaine gel has a more rapid onset time of 30–60 min as it is more lipophilic than either lidocaine or prilocaine. Amethocaine can be used safely in neonates as esterases are fully functional. Analgesia lasts several hours after removal of the gel. Neither EMLA nor amethocaine gel work for capillary heel-prick blood sampling in neonates.

Topical mucosal local anaesthesia is useful for urethral catheterization and for analgesia after circumcision. Lidocaine gel 1% or 2% is commonly used and can be reapplied to maintain analgesia. For removal of a conjunctival foreign body, local anaesthetic eye drops can be used (e.g. amethocaine, oxybuprocaine). Ultrasound can also be used to guide correct needle and catheter placement.

Instillation or infiltration of local anaesthetic into wounds can be useful for cleaning an open laceration or for suturing of small lacerations in the conscious infant. Use of a very small needle (27G or 29G), slow injection rate, warmed bupivacaine or lidocaine buffered with bicarbonate solution all help to reduce injection discomfort.

Subarachnoid block in the conscious neonate

This is useful in the ex-pre-term neonate for simple inguinal herniotomy and circumcision. These babies have a high incidence of perioperative apnoea after general anaesthesia. This technique is for the expert only and there is a failure rate of around one in five even in expert hands. Contraindications including coagulopathy, thrombocytopenia, local infection and allergy should be strictly observed. The infant should be fasted as for a general anaesthetic.

Topical local anaesthetic should be applied to the skin over the puncture site and the site for i.v. access. It is useful to keep the baby warm, avoid bright lights and noise, and give the baby a pacifier coated with 20% dextrose. A fine needle (25G or 27G) is used and bupivacaine 0.5%, 0.1 ml kg⁻¹ is commonly employed for inguinal surgery. An additional 0.1–0.2 ml is often given to allow for the dead space volume of the needle and hub. The onset time is 5–10 min but the duration of useful surgical anaesthesia may be very short at 20–60 min. This makes the single injection subarachnoid block less suitable for bilateral procedures, complex hernias or prolonged procedures. The postoperative benefits are negated by sedative supplements, although nitrous oxide up to 50% inspired concentration is very helpful and is virtually devoid of problems. Postoperative monitoring should be in a neonatal high-dependency or intensive care unit. Using this technique, there is a proven reduced incidence of postoperative apnoea and episodes of bradycardia and hypoxaemia when compared with general anaesthesia with tracheal intubation.
Caudal epidural block in the conscious neonate

The indications, preparation, intraoperative and postoperative care are very similar to subarachnoid block. The injection may be via a stilette needle (to avoid implantation dermoid), cannula or caudal catheter. The initial dose of bupivacaine is ~1 mg kg\(^{-1}\) and allowance must be made for a much slower onset of surgical anaesthesia than for subarachnoid block (15–30 min). The main advantage of caudal blockade is that the block is technically much easier to perform reliably. The cannula or catheter techniques allow supplementary top-up doses to be given for longer or more complex procedures and for continuing pain control after surgery. The use of caudal additives such as opioids, \(\alpha\)-agonists or ketamine to extend the block is not recommended in infants <6 months or very sick infants as there have been case reports of apnoea in these groups.

Combined subarachnoid epidural techniques

Some experts have developed a combined spinal–epidural technique with the advantage of rapid onset, profound intraoperative analgesia and maintenance of postoperative pain control.

Techniques for minor or intermediate surgery in anaesthetized neonates and infants

Topical local anaesthesia

Lidocaine gel applied to the site of circumcision is useful as noted above. Infiltration of simple hernia wounds and the scrotal incision for orchidopexy is very effective.

Perfusion techniques

Dressing perfusion with dilute local anaesthetic is useful for split skin graft donor sites. Bupivacaine 0.125% with epinephrine 1:400 000 up to a maximum bupivacaine dose of 2 mg kg\(^{-1}\) is placed on a foam pad which is applied to the donor site; an epidural catheter is placed on the surface of the foam dressing and bupivacaine 0.125%, 1–3 ml h\(^{-1}\) via a syringe driver perfuses the dressing thereafter. This simple method can also be used for bone graft donor sites such as from the iliac crest, a technique which is sometimes used in infants with complex cleft palate defects. Wound perfusion of laparotomy or thoracotomy wounds via an epidural catheter placed into the wound under direct vision by the surgeon before wound closure has also been described.

Peripheral nerve block

Penile block

The terminal branch of the pudendal nerve is the dorsal nerve of the penis, which is most reliably blocked by a bilateral injection method to overcome sepsation of the subpubic space and to avoid midline vessels. A short bevelled local block needle (25G or 27G) is used and injections are made bilaterally from below 0.5 cm lateral to the midline. It is useful to use the bone of the pubic arch as a depth gauge and withdraw the needle slightly before aspirating and injecting. The local anaesthetic solution must not contain vasoconstrictor and so should be double-checked and carefully documented. Plain bupivacaine 0.5%, 0.1 ml kg\(^{-1}\) per injection is safe and effective. The block is very effective and long lasting (6–18 h) and can be supplemented and prolonged by topical lidocaine gel. Care of the infant after surgery is facilitated if no dressing is applied to the operation site.

Ilioinguinal/liliohypogastric block

Injection of local anaesthetic using a short-bevelled 22G needle deep to the external oblique aponeurosis will ensure block of both nerves at a point one patient-finger’s breadth medial to the anterior superior iliac spine. Subcutaneous infiltration is not needed. The dose is 1 mg kg\(^{-1}\) in neonates and young infants and 2 mg kg\(^{-1}\) in infants >6 months. This block is as effective as caudal epidural block. A deep injection directed too medially may result in a fascia iliaca block with involvement of branches of the lumbar plexus and a consequent risk of motor block of the quadriceps muscles.

Rectus sheath block

This is useful for repair of umbilical/paraumbilical hernia, laparoscopic surgery and pyloromyotomy. A short bevelled needle is directed perpendicular to the abdominal wall 1 cm medial to lateral edge of rectus muscle. A technique of ‘scratching’ the needle from side to side helps to identify the sheath, a click indicates entry into the sheath then muscle; then scratching identifies the posterior wall of sheath. Bupivacaine 0.2–0.5 mg kg\(^{-1}\) is then deposited after an aspiration test.

Single injection paravertebral block

This technique for experts can be useful for inguinal and renal surgery. Injection is above the transverse process of the L1 vertebra.

Metacarpal/metatarsal block

For syndactyly surgery and some orthopaedic and plastic surgical procedures on the hand or foot, a metacarpal or metatarsal block is very useful. It is vital again to ensure that the local anaesthetic solution has no vasoconstrictor in it.

Infraorbital nerve block

This is used for cleft lip repair and is a very simple block in infants. Inject 1 ml bupivacaine 0.25% subcutaneously at a point half way along a line between pupil and angle of mouth.

Caudal epidural block

Single injection caudal epidural block via a needle or cannula is very effective for orchidopexy, circumcision, inguinal herniotomy, lower limb and pelvic orthopaedic surgery and lower abdominal surgery. It is important to ensure slow, fractionated injection of the correct volume and dose of local anaesthetic. Use bupivacaine 0.125–0.25%, 0.5 ml kg\(^{-1}\) solution for sacral or lumbar blockade, 0.75 ml kg\(^{-1}\) for low thoracic blockade (T10) and 1 ml kg\(^{-1}\) for
midthoracic (T8) blockade. The duration of block will be 4–8 h.
The duration is doubled by adding clonidine 1 μg kg⁻¹ or quad-
rupled by adding preservative-free or S-ketamine 0.5 mg kg⁻¹, but
these additives are not recommended in neonates and infants
<6 months.

**Techniques for major surgery in anaesthetized neonates and infants**

**Peripheral nerve blocks**

*Intercostal nerve blocks*

For thoracoabdominal surgery or renal surgery, intercostal nerve blocks produce 4–10 h of analgesia. At thoracotomy, these blocks can be performed under direct vision by the surgeon. The percu-
taneous technique is similar to that in adults. Care is required to
avoid intercostal vessels and damage to the lung.

**Plexus block**

*Paravertebral block via catheter*

This technique can be used for thoracic and renal surgery. The catheter can be sited percutaneously via a paediatric epidural
needle inserted at the paravertebral level corresponding to the
middle dermatome to be blocked. Alternatively the surgeon can
site the catheter under direct vision and lead it our via the wound.
The doses of local anaesthetic needed for this technique are
similar to those for epidurals.

**Central neuraxial block**

*Caudal epidural catheter*

A catheter can be reliably threaded up the epidural space in most
infants via the sacral hiatus. One can use a standard epidural kit
or a specific caudal cannula to thread the catheter to the middle
dermatome of the surgical wound. Recently, electrical stimulation
 catheters have been developed to check the level of the catheter and
ultrasound may help in younger infants. The doses of local anaes-
thetic are given in Table 1. For a thoracic catheter placement,
many experts reduce the initial dose by one-third to one-half.

*Lumbar epidural catheter*

Lumbar epidural access with modern 18G or 19G paediatric
Tuohy needles is commonly practiced by experts and most use
saline loss of resistance and a mid-line approach. The 18G pa-
ediatric kit is most reliable above 3 kg body weight as the catheter is
easier to manage after surgery in the awake infant. Dosages are
listed in Table 1.

**Thoracic epidural catheter**

This technique is strictly for experts as the thoracic epidural space
is very small in infants.

**Conclusions**

Most infants undergoing surgery or painful procedures can benefit
from local or regional anaesthesia. The high-risk neonate may
most safely be managed awake with an appropriate regional
block and this has proven benefits. Simple topical local anaesthetic
techniques and peripheral nerve blocks have wide utility and a very
good safety record. Plexus blocks and central blocks are very
effective but the technique must be adapted for infants and
neonates to allow for developmental differences in anatomy.
For all children receiving local anaesthesia, the correct dose of
local anaesthetic must be carefully calculated as a mass of drug
per kg body weight and should be double-checked and carefully
documented. Vasoconstrictor-free solutions are essential for
blocks near end vessels. Provided safety rules are observed,
local and regional anaesthesia is highly effective and safe in
infants.

**Key references**

Saunders, 1998

See multiple choice questions 107–111.