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REVIEW ARTICLE

Caudal blocks

Martin Jöhr[1] & Thomas M. Berger[2]

1 Pediatric Anesthesia, Department of Anesthesia, Kantonsspital, Luzern, Switzerland
2 Neonatal and Pediatric Intensive Care Unit, Children's Hospital, Luzern, Switzerland

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Correspondence
Martin Jöhr,
Institut für Anästhesie, Kantonsspital,
6004 Luzern, Switzerland
Email: joehrmartin@bluewin.ch

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Caudal anesthesia is the single most important pediatric regional anesthetic technique. The technique is relatively easy to learn (1), has a remarkable safety record (2), and can be used for a large variety of procedures. The technique has been reviewed in the English (3) and French (4) literature, as well as in German guidelines (5) and in pediatric anesthesia textbooks (6).

Indication, risk, and benefit

Caudal block or peripheral nerve block

All types of surgery below the umbilicus can be covered by a caudal block: 'one technique fits all'. This is relevant, because not all anesthesiologists are familiar with the necessary spectrum of peripheral nerve blocks in children. On the other hand, peripheral nerve blocks provide prolonged analgesia restricted to the site of surgery and should be preferred, e.g., penile block for circumcision or sciatic nerve block for podiatric surgery.

The main goal of caudal block is to provide postoperative pain relief, and it is accepted that the block is performed in anesthetized children (7). By using morphine, even upper abdominal and thoracic incisions can be covered. However, some experts use caudal analgesia as the primary anesthetic technique in fully awake (8) or in slightly sedated infants (9), e.g., for inguinal hernia repair.

Safety

Single-shot caudal anesthesia is remarkably safe: In a retrospective audit reporting on more than 158 000 patients, there was no report of permanent damage (2), and two well done prospective studies examining 12 111 (10) and 8493 (11) caudals, respectively, showed the same beneficial results. In general, neuraxial blocks have a higher number of side effects and complications compared with peripheral nerve blocks, but, remarkably, there is not a single case of epidural abscess, epidural hematoma, or paraplegia after a single-shot caudal block in world's literature. This in contrast to other neuraxial techniques in children, e.g., with thoracic epidural anesthesia where three cases with severe neurologic damage (12–14) have been reported despite the fact that this technique is rarely used in children.

Complications such as total spinal anesthesia are possible, but all were successfully managed (15–17). Local pain at the injection site or back pain has been discussed (18), but this is not a relevant problem in clinical practice. Similarly, the occurrence of urinary retention could be more common with a caudal block (19), but the authors have not seen a single child needing bladder catheterization in the absence of neuraxial opioids or preceding penile or bladder surgery.

Anatomic and physiologic considerations

Anatomic considerations

The dura and the spinal cord reach lower levels in the spinal canal in infants (spinal cord L3 at birth, L1/L2 at 1 year and dura S4 at birth, S2 at 1 year). In small infants, the end of the dural sac can be in a distance of only a few millimeters from the puncture site (20). In children before school age, the loose epidural fat facilitates an even spread of local anesthetics up to the thoracic region. In older children, weighing more than 20 kg, a thoracic spread is more difficult to achieve and caudal block is usually not the first choice for anything but the lowest of abdominal incision.

Hemodynamic changes

It has been stated that up to the age of 6–8 years even a high spinal (21) or epidural (22) block causes only minimal cardiovascular changes because of the relatively low basal sympathetic tone in this age range. Moderate blood pooling and vasodilatation in the lower part of the body (23) are counteracted by vasoconstriction in other areas of the body (24). However, individual patients, especially neonates and small infants with combined caudal and general anesthesia, can experience profound hypotension after a caudal block (Figure 1).

Technique and material

Positioning

After induction of general anesthesia, a left lateral position is obtained with the upper hip flexed 90° and the lower one only 45°. Alternatively, the prone position can be used. In fully awake newborns, caudal block is best performed with the baby in prone position.

Disinfection

Before palpating the landmarks, the region is swabbed in a cranio-caudal direction with 70% alcohol solution to reduce the amount of bacteria. Intensive disinfection with an alcoholic solution (25,26), sterile drapes, and the use of sterile gloves should be standard for every neuraxial blockade. A case of sacral osteomyelitis has been reported after the use of the watery disinfection solution octenidinum (27).

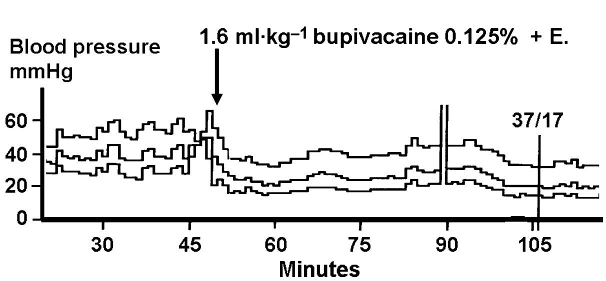

Figure 1 Hemodynamic changes can occur: Profound hypotension induced by the caudal injection of 1.6 ml·kg^{-1} of bupivacaine 0.125% with epinephrine in a 2700-g neonate presenting for the removal of a large ovary cyst under combined caudal and general anesthesia. The patient's lung was ventilated with air and oxygen and stable endtidal sevoflurane concentration of 1.5 Vol.%. The hypotension was treated with volume boluses and dopamine; the secondary drop of blood pressure at around 100 min followed surgical bleeding.

Landmarks

The upper posterior iliac spine and the sacral hiatus form the edges of an equilateral triangle. Epidural puncture is achieved in the most proximal region of the sacral hiatus with the needle inclined 45–60° to the skin. The palpating index finger of the left hand lies on the spinous process S4 (Figure 2). The needle should be inserted just below the spinous process S4. After perforation of the membrane, which occludes the sacral hiatus, the needle should only be minimally advanced, not more than 1–3 mm, in order to avoid a bloody puncture or an intrathecal injection (28). The distance between the dural sac and the puncture site can be remarkably short (20) and accidental intrathecal injections with total spinal anesthesia do occur (15–17). In the authors' institution, an incidence of approximately 1 : 1500 has been seen. With flexion of the spine, the end of the dural sack moves cranially (29), thus increasing the margin of safety. Up to 1 year of age, the correct epidural spread can be easily visualized by ultrasound (30). However, this is mainly for teaching benefits and should, in the view of the authors, not be part of the clinical routine.

Equipment

Different types of needles and cannulae are currently in use (31). Normal hypodermic needles have a long tradition and are still used; some authorities argue that this practice could be unsafe because of the risk of spreading epidermal cells into the spinal canal (32). This has been shown to be a problem in the case of lumbar puncture (33), but no such reports have been published yet after epidural injections. With modern needles, the amount of tissue coring seems to be identical with the different types of needles (34). Specially designed caudal needles with a short bevel and a stylet are a good choice and probably reduce the risk of vascular puncture (35). Plastic i.v. cannulas or lumbar puncture needles are also used (Figure 3). In any case, the type of needle used should not be bigger than 25G: a fine needle causes less trauma. The caudal needle from BRAUN® with extension tubing allows an immobile needle technique.

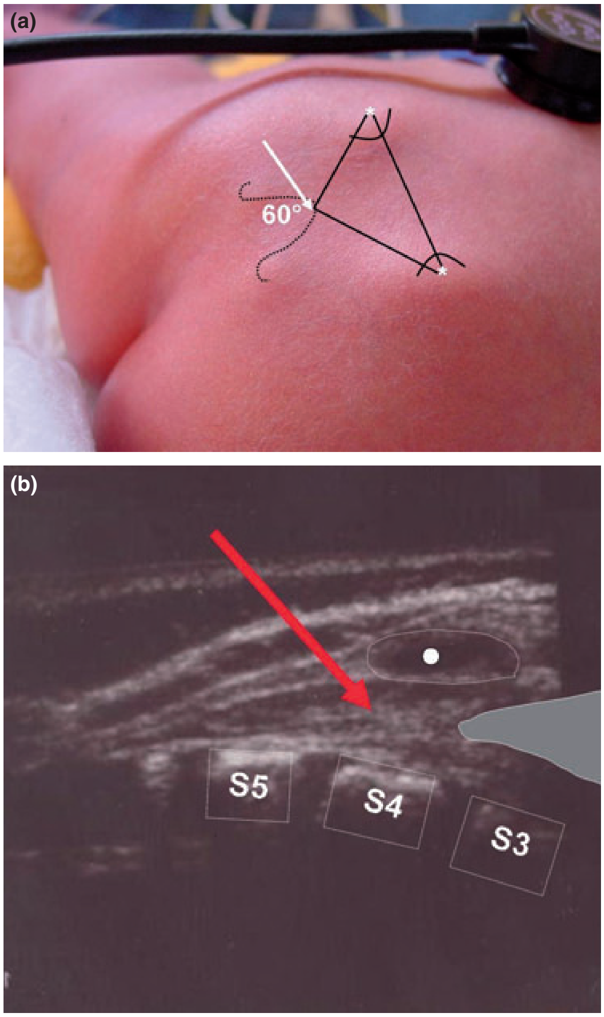

Figure 2 Anatomy of the sacral area. (a) The point of needle insertion in the apex of sacral hiatus. The baby is in prone position with the left lower limb in the top left-hand corner. (b) A sonographic view illustrating the short distance to the dural sac in this patient. The arrow illustrates the path of the needle. The cartilaginous spinous process S4 is marked .

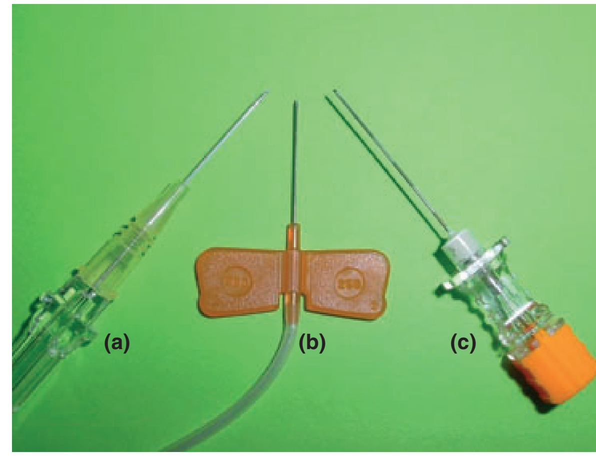

Figure 3 Commonly used needles for caudal block: (a) 24-G intravenous cannula (b) 25-G 'butterfly' needle (c) 25-G graduated special caudal needle.

Caudal catheters

By using a plastic cannula or even a Tuohy needle, it is technically easy to insert a catheter via the sacral hiatus and use it for intraoperative or postoperative pain relief. The proximity of the anal region raises concerns about the risk of bacterial contamination (36), and special precautions have to be taken; some experts advise tunneling caudal catheters (37). In larger series, no severe infections have been reported (38), and the method seems to be safe. However, an increased incidence of colonization of caudal catheters with gram-negative bacteria has been described (36,39). Furthermore, most reported septic (40–42) or technical (43) complications in connection with pediatric epidural anesthesia occurred with continuous techniques and not with single-shot caudal injections. It is therefore the authors' strong belief that caudal catheters should only be used in selected cases.

Bösenberg *et al*. (44) described the insertion of caudal catheters up to a high thoracic level ('*caudo-thoracic anesthesia*'); this was confirmed by others (45). However, this technique is only reliably successful when large-bore catheters (44) or catheters with a stylet (45) are used and malpositioning (46) does occur. Typically, the position of the catheter tip is confirmed by radiography (47), ultrasound (48), ECG tracing (49), or electrostimulation (50). By using a lumbar approach and ordinary catheters without a stylet, the tip of the catheter cannot be positioned reliably at a thoracic level (51).

Drugs and dosage

Local anesthetics

Ropivacaine 0.2% is well suited for caudal anesthesia in children. Compared with bupivacaine, it provides a similar duration of analgesia, but with a reduced incidence of motor blockade. Less severe toxicity may be expected in case of massive intravascular injection. *Bupivacaine* has been thoroughly studied, and a large global experience exists. A concentration of 0.125% is sufficient to provide postoperative pain relief without significant motor blockade (52). Slightly higher concentrations may be used for allowing very light general anesthesia during surgery (53). Therefore, considering the potency of the two drugs, *ropivacaine* 0.2% may be just right.

Table 1 Dosage for caudal anesthesia

Site of incision	Dosage (ml·kg^{-1})	Drug
Penile or anal surgery	0.5–0.75	Ropivacaine 0.2% or bupivacaine/ levobupivacaine 0.125–0.175%
Lower extremity	1.0	
Abdominal incision	1.0–1.25	

It is the authors' practice, for the occasional infant, where a caudal block is used as sole anesthetic, to administer 1–1.2 ml·kg^{-1} of *bupivacaine* 0.25% with epinephrine or in children a 1 : 1 mixture of 0.25% *bupivacaine* with 1% *prilocaine*.

A dose of roughly 1 ml·kg^{-1} is adequate for most indications. The volume is usually restricted to 25 ml. Caudal injections using local anesthetics are not recommended for abdominal incisions in children weighing more than 25 kg (Table 1).

Recently, several attempts have been made to correlate the size of the patient with the anatomic spread evaluated by X-ray (54,55) or ultrasound (56). The anatomic spread, however, only weakly correlates with the clinical extension of the blockade.

Bupivacaine, *levobupivacaine,* and *ropivacaine* are all suitable local anesthetics. In clinical practice, the use of the least toxic drug only marginally increases safety as most complications occur because of a massive intravascular injection or because of major mistakes, e.g., injecting *ropivacaine* 1% (57) or 0.75% (11) instead of 0.2%. Overall, local anesthetics have a good safety record in pediatric anesthesia; in the American Perioperative Cardiac Arrest (POCA) Registry (58,59), only a minority, 7 of 343, of all children arrested because of an accident related to local anesthetics.

Adjuvants

Adjuvants are used to prolong the duration of analgesia (60,61). *Epinephrine* (5 μg·ml^{-1}) prolongs the duration of action of caudal epidural bupivacaine in infants and allows the detection of intravascular needle placement (62) and should be used, at least with the test dose. The local anesthetic alone without epinephrine does not cause reliable ECG changes (63). It is the authors' practice to inject 0.5–1 μg·kg^{-1} *epinephrine* in 0.1–0.2 ml·kg^{-1} of the local anesthetic solution. Although scientific data are missing to support this approach, it should allow the reliable detection of an intravascular injection and the amount of local anesthetic should not cause major harm. As mentioned earlier, in infants, the correct epidural spread, and therefore the absence of intravascular injection, can be nicely demonstrated by ultrasound (Figure 4).

The addition of *clonidine*, 1–2 μg·kg^{-1} – this means in most situations 1–2 μg·ml^{-1} – prolongs the duration of analgesia after caudal bupivacaine, as shown by several authors (64). The side effects are minimal and not of clinical relevance; however, with higher doses, e.g., 5 μg·kg^{-1}, sedation, hypotension, and bradycardia are regularly seen (65). *Clonidine* should be avoided in young infants, as postoperative apnea can occur (66–69). A similar duration of analgesia has also been reported after intravenous administration of *clonidine* (70), but preference should probably be given to the caudal administration because there is a specific segmental neuraxial effect (71). In the authors' practice, clonidine is usually not given because of its prolonged sedative effects.

Morphine provides excellent, long-lasting analgesia (72). However, side effects are common, such as nausea, urinary retention, pruritus, and respiratory depression (73). Therefore, the role of caudal opioids has recently been questioned (74). But the authors of this review are convinced that for a few exceptional patients, the risk–benefit analysis is still in favor of caudal morphine. The optimal single dose in case of a caudal catheter with the option of redosing seems to be 33–50 μg·kg^{-1} (75). For single-shot injections, we use a slightly higher dose, 75–100 μg·kg^{-1}, in patients with a urinary catheter and monitor them for at least 12 h in the ICU.

The more lipophilic opioids, such as *fentanyl* (76), *sufentanil* (77), *pethidine* (78), *diamorphine* (79), or

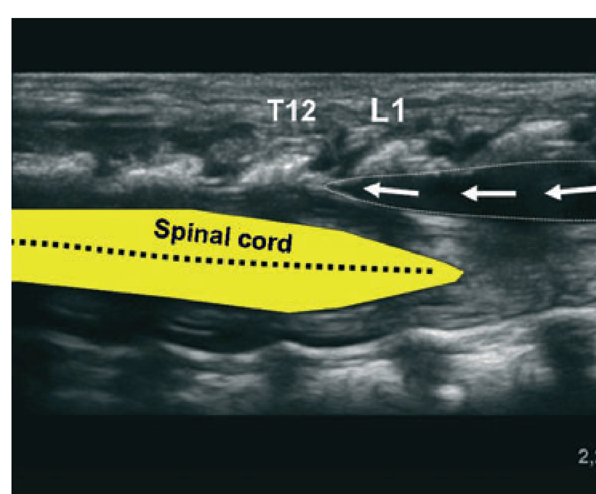

Figure 4 The correct epidural spread (arrows) can be nicely demonstrated by ultrasound. The anatomic spread up to a T12/L1 level is different to the clinically established height of the blockade.

tramadol (80), cause side effects, but do not prolong the duration of analgesia in a clinically relevant way.

The addition of *ketamine* nearly triples the duration of analgesia after caudal *bupivacaine* (81), compared with the plain solution; the optimal dose seems to be 0.5 mg·kg^{-1}. Good results have been reported with *S-ketamine*. However, potential neurotoxicity is a problem (82,83), and, similar to *midazolam* or *neostigmine*, *S-ketamine* cannot be recommended for clinical use (84). In fact, before the availability of animal data showing toxicity, ketamine and S-ketamine have been extensively administered caudally to pediatric patients, with no apparent clinical toxicity. However, with the today's knowledge, the authors of this review are convinced that it would be against good practice to continue to promote the use of epidural ketamine.

Comparison of other regional techniques with caudal block

Lumbar and transsacral epidural analgesia

Lumbar epidural anesthesia is relatively easy to perform, especially at the level L4/5 or L5/S1. The epidural space can be identified by loss of resistance to air or saline. However, no or only small amounts of air should be injected into the epidural space. The injection of large amounts of air in small infants has been related to complications (85). Side effects and technical problems do occur; however, the risk of epidural infection seems to be low. In contrast to caudal anesthesia, neurologic complications (86,87) including paraplegia (88) have been reported with the lumbar approach. Lumbar catheters are not suitable to provide analgesia after abdominal or even thoracic procedures using local anesthetics alone.

In pediatric patients, a transsacral (S2/S3) puncture is feasible (89,90); however, this technique also carries the risk of dural puncture, has no advantage compared with the L5/S1-approach, and has been abandoned by the authors.

Ilioinguinal nerve block, penile block

In children weighing more than 20–25 kg, ilioinguinal nerve block is the commonly used alternative to caudal anesthesia for providing analgesia after inguinal incisions. However, in the authors' experience, this technique is less effective and provides less complete analgesia compared to caudal block; in addition, the blind technique without ultrasound carries risks, such as intestinal puncture (91–93) and femoral nerve block (94). Typically, a rapid absorption with high plasma levels occurs (95). The use of ultrasound guidance has meant that more accurate placement of lower doses is now feasible and has led to a resurgence of enthusiasm for regional blocks.

For penile surgery, a penile block is advantageous (96,97), and it provides prolonged analgesia restricted to the site of surgery and is associated with a low complication rate (98). For extensive penile procedures, e.g., hypospadia repair, it is the authors' practice to combine caudal anesthesia (profound intraoperative analgesia) with a penile block (prolonged analgesia) (6).

Conclusions

Caudal block continues to be a great technique. It is a simple, safe, and effective way to provide pain relief after interventions below the umbilicus.

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Conflict of interest

No conflicts of interest declared.

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