Update in Anaesthesia

Paediatric caudal anaesthesia

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Summary

Caudal anaesthesia (CA) is epidural anaesthesia of the cauda equina roots in the sacral canal, accessed through the sacral hiatus. CA is a common paediatric regional technique that is quick to learn and easy to perform, with high success and low complication rates. CA provides high quality intraoperative and early postoperative analgesia for sub-umbilical surgery. In children, CA is most effectively used as adjunct to general anaesthesia and has an opioid-sparing effect, permitting faster and smoother emergence from anaesthesia.

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INDICATIONS FOR CAUDAL ANAESTHESIA

The indications for single shot CA are abdominal, urologic or orthopaedic surgical procedures located in the sub-umbilical abdominal, pelvic and genital areas, or the lower limbs, where postoperative pain does not require prolonged strong analgesia. Examples of appropriate surgery include inguinal or umbilical herniorrhaphy, orchidopexy, hypospadias and club foot surgery. CA is useful for day case surgery, but opioid additives to the local anesthetic agent should be avoided in this setting. When CA is used, requirement for mild or intermediate systemic analgesia must be anticipated to prevent pain resurgence at the end of caudal block. Catheter insertion can extend the indications to include surgical procedures located in the high abdominal or thoracic areas, and to those requiring prolonged effective analgesia.

CONTRAINDICATIONS

The usual contraindications to regional anaesthesia such as coagulation disorders, local or general infection, progressive neurological disorders and patient or parental refusal apply to CA. Furthermore, cutaneous anomalies (angioma, hair tuft, naevus or a dimple) near the puncture point require radiological examination (ultrasound, CT or MRI), in order to rule out underlying spinal cord malformation such as a tethered cord.[23] A Mongolian spot is not a contraindication to CA.

ANATOMY

Anatomical landmarks (Figure 1)

The sacrum is roughly the shape of an equilateral triangle, with its base identified by feeling the two posterosuperior iliac processes and a caudal summit corresponding to the sacral hiatus. The sacrum is concave anteriorly. The dorsal aspect of the sacrum consists of a median crest, corresponding to the fusion of sacral spinous processes. Moving laterally, intermediate and lateral crests correspond respectively to the fusion of articular and transverse processes.

The sacral hiatus is located at the caudal end of the median crest and is created by failure of the S5 laminae to fuse (Figure 1). The hiatus is surrounded by the sacral cornua, which represent remnants of the inferior S5 articular processes and which face the coccygeal cornua. Palpation of the sacral cornua is fundamental to locating the sacral hiatus and to successful caudal block.

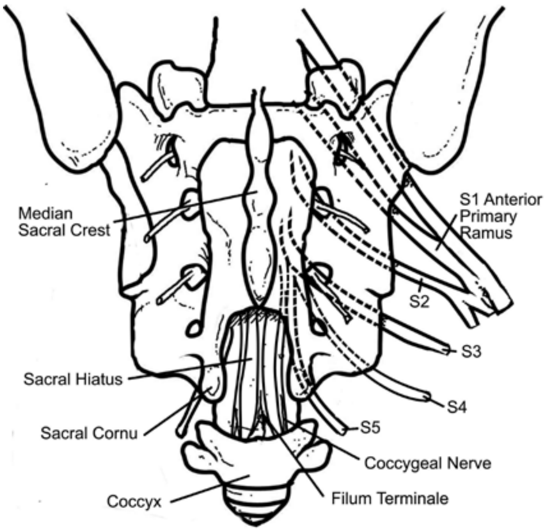


Figure 1. *The posterior aspect of the sacrum and sacral hiatus*

The sacral hiatus is the shape of an inverted U, and is covered by the sacro-coccygeal ligament, which is in continuity with the ligamentum flavum. It is large and easy to locate until 7-8 years of age. Later, progressive ossification of the sacrum (until 30 years old) and closing of the sacro-coccygeal angle make its identification more difficult. Note that anatomical anomalies of the sacral canal roof are observed in 5% of patients and this can lead to unplanned cranial or lateral puncture.

The sacral canal

The sacral canal is in continuity with the lumbar epidural space. It contains the nerve roots of the cauda equina, which leave it through anterior sacral foraminae. During CA, leakage of local anaesthetic agent (LA) through these foraminae explains the high quality of analgesia, attributable to diffusion of LA along the nerve roots. Spread of analgesia cannot be enhanced above T8-T9 by increasing injected LA volume.

The dural sac (i.e. the subarachnoid space) ends at the level of S3 in infants and at S2 in adults and children. It is possible to puncture the dural sac accidentally during CA, leading to extensive spinal anaesthesia. Therefore the needle or cannula must be cautiously advanced into the sacral canal, after crossing the sacro-coccygeal ligament. The distance between the sacral hiatus and the dural sac is approximately 10mm in neonates. It increases progressively with age (>30mm at 18 years), but there is significant inter-individual variability in children.[1] The contents of sacral canal are similar to those of lumbar epidural space, predominantly fat and epidural veins. In children, epidural fatty tissue is looser and more fluid than in adults, favoring LA diffusion.

TECHNIQUE

Preparation

Obtain consent for the procedure either from the patient or, if appropriate, from the parents. After induction of general anaesthesia and airway control, the patient is positioned laterally (or ventrally), with their hips flexed to 90° (Figure 2). Skin disinfection should be performed carefully, because of the proximity to the anus. Aseptic technique should be maintained.

Figure 2. *Preparation of patient - lateral position with the surgical site down*

According to the child's size, needle diameter and length are respectively between 21G and 25G, and 25mm and 40mm. A short bevel improves the feeling of sacrococcygeal ligament penetration and decreases risk of vascular puncture or sacral perforation.[2] Use of a needle with a stylet avoids risk of cutaneous tissue coring, and the (theoretical) risk of epidural cutaneous cell graft. If a styletted needle is not available, a cutaneous 'pre-hole' can be made with a different needle prior to puncture with the caudal needle. Another solution is to puncture with an IV catheter, the hollow needle of which is removed before injection through the sheath.

Puncture (Figures 3, 4 and 5)

After defining the bony landmarks of the sacral triangle, the two sacral cornuae are identified by moving your fingertips from side to side. The gluteal cleft is not a reliable mark of the midline. The puncture is performed between the two sacral cornuae. The needle is oriented 60° in relation to back plane, 90° to skin surface. The needle bevel is oriented ventrally, or parallel to the fibers of the sacro-coccygeal ligament. The distance between the skin and sacro-coccygeal ligament

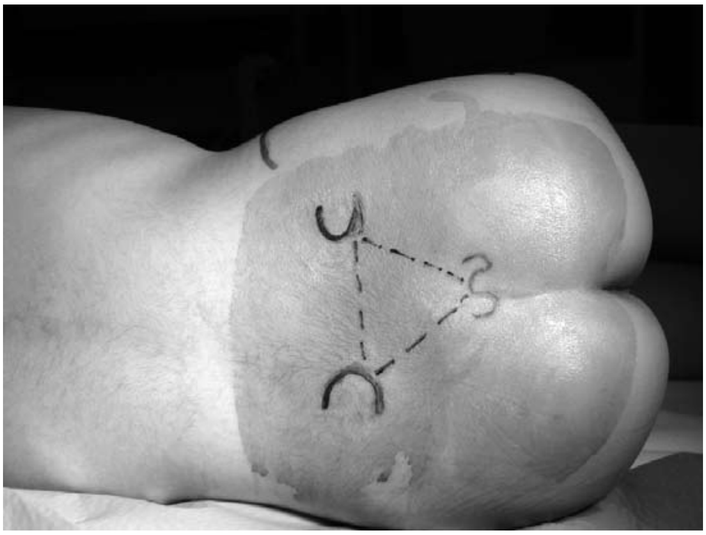


Figure 3. *Bony landmarks*

is between 5 and 15mm, depending on the child's size. The sacro-coccygeal ligament gives a perceptible 'pop' when crossed, analogous to the ligamentum flavum during lumbar epidural anaesthesia. After crossing the sacro-coccygeal ligament, the needle is redirected 30° to the skin surface, and then advanced a few millimeters into sacral canal. If in contact with the bony ventral wall of sacral canal, the needle must be moved back slightly.

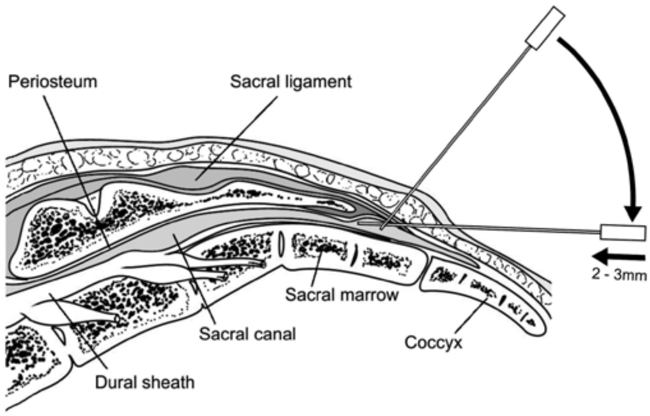
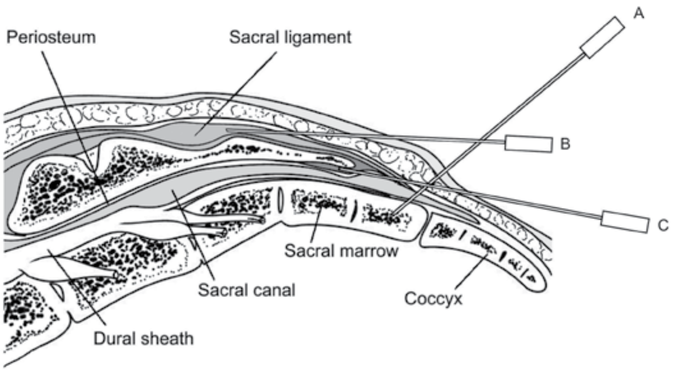


Figure 4. *Puncture - orientation of the needle and reorientation after crossing the sacro-coccygeal ligament.*

Figure 5. *Orientation of the needle during puncture*

After verifying absence of spontaneous reflux of blood or cerebrospinal fluid (more sensitive than an aspiration test), injection of LA should be possible be without resistance. Inject slowly (over about one minute). Where available this may be preceded with an epinephrine test dose under ECG and blood pressure monitoring, in order to detect intravascular placement. Subcutaneous bulging at the injection site suggests needle misplacement. Blood reflux necessitates repeating the puncture, however in case of cerebrospinal fluid reflux caudal anaesthesia should be abandoned, in order to avoid the risk of extensive spinal anaesthesia. Aspiration tests should be repeated several times during injection.

In skilled hands, the success rate of CA is about 95%, however a variety of misplacements of the needle are possible (Figure 6). The moment of surgical incision is the true test of block success, but various techniques have been suggested to authenticate the puncture success, such as injection site auscultation (the 'swoosh test'), or searching for anal sphincter contraction in response to electrical nerve stimulation on the puncture needle. No clear benefit of these techniques against simple clinical assessment have been shown.[3,4] More recently, ultrasound has been suggested to help sacro-coccygeal hiatus location and to visualize isotonic serum or LA injection into sacral epidural space (Figures 7 and 8).[5,6] These authors have also outlined the interest in ultrasound control within the context of learning the technique, rather than for use in standard practice.[5,7]



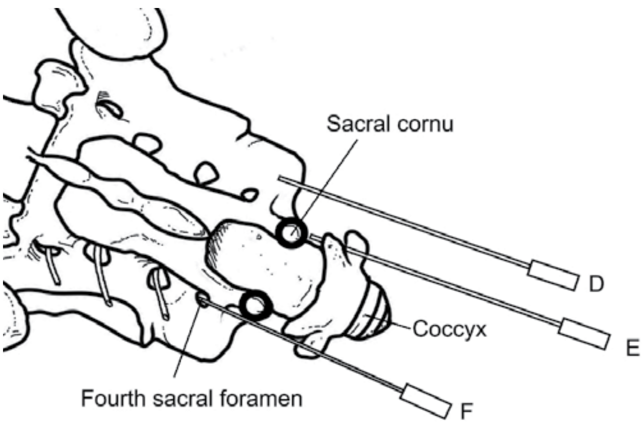


Figure 6A and B. *Needle misplacement*

A marrow (resistance +++. Equivalent to IV injection)

B posterior sacral ligament (subcutaneous bulge)

C subperiostal

D "decoy" hiatus

E intrapelvic (risk of damaging intrapelvic structures: rectum)

F 4th sacral foramen (unilateral block).

Catheter insertion

Although CA was initially described as a single shot technique, some authors have described use of a caudal catheter to prolong analgesic administration in postoperative period. In addition advancement of the catheter in the epidural space up to lumbar or even thoracic levels can achieve analgesia of high abdominal or thoracic areas.[8] However, two pitfalls restrict extension of this technique; a high risk of catheter bacterial colonization, particularly in infants and a high risk of catheter misplacement.[9,10] Subcutaneous tunnelling at a distance from the anal orifice, or occlusive dressings decrease bacterial colonization.[11] Electrical nerve stimulation or ECG recording on the catheter, or its echographic visualization have been suggested to guide its advancement in epidural space.[12,13] However, most anaesthetists presently prefer a direct epidural approach at the desired level that is appropriate to the surgical intervention.[14,15]

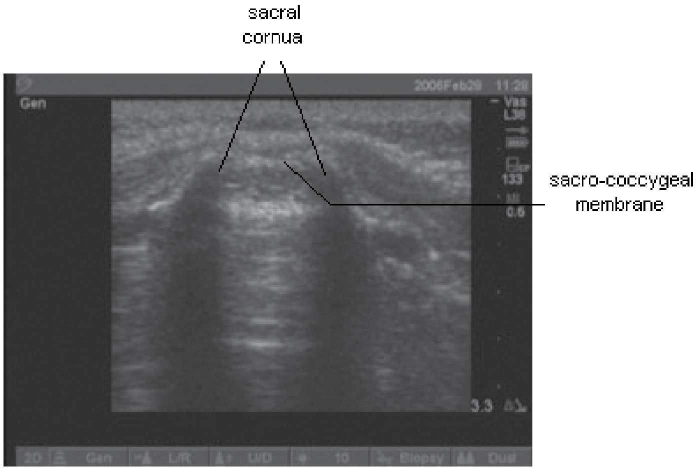
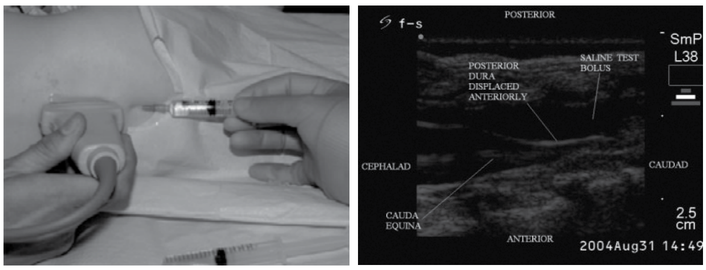


Figure 7.



Figures 8a and 8b.

LOCAL ANAESTHETIC AGENTS

Test dose

Early neurosensory warning symptoms of LA systemic toxicity are concealed by general anaesthesia. Halogenated anaesthetic agents worsen LA systemic toxicity and can also blunt the cardiovascular signs of an intravenous epinephrine test dose injection. Aspiration tests to elicit blood reflux are not very sensitive, particularly in infants. A test dose of epinephrine 0.5mcg.kg^{-1} (administered as 0.1ml.kg^{-1} lidocaine with epinephrine 1 in 200 000) allows detection of intravenous injection with sensitivity and specificity close to 100%, under halogenated anaesthesia. Warning symptoms are cardiac frequency modification (an increase or decrease by 10 beats per minute), increased in blood pressure (up to 15mmHg), or T-wave amplitude change in

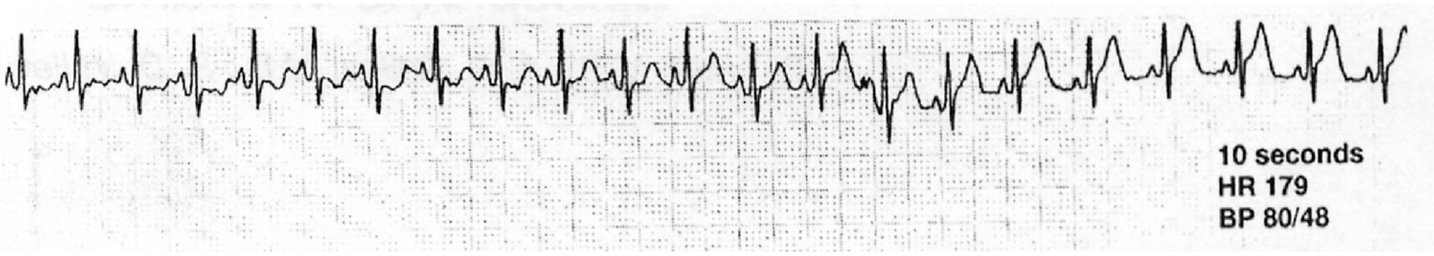


Figure 9. *T-wave amplitude change after intravascular injection of a local anaesthetic agent*

the 60 to 90 second period after injection (Figure 9).[16,17] Slow injection of the whole LA dose under haemodynamic and ECG monitoring remains essential for patient safety.

Full dose

The volume of caudally injected LA determines the spread of the block and this must be adapted to surgical procedure (Table 1). Analgesic spread will be two dermatomes higher on the down positioned side at the time of puncture. Injected volume must not exceed 1.25 $ml.kg^{-1}$ or 20 to 25ml, in order to avoid excessive cerebrospinal fluid pressure.

Table 1. *Spread of block as a function of caudally injected local anaesthetic volume*[18]

Volume ($ml.kg^{-1}$)	Dermatomal level	Indication
0.5	Sacral	Circumcision
0.75	Inguinal	Inguinal herniotomy
1	Lower thoracic (T10)	Umbilical herniorraphy, orchidopexy
1.25	Mid thoracic	

LA choice prioritizes long lasting effects with the weakest motor block possible, since motor block is poorly tolerated in awake children. Bupivacaine meets these criteria. More recently available, ropivacaine and L-bupivacaine have less cardiac toxicity than bupivacaïne at equivalent analgesic effectiveness. They may also confer a more favorable differential block (less motor block for the same analgesic power) and the 2.5$mg.ml^{-1}$ (0.25%) concentration is optimal for these agents. Four to six hours analgesia is usually achieved with minimal motor block.[19,20]

Maximal doses must not be exceeded (Table 2) but use of a more dilute mixture may allow the desired volume to be achieved within the recommended maximum dose. Hemodynamic effects of CA are weak or absent in children, so intravenous fluid preloading or vasoconstrictive drugs are unnecessary.

Table 2. *Maximal allowable doses of local anaesthetic agents*

	Plain local anaesthetic ($mg.kg^{-1}$)	With epinephrine ($mg.kg^{-1}$)	Neonates
Bupivacaine	2	2	
Lidocaine	3	7	↓ 20%
Ropivacaine	3	3	

Additives

Tables 3. *Several additives prolong CA duration when added to LA.*

Additive agent	Dose/concentration
epinephrine	5$mcg.ml^{-1}$
fentanyl	1$mcg.kg^{-1}$
clonidine	1-2$mcg.kg^{-1}$
preservative-free S(+) ketamine *(note - not the intravenous form)*	0.5$mg.kg^{-1}$

COMPLICATIONS

Complications of CA are uncommon (0.7 per 1000 cases), are more likely if inadequate equipment is used and are more frequent in infants.[16] If the technique fails it should be abandoned to avoid occurrence of potentially serious complications.

Significant complications, in order of decreasing frequency, are:

- **Dural tap.** This is more likely if the needle is advanced excessively in the sacral canal when subarachnoid injection of local anaesthetic agent may cause extensive spinal anaesthesia. Under general anaesthesia this should be suspected if non-reactive mydriasis (pupillary dilation) is observed.
- **Vascular or bone puncture** can lead to intravascular injection and consequently LA systemic toxicity. Preventative measures are use of a test dose, cessation of injection if resistance is felt and slow injection under hemodynamic and ECG monitoring. Sacral perforation can lead to pelvic organ damage (e.g. rectal puncture).
- **Exceeding the maximal allowed LA dose** risks overdose and related cardiovascular or neurological complications.
- **Delayed respiratory depression** secondary to caudally injected opioid.
- **Urinary retention** - spontaneous micturition must be observed before hospital discharge.
- **Sacral osteomyelitis** is rare (one case report).[22]

CONCLUSION

This technique has an established role in paediatric regional anaesthesia practice since it is easy to learn and has a favorable risk/benefit ratio. Despite being more complex to learn, alternative peripheral regional anaesthesia techniques are gaining popularity and may begin to replace caudal anaesthesia as a popular choice.

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