Caudal anaesthesia under sedation: a prospective analysis of 512 infants and children


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Background. Caudal anaesthesia is a common procedure for infants and children undergoing subumbilical surgery, mostly performed in conjunction with general anaesthesia. Even if complications are rare, the risk of postoperative apnoea is significant, especially in infants born preterm or operated upon before 46 weeks of post-conceptual age. Caudal block in sedated, spontaneously breathing patients might be a safe alternative.

Methods. We investigated 512 infants and children. Premedication consisted of midazolam, sedation was induced with i.v. nalbuphine 0.1 mg kg\(^{-1}\) and propofol 1 mg kg\(^{-1}\), and maintained with propofol 5 mg kg\(^{-1}\) h\(^{-1}\) in children, if necessary. Caudal block was performed with ropivacaine 1 ml kg\(^{-1}\) (0.2% or 0.35%).

Results. Data were obtained from 228 infants and 284 children. Median (IQR) age was 1.3 (0.2, 3.4) yr; median body weight was 10.0 (4.8, 15.3) kg. Two hundred and thirty-three (45.51%) were born preterm and 47 (9.18%) were operated upon before 46 weeks of post-conceptual age. Caudal block was successful in 98.05% and adverse events occurred in 7.03% patients. The incidence of adverse events was not higher in born preterm or operated upon before 46 weeks of post-conceptual age than in term born infants (\(P=0.35\) and 0.35, respectively), or in infants vs children (\(P=0.61\)). There was no correlation between the incidence of adverse events and continuous sedation (\(P=0.07\)), coexisting diseases (\(P=0.11\)), or ASA classification (\(P=0.33\)).

Conclusions. Caudal anaesthesia under sedation is associated with high success rates and a low incidence of adverse events, but requires careful and anticipatory perioperative management.

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Caudal anaesthesia is the most commonly performed regional anaesthetic technique in infants and children undergoing inguinal, anorectal, and lower extremity surgery procedures. The majority of caudal blocks are still performed in conjunction with general anaesthesia.\(^1\) Even if serious complications of general anaesthesia with modern anaesthetic agents are rare, the risk of postoperative apnoea is significant, especially in infants born preterm and operated upon before 46 weeks of post-conceptual age.\(^2\) Caudal block and subsequent surgery in sedated, spontaneously breathing infants and children might be a safe alternative.

Some case reports\(^1,4\) and only a few small studies have been published on caudal anaesthesia as a sole anaesthetic technique.\(^5–7\) Large case series about the benefits and adverse events are still missing.

We therefore designed a study to analyse the feasibility of caudal anaesthesia for subumbilical surgery under sedation in a large case series of infants and children.

Methods

After Institutional Ethics Committee approval, 512 consecutive ASA I–III infants and children, aged up to 6 yr, weighing up to 25 kg undergoing subumbilical surgery from January 2007 to October 2009, were enrolled in this study. Informed consent was obtained from the parents of
all infants and children. The patients had no contraindications to caudal block or history of allergy to local anaesthetics. Exclusion criteria were ASA status >III, anatomic abnormalities in the caudal region, and parental refusal to participate in the study.

**Patient evaluation**

In a preprocedure interview, all parents were instructed about patient fasting as recommended by the ‘American Society of Anesthesiologists Preprocedure Fasting guidelines’: clear liquids were withheld for at least 2 h, breast milk for 4 h, and infant formula and solid food for 6 h. The fasting periods were applied to all ages.8

**Premedication**

One hour before induction, an eutectic mixture of lidocaine 2.5% and prilocaine 2.5% (EMLA cream) was applied on the back of both hands, and on the caudal region, to reduce puncture pain.

Infants were premedicated rectally with midazolam 1 mg kg–1; children were premedicated rectally or orally depending on patient’s age and compliance also with midazolam 1 mg kg–1. Oral midazolam was mixed with syrup 1:10. The total dose of midazolam did not exceed 15 mg, and the orally administered volume did not exceed 3.3 ml. If an i.v. access had previously been established, patients were premedicated with midazolam 0.1 mg kg–1 i.v.

Then patients were transferred into the operating theatre, placed on a forced-air warming device (Bair Hugger warming blanket, Arizant Inc., Eden Prairie, MN, USA), and an i.v. line was established. If premedication did not provide adequate sedation for i.v. cannulation, inhalational sedation with 100% oxygen plus sevoflurane up to 8% via a facemask was performed and discontinued after successful insertion.

According to the hospital protocol, Ringer’s lactate/glucose 4:1 was administered in infants and Ringer’s lactate in children, at an infusion rate of 10 ml kg–1 h–1.

Standard monitoring included ECG, non-invasive arterial pressure, peripheral oxygen saturation (SpO2), and end-tidal carbon dioxide ($\text{CO}_2$). Vital signs were monitored continuously during the procedure and recorded at 5 min intervals. SpO2 and ECG were monitored during the first 24 h after operation in patients up to an age of 60 post-conceptual weeks. All other patients received standard monitoring during the immediate postoperative period in the post-anaesthesia care unit.

**Sedation regimen**

Sedation was induced with nalbuphine 0.1 mg kg–1 and a loading dose of propofol 1 mg kg–1, administered over 30 s. If necessary, supplemental doses of propofol 0.5 mg kg–1 were administered until adequate sedation was achieved. Sedation was considered adequate, when the patient was unconscious and arousable only with significant physical stimulation.9 The maintenance of spontaneous respiration was verified and a mixture of 50% oxygen in air was administered via a facemask. Sedation was maintained with propofol 5 mg kg–1 h–1 in children older than 1 yr, if necessary.

**Caudal block**

The patients were turned into the left lateral position, and 1 ml kg–1 ropivacaine 0.2% or 0.35% was injected into the caudal space under aseptic conditions. According to the hospital protocol, ambulatory patients and infants below an age of 60 post-conceptual weeks received ropivacaine 0.2%, whereas in-hospital patients received ropivacaine 0.2% or 0.35%, depending on the requested level of motor block. When the anticipated surgical time was more than 1 h and the child was older than 1 yr, clonidine 2 μg kg–1 was added.

An ‘immobile needle technique’ was performed using a 30 mm, 24 G Quincke needle connected with a 25 cm injection line (Marhofer Set, Pajunk Inc., Geisingen, Germany).

The patients were turned supine immediately after caudal block. Skin incision followed 15 min later.

**Definitions**

Infants were defined as born preterm when born at a gestational age <37 weeks.

Caudal block was defined as successful, when patients remained haemodynamically stable (for definitions see below), and in the absence of lower limb movements after surgical incision. Insufficient surgical block resulted in general anaesthesia with laryngeal mask airway insertion.

Apnoea was defined as the cessation of respiratory movements of more than 15 s or less when combined with oxygen desaturation below 80% and treated with assisted ventilation via a bag-valve mask until spontaneous respiration resumed. Caffeine citrate 10 mg kg–1 was administered in all infants with a post-conceptual age of <60 weeks at the end of the surgical procedure.

Bradycardia was defined as a decrease in heart rate below 110 beats min–1 in infants, and 90 beats min–1 in children, and treated with supplemental oxygen or atropine 20 μg kg–1 as appropriate. Tachycardia was defined as an increase in heart rate above 160 beats min–1 and treated with a bolus of 10 ml kg–1 fluid, or additional analgesics, as appropriate.

**Statistical analysis**

Data are presented as median (IQR) or mean (SD) depending on their distribution. Further analysis was performed with Student’s t-test or Mann–Whitney U-test for continuous data and Fisher’s exact test for frequency data. An analysis of variance (ANOVA) was used to compare ASA, coexisting...
diseases, and adverse events, with Fisher’s LSD as post hoc test. Since the type of the study is descriptive, P-values have not been corrected for multiple testing and are exploratory. SAS 9.1 (Cary, NC, USA) was used for statistical analysis. A value of \( P < 0.05 \) was considered significant.

**Results**

Data were obtained from 512 consecutive patients who received caudal block for subumbilical surgery. No parental refusal was observed throughout the study period. Patient characteristic and morphometric data are presented in Table 1. The different types of surgery are presented in Table 2.

Sevoflurane was used for establishment of venous access in 147 patients (29.4%). Ropivacaine concentration was 0.2% in 259 (50.59%) and 0.35% in 253 (49.41%) of blocks, and clonidine 2\( \mu g \)kg\(^{-1}\) was added 42 (8.20%) times. Caudal puncture was successful in 98.05% of cases. Insufficient block (\( n = 10 \)) was always caused by poor anatomical landmarks and subsequent impossibility of correct needle placement.

Three hundred and ninety-one (76.37%) patients did not require further sedation after caudal block. No infant required additional sedation after successful caudal block. One hundred and twenty-one (42.61%) of the 284 children older than 1 yr required continuous propofol infusion during surgery. Intraoperatively, self-limiting movements of the non-blocked areas were documented in 77 of 512 (15.04%) patients, and only 19 of these patients required further sedation.

In 36 (7.03%) patients, adverse events were recorded (Table 3). Short apnoea after the induction of sedation required assisted ventilation via a bag-valve mask until spontaneous respiration reoccurred. Laryngospasm and stridor were treated in all cases with conservative management.

The incidence of adverse events was not higher in born preterm and operated upon before 46 weeks of post-conceptual age than in infants born at term (\( P = 0.35 \) and 0.35, respectively), or in infants vs children (\( P = 0.61 \)). There was no correlation between continuous sedation and the incidence of adverse events (\( P = 0.07 \)). Furthermore, there was no statistically significant correlation between coexisting disease, or ASA classification, and the incidence of adverse events (\( P = 0.11 \) and 0.33, respectively).

**Discussion**

To the best of our knowledge, this prospective, observational study documents the largest series of caudal anaesthesia under sedation in infants and children. We could demonstrate that this anaesthetic regimen is associated with high success rates and a low incidence of adverse events. We recommend this regimen for subumbilical surgical procedures in infants and children.

A large number of infants and small children require inguinal, anorectal, and lower extremity surgery. Caudal anaesthesia is established to be safe in these patients, because the procedure is technically simple to perform, the success rate is high, and complications are rare and

### Table 1 Patient data. Values are median (IQR), percentage, or numbers.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>1.3 (0.2, 3.4)</td>
</tr>
<tr>
<td>Age &lt;1 yr</td>
<td>228 (44.53%)</td>
</tr>
<tr>
<td>Born preterm</td>
<td>233 (45.31%)</td>
</tr>
<tr>
<td>Operated upon before 46 weeks of post-conceptual age</td>
<td>47 (9.18%)</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>399/113</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>10.0 (4.8, 15.3)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>80 (57, 101)</td>
</tr>
<tr>
<td>ASA status (I/II/III)</td>
<td>421/77/13</td>
</tr>
<tr>
<td>Coexisting disease</td>
<td>97 (18.95%)</td>
</tr>
</tbody>
</table>

### Table 2 Types of surgery. Data are presented as numbers and percentages.

<table>
<thead>
<tr>
<th>Surgery</th>
<th>n=512</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inguinal hernia repair, unilateral</td>
<td>280 (54.70%)</td>
</tr>
<tr>
<td>Orchidopexy</td>
<td>42 (8.20%)</td>
</tr>
<tr>
<td>Circumcision</td>
<td>41 (8.01%)</td>
</tr>
<tr>
<td>Inguinal hernia repair, bilateral</td>
<td>31 (6.05%)</td>
</tr>
<tr>
<td>Hydrocele repair</td>
<td>21 (4.10%)</td>
</tr>
<tr>
<td>Hypospadia repair</td>
<td>20 (3.91%)</td>
</tr>
<tr>
<td>Rectal abscess incision</td>
<td>19 (3.71%)</td>
</tr>
<tr>
<td>Cystoscopy</td>
<td>14 (2.73%)</td>
</tr>
<tr>
<td>Coloscopy</td>
<td>6 (1.17%)</td>
</tr>
<tr>
<td>Other</td>
<td>38 (7.42%)</td>
</tr>
</tbody>
</table>

### Table 3 Adverse events. Data are presented as numbers and percentages. *Infants >46 weeks of post-conceptual age

<table>
<thead>
<tr>
<th>Age</th>
<th>&lt;1 month</th>
<th>1–6 months</th>
<th>6 months–1 yr</th>
<th>1–3 yr</th>
<th>&gt;3 yr</th>
<th>Total</th>
<th>% rel. to all patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of patients</td>
<td>22</td>
<td>145</td>
<td>61</td>
<td>131</td>
<td>153</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>Born preterm</td>
<td>8</td>
<td>81</td>
<td>23</td>
<td>53</td>
<td>68</td>
<td>233</td>
<td></td>
</tr>
<tr>
<td>Operated upon before</td>
<td>22</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>46 weeks of post-conceptual age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apnoea</td>
<td>1</td>
<td>3*</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>18</td>
<td>3.52</td>
</tr>
<tr>
<td>Laryngospasm</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>1.37</td>
</tr>
<tr>
<td>Stridor</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>1.37</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0.39</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0.39</td>
</tr>
</tbody>
</table>
However, there are still controversies about the use of caudal anaesthesia in conjunction with general anaesthesia or as an awake technique. On the one hand, it is suggested that awake caudal block may be stressful for the child, is associated with a significant failure rate, and requires experienced performers. Sedation during the performance of the block might minimize these limitations. Our sedation regimen provided optimal conditions for caudal puncture represented by our success rate of more than 98%. The use of ultrasound for caudal puncture with direct visualization of the spread of local anaesthetic may possibly further increase this success rate. A controlled study is planned to determine this potential improvement.

On the other hand, general anaesthesia is regarded to be safe, but the risk of postoperative apnoea and hypoxaemia is not negligible in infants who are born preterm and operated upon before 46 weeks of post-conceptual age. The probability of apnoea in these patients may be up to 20%, especially in infants with a post-conceptual age <45 weeks. The rate of apnoea in our patients was very low, and no difference between infants, who are born preterm or operated upon before 46 weeks of post-conceptual age, and children was observed. However, infants at risk of postoperative apnoea received prophylactic caffeine. Adverse events resulting in respiratory support and subsequent tracheal intubation were not detected. Short apnoea after induction of sedation required short bag-valve-mask ventilation until spontaneous respiration reoccurred. The 14 patients who suffered from laryngospasm and stridor could be treated with conservative management.

The potential for adverse events may be increased when three or more sedating medications are administered. Nevertheless, we have used the described regimen successfully in our department for several years. It was published previously in 500 infants and children undergoing magnetic resonance imaging.

One may argue that adding the partial agonist–antagonist opioid nalbuphine to a sedation regimen is not necessary for the performance of caudal puncture. However, it was included in our protocol, since nalbuphine is described to decrease the frequency of unintentional movements induced by propofol. Owing to the additional sedative effect of nalbuphine to propofol, we provide sufficient sedation with low propofol dosages. Using propofol alone would require higher doses to achieve sufficient sedation, and the requested level of sedation may slip easily to unintended level of anaesthesia with the loss of spontaneous respiration. Furthermore, it should be mentioned that propofol, administered in high doses for long-term sedation, seems to increase the risk of ‘propofol infusion syndrome’ in both children and adults. However, no case report of propofol infusion syndrome after short-term sedation is documented until now, and most institutions administered higher propofol doses than we did. Additionally, unexpected neurological sequelae after propofol anaesthesia were reported recently in three infants, but the causal relationship between propofol anaesthesia and the neurological symptoms could not be ascertained by the authors. Nevertheless, clinicians should be aware of possible unusual propofol-related adverse events.

All infants remained asleep after the performance of the block. Some papers have already mentioned the sedative effects of sensory deafferentation after spinal block in infants. Additionally, changes in EEG tracings after awake caudal block in infants have been observed too. A systemic sedative effect of the local anaesthetic thus cannot be excluded completely. However, none of our patients showed any other signs of local anaesthetic toxicity, like seizures, or ECG changes.

Caudal block under sedation is a safe and effective procedure for paediatric subumbilical surgery. The incidence of adverse events was low, and we recommend this anaesthetic regimen for subumbilical surgery in infants and children.

Conflict of interest
None declared.

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