Caudal anaesthesia for postoperative pain relief in children: a comparative trial of different regimens using plain bupivacaine

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Key words: ANALGESIA, POSTOPERATIVE; ANAESTHETICS, LOCAL, BUPIVACAINE; ANAESTHETIC TECHNIQUE, REGIONAL, CAUDAL

Summary
A comparative trial between three different dosage regimens of bupivacaine administered by the caudal route, used for the prevention of postoperative pain in children undergoing elective inguinal herniotomy or ligation of patent processus vaginalis was undertaken.

The regimens compared were bupivacaine 0.25% (1 ml/kg), bupivacaine 0.25% or 0.5%: (Age (years)+2)/10 ml per dermatome to be blocked. This being calculated for inguinal surgery to be Age (years) + 2 ml.

A linear analogue pain scale was used to evaluate pain, all three regimens being found to produce excellent anaesthesia, there being no significant difference between the pain scores of the three groups.

Time to onset of analgesia, as indicated by changes in intra-operative heart rate in response to surgical stimulation were also similar in all groups.

No evidence of postoperative motor weakness or disturbance of bladder function was found and there were no symptoms or signs attributable to local anaesthetic toxicity.

Introduction
Epidural anaesthesia administered by the caudal route is regularly employed by anaesthetists as a means of preventing postoperative pain in children undergoing surgery at a level below the umbilicus. Many reports attest to the ease of performing this procedure, and to its efficiency (1-4). It has also been shown to be superior to conventional opiate analgesics in the early postoperative period (5).

Bupivacaine appears to be the local anaesthetic most used for this purpose (6). Although epidural opiates have been shown to have considerably longer duration of action, concern remains about possible delayed respiratory complications (7).

There are many different recommendations as to the dosage of local anaesthetic used. To some extent these differences may be explained by the addition or omission of general anaesthesia or various types of sedative regimens during the operation itself. Two schemes of dosage are commonly employed in Britain (6) (Table 1). Part of this study compares the adequacy of pain relief and the incidence of any associated complications using these schemes in children undergoing elective inguinal surgery.

It has been our clinical impression that bupivacaine 0.5% given according to the Hain (8) formula is associated with an earlier onset of analgesia (as indicated by alterations of pulse rate in response to surgery) than 0.25% bupivacaine.

Accordingly, the second part of this study has been to investigate this hypothesis and also to determine whether analgesia using the higher concentrations was longer lasting and whether it was associated with a greater incidence of urinary retention, and motor blockade.

Children assigned to receive local anaesthetic solution by this formula received either 0.25% or 0.5% bupivacaine on a random double-blind basis.

Method
Sixty children were admitted to the study. All were healthy (ASA Class 1) and scheduled for inguinal surgery (herniotomy or ligation of patent processus vaginalis).

Preoperative assessment was made in all cases and premedication consisted of diazepam 0.5 mg/kg (maximum 20 mg) 1–2 h preoperatively.

The patients were assigned randomly into two groups: group A receiving 1 ml/kg 0.25% bupivacaine (20 patients), the remainder receiving Age (years) + 2 ml bupivacaine, either 0.25% or 0.5% from an ampoule masked and relabelled so that the anaesthetist was unaware of which concentration was in use (40 patients).

The sequence of study ampoules was randomised by the hospital pharmacy.

At the conclusion of the study the code was broken and patients who had received 0.25% bupivacaine were assigned to group B, and those who had received 0.5% bupivacaine became group C.

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Anaesthesia was induced in all children either intravenously using thiopentone (4.5 mg/kg) or by inhalation, using halothane with nitrous oxide–oxygen mixtures. Maintenance of anaesthesia in all cases consisted of spontaneously breathing nitrous oxide–oxygen and halothane using either a T-piece or Mapleson A system.

After induction of anaesthesia, monitoring of the ECG and blood pressure (Dinamap® 845) was instituted.

Following the establishment of monitoring of the anaesthetised child was turned into the left lateral position. A standard technique of skin cleansing and epidural placement of the local anaesthetic solution by the caudal route was adopted for all cases. The child was then returned to the supine position and taken into the operating theatre.

Readings were taken of pulse rate and blood pressure at 2 min intervals intraoperatively.

At the conclusion of surgery the patient was taken to the recovery room. Here a senior nurse, previously instructed, observed the child closely, indicating on a 10 cm linear analogue scale her assessment of the patient’s pain, from none to the worst pain imaginable. This reading was made on admission to the recovery area and at 10, 20 and 30 min afterwards. It was arranged that at each observation the results of the previous observations were not visible to the observer.

Before return to the ward, patients were assessed by one of the authors.

On return to the ward further linear analogue pain scales were recorded: on admission (taken to represent 1 h postoperatively), and at 2, 3 and 5 and 7 h postoperatively. The nursing staff were familiar with this approach to the assessment of postoperative pain.

At 5 and 7 h postoperatively, it was also recorded whether the patients had passed urine, and whether there was any weakness of the legs, indicated by ability to move them.

Although all the patients were scheduled to be assessed at 7 h postoperatively, it was found that they had all returned home by this time.

Statistical analysis was undertaken using the unpaired Student’s t test for demographic data and for intraoperative heart rates, and the Wilcoxon rank sum test for visual analogue pain scores.

**Results**

Completed pain questionnaires (linear analogue scales plus observations on micturition and motor blockade) were received for 48 of the 60 patients admitted to the study. In two cases no analgesia was observable, giving a failure rate for the procedure of 4.2%. This was gauged by increased intraoperative pulse rate and blood pressure in response to surgical manipulation, and also by the concentration of volatile anaesthetic required to maintain clinical anaesthesia. Both these patients scored 10 on the linear analogue scale on the initial reading taken in the recovery area postoperatively. These patients were managed with intramuscular diamorphine and are omitted from the statistical analyses on the assumption that the local anaesthetic solution had not been correctly placed. One of these patients was from group A and the other from group C.

The three groups were comparable in age and weight (Table II). The mean dose of bupivacaine (mg/kg body weight) received by patients in each of the three groups is shown in (Table III).

Figure 1 shows the mean linear analogue scores in each group at each of the specified times postoperatively. At no time are differences statistically significant.

Heart rates before institution of caudal anaesthesia were similar in all three groups, as was the time interval between the institution of caudal anaesthesia and surgical incision (Table IV).

There was no significant change in heart rate from baseline levels in any of the three groups during surgery (Table IV).

All patients had passed urine by 5 h postoperatively, and there was no recorded incidence of motor blockade (Table V).

**Discussion**

This study confirms previous work that caudal analgesia in children is a quick and easy procedure to perform,
Spiegel (1) used height as a guide to the dose required. His formula to obtain a level above T₁₀ was \( V = 4 + (D - 15)/2 \), where \( V \) = volume in millilitres, and \( D \) = the distance between C₇ and the sacral hiatus in centimetres.

Using height as a guide, Davenport (12) recommended a dose of lignocaine (5 mg/kg). He used lignocaine 1% for children under 5 years of age, and lignocaine 1.5% with adrenaline for children over 5 years old.

Melman et al. (2) recommended lignocaine (6–8 mg/kg) using 1.5% for children 2–6 years of age and 2% for ages 6–13 years. In both these studies caudal anaesthesia was used as a supplement to general anaesthesia.

Schulte-Steinberg and Rahlfis (13,14) studied the spread of different local anaesthetics after caudal anaesthesia in children and correlated the dose required per segment to the age, weight and height of the patient. They confirmed a correlation between these factors and the dose. The highest correlation coefficient was found between the dose per segment and the age \((r = 0.95)\).

The regression equation obtained when they used lignocaine 1% with adrenaline was \( y = 0.0588 + 0.09729 \times \text{age (years)}; y \) being the dose in ml per segment. They also found a parallel relationship with other local anaesthetics.

Hain (8) simplified this equation to obtain a dose required of \((\text{Age (years)} + 2)/10\) ml per segment to be blocked.

McGown (4), however, found weight to be a more accurate predictor of the dose per segment, and also found that the concentration of local anaesthetic did not seem to be important in determining the level of neural blockade, whereas the volume of local anaesthetic did. However, the majority of children in his study did not receive general anaesthesia as a supplement to the caudal block, and this makes comparisons with other studies difficult.

Armitage (15) found the following dosage scheme based on weight and using 0.25% bupivacaine to be effective: block of sacral nerves (eg circumcision) 0.5 ml/kg, block of lower thoracic nerves (eg inguinal herniotomy) 1 ml/kg, and block to midthoracic level (eg orchidopexy or umbilical herniotomy) 1.25 ml/kg. In all of these groups, if the volume to be given was greater than 20 ml then the concentration was reduced to 0.19% in an effort to reduce the occurrence of motor blockade.

Our study, which has compared two of the most commonly used dosage regimens, has failed to show any difference in the quality of postoperative analgesia between a group where dosage was based on weight (group A) and groups where dosage was based on age (groups B and C).

This finding is in broad agreement with the finding of Schulte-Steinberg and Rahlfis (14) who, although finding the best correlation \((r = 0.95)\) for the amount of local

![FIG. 1 Mean pain scores during first 5 h postoperatively.](image)

**TABLE IV** Heart rate and time interval between institution of caudal anaesthesia and incision (mean (SD))

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-block</th>
<th>Time interval (min)</th>
<th>Incision</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>99.6 (12.6)</td>
<td>7.5 (2.3)</td>
<td>94.5 (9.1)</td>
<td>90.7 (9.9)</td>
<td>90.9 (4.6)</td>
<td>90.6 (6.5)</td>
<td>91.5 (6.2)</td>
<td>90.5 (6.3)</td>
</tr>
<tr>
<td>Group B</td>
<td>98.0 (11.6)</td>
<td>7.4 (2.1)</td>
<td>95.1 (14.1)</td>
<td>95.6 (14.2)</td>
<td>94.3 (9.3)</td>
<td>94.8 (9.8)</td>
<td>95.2 (6.8)</td>
<td>95.1 (5.9)</td>
</tr>
<tr>
<td>Group C</td>
<td>96.0 (12.1)</td>
<td>7.7 (1.7)</td>
<td>96.0 (11.2)</td>
<td>92.1 (9.2)</td>
<td>93.4 (7.8)</td>
<td>90.8 (4.7)</td>
<td>92.6 (5.2)</td>
<td>89.5 (4.5)</td>
</tr>
</tbody>
</table>

**TABLE V** Number of patients in each group demonstrating a complication of caudal anaesthesia

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to block</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Failure to pass urine</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Postoperative weakness of legs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
anaesthetic was the age, also found a high correlation
(r=0.9) when using a regimen based on weight.

Our study also fails to show any difference in analgesia
produced by using different concentrations of local
anaesthetic (groups B and C).

This is in agreement with the work of McGown (4) who
also found that the concentration of local anaesthetic
produced no difference in the degree or duration of the
neurological blockade produced.

Taking the criterion suggested by Lunn (5) that a
linear analogue score of less than 2 cm probably indi-
cates a satisfactory degree of analgesia, we conclude
that all three dosage schemes employed in this study provide
satisfactory analgesia throughout the postoperative
period studied, none of the children requiring any addi-
tional analgesia. There was no statistical difference in
analgesia between any of the three groups.

Analysis of the heart rate throughout the operative
period revealed no significant increase after surgical
incision compared with levels measured in the anaesthe-
tic room prior to establishment of caudal anaesthesia.
This suggests that the onset of analgesia had commenced
before the surgical incision, which occurred within 8 min
of institution of caudal blockade in all groups. This does
not confirm our supposition that the use of higher con-
centrations of local anaesthetic is associated with an
earlier onset of analgesia, but in order to refute this
hypothesis it would be necessary to study shorter time
intervals between institution of caudal blockade and
surgical incision. McGown (14) abandoned the use of
bupivacaine in favour of lignocaine, finding that the
onset of blockade using bupivacaine was too slow.
However, the patients in this study did not receive
general anaesthesia as a supplement to caudal blockade,
and we would agree that it seems unlikely that had our
patients not received a general anaesthetic they would
have remained pain free. However, the block was
evidently sufficient to attenuate autonomic responses to
surgery under these conditions.

None of the patients in our study showed any altera-
tion in bladder function or motor weakness in the post-
operative period, so it is not possible for us to conclude
that the use of higher concentrations of local anaesthetic
is associated with a higher incidence of neurological
complications. This is obviously important as both these
symptoms may be distressing to both children and par-
ents, and may prolong hospital stay for operations that
are often carried out on a day case basis. This finding is
at variance with the work of Yeoman et al. (16) who
found that 31% of their patients were unable to walk 6 h
after receiving a caudal block using 0.5% bupivacaine,
using the same dosage as patients in group C of our
study. The only apparent explanation for this difference
is that in our study motor weakness was determined by
the inability of patients to move their legs, whereas
Yeoman et al. (16) actually tested the ability of the
patients to stand and walk. Armitage (15) minimises the
risk of motor blockade by reducing the concentration of
bupivacaine from 0.25% to 0.19% whenever the calcu-
lated volume is greater than 20 ml.

The maximum dose of bupivacaine used in this study
was 2.5 mg/kg (group A). Although this exceeds the
normally recommended maximum dose of 2 mg/kg, we
failed to demonstrate any signs of local anaesthetic toxic-
ity, which is in agreement with the findings of Armitage
(15) who used this dose in our 1100 cases and failed to
demonstrate any signs of local anaesthetic toxicity.

In conclusion we have confirmed that caudal anaes-
thesia is a simple and effective means of producing
postoperative analgesia in children undergoing surgery
below the umbilicus, avoiding the need to use parenteral
opiates. We have not confirmed our clinical impression
that the speed of onset of a higher concentration is
quicker. Nor, however, did we find a higher incidence of
neurological complications with the higher concentra-
tion. If we accept the adage of Steward (17) that "the
appropriate dose is the least that will assuredly produce
the desired result", it follows that the favoured regimen
for caudal anaesthesia should be that enjoyed by group
B, namely those receiving (Age (years)+2)/10 ml per
segment to be blocked of 0.25% bupivacaine.

The authors would like to thank the nursing staff in theatre, in
the recovery area, and on the paediatric surgical wards for their
help in completing the linear analogue pain scales; and to Miss
M J Mayell and Miss L Kapila for permission to study patients
under their care.

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Received 4 November 1988