Outcomes after single injection caudal epidural versus continuous infusion epidural via caudal approach for postoperative analgesia in infants and children undergoing patent ductus arteriosus ligation

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Summary
Adequate postoperative analgesia enhances deep breathing and minimizes respiratory complications after thoracotomy. This study compares postoperative outcomes after single injection caudal epidural vs continuous infusion epidural via caudal approach for postoperative analgesia in infants and children undergoing thoracotomy for patent ductus arteriosus (PDA) ligation. A retrospective chart review was performed for 27 children who had undergone PDA ligation. The children were divided into three groups. We compared patient demographics, surgical duration, anaesthesia duration, length of ICU stay, incidence of emesis requiring treatment, time required to establish regular oral intake, requirement for supplemental intravenous opioids during the first postoperative day, and length of hospital stay. For paediatric patients undergoing PDA ligation, postoperative analgesia with continuous infusion epidural via caudal approach produced shorter ICU stay, less occurrence of postoperative emesis, earlier oral intake, elimination of intravenous opioid supplementation, and shorter hospital stay compared with single injection caudal epidural techniques.

Keywords: patent ductus arteriosus; analgesia; epidural

Introduction
Pain causes suffering and physiological abnormalities in infants and children similar to those in adults. Perioperative pain may result in adverse effects in neonates undergoing cardiac surgery. Epidural
analgesia can provide effective postoperative analgesia in infants and children undergoing thoracic, abdominal, perineal and lower extremity surgery. The epidural space is most frequently approached at the lumbar or the caudal level. Single injection caudal epidural with preservative free morphine sulphate is a simple, effective, and safe method for providing postoperative analgesia in infants and children undergoing major thoracic, abdominal, and orthopaedic surgery (1). From a caudal approach, the epidural catheter can also be threaded cephalad to the thoracic level. In this study, we compared postoperative outcomes in infants and children undergoing thoracotomy for PDA ligation who had received a single injection caudal epidural versus continuous infusion epidural via the caudal approach threaded to approximately T2-4 level for postoperative analgesia.

**Materials and methods**

A retrospective chart review was performed for all infants and children undergoing thoracotomy for PDA ligation between October 1992 and September 1994. The criteria for exclusion were prematurity, co-existing major medical disease, and significant postoperative complications such as pneumothorax or pleural effusion. Twenty-seven patients were included in the study. All patients received general anaesthesia with mask inhalational induction, tracheal intubation, and epidural analgesia. All patients were extubated at the end of surgery. The epidural catheters utilized were either Preferred Medical Product 20 gauge 1.5 inch Tuohy needle with 24 gauge catheter or Abbott 18 gauge 2 inch Tuohy needle with 20 gauge catheter.

The patients were divided into three groups. Group 1 received a single injection caudal epidural of 0.25% bupivacaine 1 ml·kg⁻¹ with 1:200 000 adrenaline after induction of general anaesthesia. Group 2 received a single injection caudal epidural of 0.25% bupivacaine 1 ml·kg⁻¹ with 1:200 000 adrenaline and PFMS 50–100 μg·kg⁻¹ after general anaesthesia. Group 3 received epidural analgesia via a caudal epidural catheter threaded to approximately T2-4 level after general anaesthesia. For Group 3, an intraoperative loading dose of 0.25% bupivacaine 0.5–0.75 ml·kg⁻¹ with adrenaline 1:200 000 and PFMS 10–30 μg·kg⁻¹ was followed by continuous epidural infusion of 0.1% bupivacaine with PFMS 10 μg·ml⁻¹ initially at 0.25–0.3 ml·kg⁻¹·h⁻¹ during the first postoperative day. An infant/nonverbal child pain evaluation scale (Table 1) (2) ranging from 0 (no pain) to 10 (severe pain) was utilized to measure pain. Postoperatively, patients in Groups 1 and 2 received supplemental intravenous opioids, fentanyl 0.5–1 μg·kg⁻¹ every 0.5–1 h or morphine 50–100 μg·kg⁻¹ every 1–2 h, as necessary to maintain pain scores below 4. Postoperatively, Group 3 patients received epidural catheter infusion rate increases in increments of 10% every 1–2 h up to a maximum rate of 0.5 ml·kg⁻¹·h⁻¹, as necessary to maintain pain scores below 4. According to our protocol, if the maximum infusion rate of 0.5 ml·kg⁻¹·h⁻¹ was insufficient to maintain pain scores below 4, the continuous infusion epidural would be discontinued and replaced with intravenous opioids, fentanyl 0.5–1 μg·kg⁻¹ every 0.5–1 h or morphine 50–100 μg·kg⁻¹ every 1–2 h.

The following variables were analysed: patient demographics, surgical duration, anaesthesia duration, length of ICU stay, incidence of emesis requiring treatment, time required to establish regular oral intake, requirement for supplemental intravenous opioids during the first postoperative day, and length of hospital stay. From October 1992 to September 1994, perioperative protocols for patients...
<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
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</thead>
<tbody>
<tr>
<td>Single injection</td>
<td>Single injection</td>
<td>Continuous epidural</td>
</tr>
<tr>
<td></td>
<td>bupivacaine</td>
<td>bupivacaine plus morphine</td>
</tr>
<tr>
<td>Number of patients</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Age (months)</td>
<td>13 ± 3.3</td>
<td>22 ± 5.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>8 ± 1.2</td>
<td>10.4 ± 1.4</td>
</tr>
<tr>
<td>Surgical duration (min)</td>
<td>76.6 ± 3.0</td>
<td>76.4 ± 6.3</td>
</tr>
<tr>
<td>Anaesthesia duration (min)</td>
<td>180 ± 9.1</td>
<td>151.8 ± 9.3</td>
</tr>
<tr>
<td>ICU stay (h)</td>
<td>33.5 ± 3.5</td>
<td>36.2 ± 4.2</td>
</tr>
<tr>
<td>Emesis requiring treatment</td>
<td>33.3%</td>
<td>63.6%*</td>
</tr>
<tr>
<td>Establishment of regular oral intake (h)</td>
<td>16.5 ± 4.7</td>
<td>19.2 ± 2.1</td>
</tr>
<tr>
<td>Fentanyl iv (µg·kg⁻¹·day⁻¹)‡</td>
<td>26.1 ± 17</td>
<td>8.4 ± 1.9</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>4 ± 0.5</td>
<td>3.3 ± 0.2</td>
</tr>
</tbody>
</table>

The results are expressed as mean ± SEM. * P<0.05 vs Group 1. † P<0.05 vs Group 2. ‡ For all groups, total administered doses of supplemental intravenous opioids on the first postoperative day were converted to equianalgesic doses of intravenous fentanyl.

undergoing PDA ligation and criteria for discharging from the ICU and the hospital were unchanged. ICU discharge criteria included no major complications, stable vital signs, return to baseline neurological status, and approval by the surgical team. Hospital discharge criteria included stable postoperative course, no complications, discontinuation of all tubes and catheters, resumption of regular oral intake, and approval by the surgical team. For comparison purposes, total administered doses of supplemental intravenous opioids during the first postoperative day were converted to equianalgesic doses of intravenous fentanyl (i.e. 100 µg of morphine equals 1 µg of fentanyl). Statistical analysis was performed with ANOVA and Chi-square test (with significance accepted at P<0.05).

**Results**

The results are summarized in Table 2. There were six patients in Group 1, eleven patients in Group 2, and ten patients in Group 3. The three groups did not differ significantly in age, weight, and surgical duration. Anaesthesia duration was prolonged for Group 3 compared with Group 2 (P<0.05) and Group 1. The length of ICU stay was shorter for Group 3 compared with Group 2 (P<0.05) and Group 1. The incidence of emesis requiring treatment was lower for Group 3 compared with Group 2 (P<0.05) and Group 1. Group 2 had significantly higher incidence of emesis requiring treatment compared with both Groups 1 and 3 (P<0.05). Regular oral intake was established faster for Group 3 compared with Group 2 (P<0.05) and Group 1. No supplemental intravenous opioid was required for Group 3 compared with both Groups 1 and 2 (P<0.05). The length of hospital stay was shorter for Group 3 compared with Group 1 (P<0.05) and Group 2. None of the patients experienced pruritus, urinary retention, postoperative respiratory depression, postoperative reintubation, or convulsions. No Group 3 patients experienced any epidural catheter-related complications.

**Discussion**

Thoracotomy produces one of the most intense postoperative pain experiences (3,4). Post-thoracotomy pain derives from the surgical wound, the disruption of ribs and intercostal nerves, the damage to the chest wall and the pleura, and the presence of multiple thoracotomy tubes (5). Inadequately treated postoperative pain compromises respiratory function and interferes with recovery. Epidural morphine is effective in controlling postoperative pain following general surgery (6) and cardiac surgery (7) in infants and children.
In our study, patients having thoracotomy for PDA ligation and had received a single injection caudal epidural of 0.25% bupivacaine 1 ml kg⁻¹ with 1:200,000 adrenaline required supplemental intravenous opioids equivalent to fentanyl 26.1 ± 17 μg kg⁻¹ day⁻¹ for pain control during the first postoperative day. This finding suggested that a single injection caudal epidural using 0.25% bupivacaine 1 ml kg⁻¹ with 1:200,000 adrenaline produced incomplete postoperative analgesia following thoracotomy for PDA ligation. The single injected volume of bupivacaine was insufficient to produce prolonged effective analgesia at a thoracic level.

The small numbers of patients in all three groups made the demonstration of statistical significance not always possible. However, the overall trends suggested that following thoracotomy for PDA ligation, postoperative outcomes were more favourable in infants and children who had received continuous infusion epidural analgesia via the caudal approach rather than a single injection caudal epidural analgesia. Continuous epidural analgesia via a caudal approach resulted in longer anaesthesia duration, related to the additional time required for inserting and threading a caudal epidural catheter to approximatley T₃₋₄ level. However, the additional time requirement was more than justified by the shortened ICU stay, the decreased incidence of emesis requiring treatment, the decreased time to establish regular oral intake, the elimination of supplemental intravenous opioids, and the shortened hospital stay.

We demonstrated that continuous infusion epidural analgesia provided effective postoperative analgesia without additional systemic intravenous opioids. In addition, the decreased incidence of emesis requiring treatment and the decreased time to establish regular oral intake improved the overall postoperative patient experience. Given the current economic constraints on the health care system with the requirement for cost effectiveness, the shortened ICU stay and the shortened hospital stay are important considerations.

For children undergoing thoracotomy, epidural analgesia at the thoracic level can be achieved via a single injection from the caudal or lumbar approach, continuous infusion via a catheter threaded from caudal or lumbar approach, or continuous infusion via a catheter inserted directly at the thoracic level. Studies have demonstrated improved reliability for epidural catheters threaded to thoracic levels via a caudal approach compared with lumbar approach (8–10). Bösenberg et al. utilized the caudal approach to place thoracic epidural catheters in twenty infants undergoing biliary tract surgery; radiographic examinations confirmed that, in nineteen out of twenty patients, the epidural catheter tips were in thoracic locations (9). Gunter & Eng studied thoracic epidural analgesia via the caudal approach in 20 children; radiographic examination demonstrated that, in 17 out of 20 patients, the catheter tips were located within two vertebral levels of the targeted thoracic level (10). Blanco et al. demonstrated that lumbar insertion of epidural catheters in infants and children reached the desired thoracic level in only 22% (8). Tobias et al. reported that 63 infants and children (aged 3 months to 18 y) received directly placed T₅ to T₁₁ thoracic epidural catheters for postoperative analgesia without any adverse effects (11). In our retrospective study, the caudal approach was utilized for both single injection and continuous infusion techniques.

Epidural administration of fentanyl like lipophilic opioids produces rapid onset and more segmental analgesia. Epidural administration of small doses of morphine like hydrophilic opioids in combination with local anaesthetics may offer significant clinical advantages over systemic administration of opioids alone (12). Morphine was our choice of opioid for our study patients.

For neonates undergoing thoracotomy, epidural analgesia at the thoracic level not only provides postoperative analgesia but also decreases requirement for postoperative ventilatory support. Bösenberg et al. compared 36 neonates undergoing oesophageal atresia repair under general anaesthesia with 35 neonates undergoing the same surgical procedure under general anaesthesia combined with thoracic epidural analgesia via the caudal approach; only 16% of neonates who had received general anaesthesia combined with thoracic epidural analgesia required postoperative ventilatory support, whereas 53% of neonates who had received general anaesthesia alone required postoperative ventilatory support (13).

In children, epidural analgesia using local anaesthetics and opioids may produce complications such as respiratory depression and convulsions (14). Single injection caudal morphine has caused delayed
respiratory depression with 0.1 mg·kg⁻¹ (15) and 0.04 mg·kg⁻¹ (16). Fortunately, in our study, neither single injection caudal epidural nor continuous infusion epidural via caudal approach produced complications such as pruritus, urinary retention, respiratory depression, and convulsions. For all patients in our study, total bupivacaine doses did not exceed current recommended doses of 0.4–0.5 mg·kg⁻¹·day⁻¹ for older infants, toddlers, and children (14).

We recognized the limitations of a retrospective review, but our findings strongly suggest that for infants and children undergoing thoracotomy, postoperative analgesia was more effectively achieved by continuous infusion epidural technique via a caudal approach rather than by single injection caudal epidural techniques. The decreased incidence of emesis requiring treatment and the decreased time to establish regular oral intake contributed to improvements in patient comfort. The shortened ICU stay and hospital stay resulted in important cost savings.

References


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