Caudal Epidural Morphine for Control of Pain Following
Open Heart Surgery in Children

Kathleen R. Rosen, M.D., * David A. Rosen, M.D. *

The safety and efficacy of epidural morphine injected into the caudal space for control of postoperative pain following open cardiac surgery in children was studied. Thirty-two children between the ages of 2–12 yr for whom early postoperative tracheal extubation was anticipated were randomly assigned to control and study groups. Study subjects received a caudal injection of preservative-free morphine sulfate (0.075 mg/kg) in preservative-free normal saline (5–10 ml) following completion of surgery, but prior to awakening and extubation of the trachea. Supplemental intravenous morphine administration and pain scores were recorded for 24 h. Patients in the study group received significantly less (P < 0.05) morphine (0.32 mg·kg⁻¹·24 h⁻¹) and had significantly lower pain scores than did patients in the control group (0.71 mg·kg⁻¹·24 h⁻¹). The mean duration of complete analgesia in patients receiving caudally administered morphine was 6 h (range 2–12), but decreased analgesic requirements were noted for the entire 24 h. No respiratory depression was evident by clinical variables or repeated arterial blood gas values. Nausea without vomiting occurred in 4/16 patients in the study group. No patient described pruritis. The authors were unable to evaluate the occurrence of urinary retention because all patients had indwelling urinary catheters. They found caudal epidural morphine to be safe and effective in the treatment of postoperative pain in children following open heart surgery. (Key words: Anesthesia, pediatric cardiac. Anesthetics, epidural: morphine. Pain: postoperative. Surgery: cardiac.)

THE USE OF PERIDURAL OPIATES for the control of postoperative pain has achieved widespread recognition and acceptance in clinical practice since the introduction of this technique a decade ago.1 The technical expertise required for this pain-control modality has limited its use in children and results describing applications of epidural opiates in only 100 children have been reported in the English literature.2-8 However, the caudal approach to the epidural space for anesthesia and analgesia has been more extensively noted in children.9 Initial reports described caudal epidural morphine injection for pain relief following genito-urinary or lower extremity procedures.5 Similar analgesic therapy for thoracic pain has been described in only a few cases.4,7 The documented use of epidural opiates for analgesia in adults following thoracic procedures is similarly limited.

It was initially postulated that epidural opiates are active solely at a segmental level.10 Therefore, a thoracic epidural injection was believed necessary for the control of thoracic pain. This has been challenged,11-14 and adequate thoracic analgesia has been achieved following instillation of opiates in the lumbar epidural space. In these patients, advancement of the catheter a few cm15 or increasing the injectate volume18-14 were suggested as important in the success of this approach. The use of epidural opiates for analgesia after cardiac surgery has been also hindered by concerns about anticoagulation and potential complications. Recent studies describe safe epidural catheterization in patients with prior or subsequent anticoagulation.15-17 In this study, our objectives were: 1) to quantify the extent of pain following cardiac surgery in children, 2) to gain further experience with epidural opiates in children, and 3) to evaluate the safety and efficacy of caudal morphine in the control of pain following cardiothoracic surgery in children.

Materials and Methods

PATIENTS

Thirty-two children age 2–12 yr undergoing open cardiac surgical procedures were entered into the study if early postoperative tracheal extubation was anticipated. The ability to verbally communicate pain was necessary for documentation of the pain experience. This study received institutional approval by the human experimentation and research committee. Informed consent was obtained from parent or guardian. Patients were assigned to control or study groups by random selection of a sealed envelope noting group assignment which was opened at the end of the surgery. There were 16 patients in each group. There was no difference between the two groups with respect to age, sex, surgical approach, or cardiac lesion. The median age for both groups was 5 yr. Because of the requirement for early tracheal extubation, the cardiac anomalies were not complex. Atrial or ventricular septal defects and tetralogy of fallot account for more than 90% of the cases.

ANESTHESIA TECHNIQUE

All children received preoperative sedation with im morphine 0.15 mg/kg plus pentobarbital 4 mg/kg (maximum pentobarbital dose 100 mg). Induction of anesthesia
was achieved with inhalation of either halothane or isoflurane with nitrous oxide 50–70%. A predominantly in-halation technique was chosen for all except one patient. A retrospective analysis of the utilization of supplemental intravenous opiates intraoperatively found no significant difference between control and study patients. Activated clotting time was measured before and during administra-
tion of heparin and following antagonism of its effect with protamine. There was no clinical evidence of bleed-
ing diathesis, and activated clotting time was within 10% of control values prior to the injection of morphine into the caudal canal.

After application of the surgical dressing and prior to awakening from anesthesia, both control and study pa-
tients were placed in the lateral decubitus position and the skin overlying the sacral region was painted with a povidine-iodine solution. Control patients simply had a bandage placed at the appropriate location and were then returned to the supine position and anesthesia was ter-
mminated. In the study subjects, using a sterile technique, the caudal epidural space was entered using a 23-gauge 1-inch needle and 0.075 mg/kg of preservative-free mor-
phine was injected. The drug was diluted in preservative-
free normal saline with an injectate volume of 10 ml if the morphine dose was greater than 1 mg and 5 ml if less than 1 mg. Residual paralysis from muscle relaxant was pharmacologically antagonized and tracheal extubation followed in the operating room or immediately after transport to the intensive care unit. All patients received continuous ICU monitoring of vital signs for at least 24 h postoperatively.

POSTOPERATIVE EVALUATION

Postoperative care was provided by specially trained cardiac clinical nurse specialists. These nurses also served as experimental observers who were unaware of patient group. The observers were trained in the use of two pain evaluation scores. One pain score was a visual analog scale on which the observer selected an integer value between 0 and 10. A score of zero was labeled as no pain. A score of 10 was labeled extreme pain. The second score was based upon a modification of that described by Hannallah et al. (table 1). Assessment of pain was completed every time supplemental analgesia was required or at a minimum of every 6 h. The nurses were instructed to administer analgesic medication on a PRN basis as guided by their subjective assessment of the patient. This is not different from routine clinical practice. The opiate utilized was intravenous morphine sulphate at a dose between .05 and .2 mg/kg (mean 0.09 ± 0.03). The nurses also were in-
structed to note the occurrence, frequency, severity, and duration of any pruritis, nausea and vomiting, and respira-
tory depression.

<table>
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<th>Observation</th>
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<tr>
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<tr>
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<td>Crying and does not respond to TLC</td>
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<td>Movement</td>
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<tr>
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<td>Localizes pain</td>
<td>2</td>
</tr>
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</table>

STATISTICAL ANALYSIS

To determine differences between morphine dose for the two groups, statistical analysis was performed using Student's t test. Values are expressed as mean ± S.D. Pain scores were compared using the Mann Whitney test. Median values are noted. Significance was accepted at P < 0.05.

Results

ANALGESIC REQUIREMENTS

The patients receiving morphine in the caudal canal required 0.32 ± 0.14 mg/kg of intravenous morphine during the first 24 h postoperatively, compared with 0.71 ± 0.24 mg/kg received by patients in the control group (P < 0.01). Supplemental intraoperative opiate use was noted retrospectively to be limited to morphine 0.05–0.32 mg/kg or fentanyl 5–16 µg/kg (table 2). There was no significant difference between control and study pa-
tients for choice of intraoperative opiate or dose. Within each group, there was no significant difference in postoperative analgesic requirements as a function of intra-
operative opiate selection. By 2 h and 4 h, 75% and 100%, respectively, of control patients required supplemental analgesia. In contrast, only 12.5% and 25% of the patients in the study group were medicated at similar times (P < 0.01). Only after 12 h did all study patients need sup-
plemental analgesia. Cumulative analgesic requirements during the study period were significantly different during each time interval (P < 0.01) (table 3).
There was no significant difference between control and study patients for choice of intraoperative opiate or dose. Within the control and study groups, there was no significant difference in postoperative analgesic requirements as a function of intraoperative opiate selection.

* Level of significance for difference from control group $P < 0.03$.

**PAIN EVALUATION**

Patients who received caudal epidural morphine had significantly lower pain scores ($P < .01$) at the time of initial postoperative pain evaluation prior to any intravenous morphine. Initial median visual analog scores were 2 and 5 for the study and control groups, respectively. The initial multifactor pain scale yielded values of 1 and 5 for these groups. The median pain scores for the entire study period were also significantly different. The median pain score over 24 h was 5 for control patients on both scales. Overall median pain scores for study patients were 5 and 4 on the analog and multifactor scales, respectively (table 3).

**SIDE EFFECTS**

No patient demonstrated respiratory depression, early or delayed, as evidenced clinically by evaluation of respiratory rate and effort or by blood gas analysis. No patient received naloxone or required ventilatory support. No patient reported pruritis. Nausea was reported in four study patients receiving caudal epidural morphine and one control patient. The nausea was usually mild, and limited to a single short occurrence. A single patient in each group reported two to three episodes of nausea.

**Discussion**

Although the use of caudal injections of local anesthetic, opiate, or a combination of these two has proven safe and effective for postoperative analgesia in children following orthopedic or genitourinary surgery, no previous attempt has been made to study the efficacy of caudal opiates in the control of higher segmental pain. In this study, injection of morphine into the caudal canal attenuated the pain following open heart surgery. Furthermore, our results challenge the concept of a segmental site of action for relatively water-soluble epidural opiates, such as morphine.10 Efficacy in treatment of thoracic pain by distal epidural injection has been reported in adults.11-14 Recently, thoracic anesthesia has been described in infants through use of epidural catheters introduced via the caudal canal and advanced cephalad to the lower thoracic segments.15 We advanced neither the needle nor a catheter cephalad to insure rostral spread, nor did we use a large injection volume as previously suggested.12-14 Site of opiate injection (caudal) was much more distant than that described in adults (L1–L4).11-14 This caudal epidural injection is safe and easy to perform in even the smallest child, especially when compared with the thoracic approach. There were no neurologic complications in our patients.

We did not control two factors in the anesthetic technique, verification of proper caudal epidural instillation of drug and intraoperative opiate use. If one assumes that fentanyl has a potency of 100 compared with that of morphine, total intraoperative and postoperative opiate requirements can be compared. The total intravenous morphine equivalent dose for control patients was $0.90 \pm 0.56$
mg/kg. The total analgesic dose, intravenous and caudal, for study patients (0.48 ± 0.15 mg/kg) was significantly less (P < 0.01). If we had used local anesthetic in the injection in the caudal canal to verify accurate epidural placement of morphine or controlled the dose of intraoperative opiates, the results of this study would have further favored the administration of caudally administered morphine.

Reported duration of analgesia following thoracic epidural morphine following thoracic or upper abdominal surgery in children ranges from 4–24 h. The mean duration of analgesia in our children was 6 h with a range of 2–12 h. Although caudal morphine did not provide total pain relief following surgery, analgesic requirements were significantly reduced for 24 h. Intravenous morphine provided approximately 3 h of analgesia in control patients compared to 6–8 h in patients receiving caudal epidural morphine.

The occurrence of opiate-induced side effects was minimal. The incidence of early or delayed respiratory depression following peridural opiates in adults is reported to vary between 0.25–0.9%. We are aware of only one case report of late respiratory depression in a child. Although respiratory rate, tidal volume, minute ventilation, and end-tidal CO₂ were unaffected by epidural morphine (0.05 mg/kg) in children following abdominal or urologic surgery, ventilatory response to CO₂ was decreased for up to 22 h. We observed no respiratory depression or blood gas abnormalities. However, more sensitive studies of ventilatory function were not performed. No child in our study experienced pruritus. Previous studies note an incidence of 13–100% for itching in children. Mild nausea or vomiting occurred in 25% of patients receiving caudal morphine. An incidence similar to the 33–47% reported in children receiving epidural opiates. The distal site of injection and low dosage 0.075 mg/kg may contribute to the small incidence of observed side effects.

In summary, caudal epidural morphine is effective in children for control of postoperative pain following cardiac surgery. Although the mean duration of effect was only 6 h, supplemental analgesic requirements were reduced during the entire 24-h study period. The quality of this route of opiate analgesia was reflected in low pain scores. The only side effect observed was mild nausea in 25% of the study subjects.

References