Thoracic Epidural Anesthesia via the Caudal Approach in Children

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We investigated the feasibility of performing thoracic epidural anesthesia via the caudal approach in 20 children (age 62 ± 38 months and weight 18.5 ± 7.3 kg; mean ± standard deviation). Based on external landmarks, a predetermined length of 24-G epidural catheter (Concord Portex 20/24 microcatheter system®) with stylet was passed into the epidural space through a 20-G intravenous catheter inserted through the sacroccocygeal ligament, and a radiograph of the abdomen and chest was obtained. The radiographically determined catheter tip position was within two vertebras of the target position in 17 of 20 subjects. In one subject, it was impossible to advance the catheter more than 10 cm. The other two malpositioned catheters were successfully reinserted. Intraoperative caudal anesthesia and postoperative pain relief were satisfactory in all 20 subjects. We have found it possible to use the caudal approach to thoracic epidural anesthesia in children as old as 10 yr. Ease of removal of the stylet, ease of injection, and negative aspiration and test doses predict successful placement and obviate the need for routine radiographic confirmation of catheter position. (Key words: Anesthesia: pediatric. Anesthetic techniques: caudal; epidural.)

CAUDAL EPIDURAL TECHNIQUES have gained widespread acceptance among pediatric anesthesiologists1,2; however, anesthesia of the thoracic dermatomes from a caudal epidural injection requires large doses of local anesthetic and also includes anesthesia of the intervening sacral and lumbar dermatomes.3 Lumbar and thoracic epidural techniques offer the advantages of reduced local anesthetic requirements and development of segmental anesthesia, but these techniques are technically more challenging than caudal epidural anesthesia and are associated with the possibility of dural puncture and direct nerve injury.3,4 Two previous reports have demonstrated the feasibility of performing lumbar and thoracic epidural anesthesia via the caudal approach in infants.5,6 We investigated the feasibility of placing thoracic epidural catheters via the caudal approach in children from 1 to 10 yr of age.

Materials and Methods

This study was approved by the University’s Human Studies Committee, and written consent was obtained from each subject’s parent(s). Twenty children, ages 1–10 yr, scheduled for abdominal or thoracic surgery were recruited. Anesthesia was induced either by inhalation of halothane in nitrous oxide and oxygen or by intravenous sodium thiopental. Following induction of anesthesia, an intravenous catheter was inserted and atropine 10 µg·kg−1 was administered. Tracheal intubation was facilitated by atracurium.

The subject was then turned to the lateral decubitus position and external sacral and thoracic landmarks identified. The distance from the sacral hiatus to the target thoracic level was measured. In 13 subjects, a radiopaque marker was taped to the back lateral to the target thoracic level. The sacral area was then prepared and draped in a sterile fashion. A 20-G 1.25-inch catheter over needle (Angiocath®, Deseret Medical, Inc., Sandy, UT) was inserted through the sacroccocygeal ligament and advanced its full length into the sacral epidural space. The desired length of 24-G epidural catheter (Concord Portex 20/24 microcatheter system) was then inserted through the intravenous catheter. If resistance was encountered during insertion of the epidural catheter, it was withdrawn a short distance and twisted prior to reinsertion. If continued resistance was encountered, the catheter was withdrawn a short distance and the knees flexed to the chest to straighten the spine prior to attempts at reinsertion.

The epidural catheter was not forcibly advanced against resistance.

When the desired length of epidural catheter had been inserted, the intravenous catheter was withdrawn and the epidural catheter with radiopaque stylet in place was coiled on the back and covered by a sterile dressing. The subject was then turned supine, the genitalia and pelvis covered with a lead shield, and a radiograph of the chest and abdomen was obtained. The epidural catheter was then uncovered and the wire stylet removed. A test dose of 0.1 ml·kg−1 of 1% lidocaine with 1:200,000 epinephrine was then administered. If the heart rate did not increase by more than 10 beats·min−1 within 60 s, a loading dose of 0.175% bupivacaine with 1:200,000 epinephrine was administered incrementally with frequent aspiration tests. The loading dose of bupivacaine was calculated as 0.05 × weight (kg) × number of segments to be blocked.7

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Spread of local anesthetic from the catheter tip was assumed to be symmetric; therefore, the number of segments to be blocked was calculated as $2 \times$ (catheter tip level — desired upper anesthetic level). Subjects having perineal as well as abdominal surgery received 0.33 ml·kg$^{-1}$·h$^{-1}$ 0.175% bupivacaine through the intravenous catheter prior to placement of the epidural catheter to ensure anesthesia of the sacral dermatomes. A continuous infusion of 0.175% bupivacaine with 1:200,000 epinephrine was then started at a rate of 0.15 ml·kg$^{-1}$·h$^{-1}$.

General anesthesia was maintained with inhalation of halothane or isoflurane in nitrous oxide and oxygen (15 subjects) or air and oxygen (5 subjects). The inspired concentration of inhaled anesthetic was reduced to less than one-half MAC following surgical incision to confirm effective epidural anesthesia by lack of response to surgical stimulation. Muscle relaxation was maintained with additional doses of atracurium in subjects having intraabdominal or intrathoracic surgery; continued muscle relaxation was optional for subjects having orchiopepsy. If evidence of inadequate epidural anesthesia was seen during surgery, a bolus dose of bupivacaine equal to the hourly infusion rate was given and the infusion rate increased by 25%.

At the conclusion of surgery, the subjects were awakened and, after tracheal extubation, were transported to the postanesthesia care unit (PACU) with the epidural catheter in place. A continuous epidural infusion of 0.125% bupivacaine with 1:200,000 epinephrine was administered in the PACU at the same rate as that used during surgery. When subjects were awake, the anesthetic level was determined by light pinch on the trunk, and any discomfort was noted; if indicated, an additional bolus of 0.125% bupivacaine with 1:200,000 epinephrine was administered (test dose as above, and bolus volume calculated as above using the number of additional segments to be blocked). When subjects had an adequate level of epidural anesthesia and met all other discharge criteria, the epidural catheter was removed and the subjects were discharged to the ward.

Parametric data are presented as mean ± standard deviation. Correlation was examined using linear regression and Spearman’s rank order correlation coefficient. Results were considered significant for $P < 0.05$.

**Results**

The mean age of the subjects was $62 \pm 38$ months (range 11 months to 10 yr). The mean weight of subjects was $18.5 \pm 7.5$ kg (range 8.4–36 kg). Surgical procedures included ligation of patent ductus arteriosus ($n = 4$), ureteral reimplantation ($n = 7$), orchiopexy ($n = 4$), repair of bladder exstrophy ($n = 1$), Mitrofanoff bladder augmentation ($n = 1$), nephrectomy ($n = 1$), pyeoplasty ($n = 1$) and Soave endorectal pull-through for Hirschsprung’s disease ($n = 1$). The desired catheter location was T12 in nine, T10 in seven, and T6 in four subjects.

To confirm accuracy of external landmarks in identifying the target thoracic level, an external marker was placed on 13 of the subjects. In 11 of these, the marker was within one vertebra of the target level, and in the remaining 2 it was within two vertebrae of the target level. Catheters were threaded the predicted length in 19 of 20 subjects (fig. 1). In one subject, it proved impossible, despite manipulation, to advance the catheter beyond 10 cm; on the radiograph, the catheter was noted to take an abrupt bend laterally after entering the sacrum. Of the 19 subjects in whom the catheter was inserted the predicted length, 17 of the catheter tips were located within two vertebrae of the target location. One malpositioned catheter was coiled in the sacrum; the catheter would have been removed on clinical grounds, because the stylet was extremely difficult to remove. The second catheter was tunneled subcutaneously; this catheter also would have been removed on clinical grounds, because it was impossible to inject through the catheter. Both of these failures occurred with residents making their first attempt at caudal epidural catheter placement and were replaced without difficulty by an anesthesiologist more experienced in the technique. Blood was aspirated through one properly positioned catheter; it was successfully replaced.

The relationship between target and observed catheter tip location is shown in figure 2. Observed and target
catheter tip location showed a strong correlation and a slope equal to unity for the 17 catheters that were inserted to the predicted depth and that functioned properly (observed = 0.49 + 0.99 × target; $r = 0.873; P < 0.0001$).

Satisfactory intraoperative epidural anesthesia was achieved in all 20 subjects. No subject required an additional bolus dose of bupivacaine during surgery. Median anesthetic level in PACU was T5 (range T3–T10). Twelve subjects received additional bolus doses of bupivacaine in the PACU; mean volume dose of the bupivacaine bolus was $0.37 \pm 0.05$ ml·kg$^{-1}$. Two subjects received intravenous morphine in the PACU (30 and 50 μg·kg$^{-1}$); both subjects had ligation of patent ductus arteriosus. There was no evidence of postoperative neurologic injury (change in gait or complaint of numbness, paresthesia, or weakness) in any subject on the day after surgery or in any of the 19 subjects contacted by phone 9–12 months after surgery (no current address or phone number was available for the remaining subject).

**Discussion**

Several factors may have contributed to our success in achieving thoracic epidural anesthesia via the caudal approach in children. A previous presentation of a similar technique in children, using a 20-G catheter without a stylet, did not achieve our degree of success.§ We believe that the 24-G polyurethane catheter with the stylet was small enough to thread easily in the epidural space and stiff enough to avoid coiling. In our experience, 28-G and 32-G catheters are too flexible to thread within the epidural space and present unacceptable resistance to injection.

An intravenous catheter was used to introduce the epidural catheter, because our technique of insertion can involve advancement, withdrawal, and readvancement of the epidural catheter. Manipulation through a needle risks shearing the epidural catheter. Easy threading of the intravenous catheter into the sacrum also confirms placement within the sacral epidural space.

The epidural fat of the infant is loose and gelatinous, becoming more firmly packed as the child approaches adolescence. In our experience, almost no resistance to threading the epidural catheter is encountered in infants, whereas threading the epidural catheter in preadolescent and adolescent children may require considerable manipulation. Attempts to extend this technique to preadolescent and adolescent children have met with only limited success.

The 24-G epidural catheter required careful handling to avoid obstruction to injection due to kinking. The wire stylet ends about 4 mm proximal to the tip of the epidural catheter; it is therefore possible for the tip of the catheter to fold back on itself during insertion. If obstruction to injection is encountered on the first attempt, the catheter can be withdrawn 1 or 2 cm to allow the tip to unfold. It has now become our practice to insert the epidural catheter 1 or 2 cm beyond the predicted depth and then withdraw the catheter to the predicted depth after removing the stylet. In order to avoid kinking at the skin, the epidural catheter should exit the skin parallel to the plane of the back.

Previous examination of this technique in a piglet model revealed little potential for neurologic injury. Nonetheless, great care is required with this technique, and the epidural catheter should never be advanced forcefully against resistance. With the exception of the catheter that coiled in the sacrum, all of the catheters followed a straight path in the epidural space; however, it is possible that a catheter could become looped or knotted around a nerve root either during insertion or prolonged use. The epidural catheter should require only gentle traction to remove; if resistance is encountered during removal, extension or flexion of the back will usually relieve the resistance. If resistance still is encountered despite repositioning of the patient, forceful attempts to remove the catheter should be avoided, because forceful traction on a knotted catheter could result in nerve injury.

If it is still possible to inject through the retained epi-

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dural catheter, injection of a small amount of radiopaque dye will allow radiographic visualization of the tip of the catheter; the small caliber of the 24-G epidural catheter may make radiographic visualization of the catheter itself difficult, even with radiopaque dye in the lumen. If a knot is discovered during radiographic examination of the catheter or if it is not possible to visualize the catheter radiographically, it may be necessary to explore the epidural space surgically. Insertion of a sterile stylet into the retained epidural catheter as far as possible without resistance will allow radiographic visualization of the level at which coiling or knotting has occurred. Reinsertion of the stylet also may serve to straighten simple loops or coils in the epidural catheter. Intravenous placement of the tip of the epidural catheter in 1 of 20 subjects in this study is consistent with our overall experience with this technique. We have not experienced nor are we aware of reports of subdural placement of epidural catheters inserted via the caudal approach.

In conclusion, we have demonstrated the feasibility of performing thoracic epidural anesthesia via the caudal approach in children ages 1 to 10 yr using a 24-G epidural catheter with stylet. Routine radiographic confirmation of catheter position should not be necessary provided that the desired length of catheter is inserted, the stylet can be removed without difficulty, it is possible to inject through the catheter, and a negative aspiration test and test dose are obtained. Radiographic visualization may be helpful if difficulties are encountered during insertion, injection, or removal of the epidural catheter. This technique offers the advantage of segmental thoracic epidural anesthesia without the technical challenges and potential complications of lumbar or thoracic epidural techniques.

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References