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Caudal Anesthesia in the Awake, High-risk Infant

ROBERT M. SPEAR, M.D.,* JAYANT K. DESHPANDE, M.D.,† LYNNE G. MAXWELL, M.D.†

Caudal epidural anesthesia is an accepted and frequently utilized procedure in pediatric anesthesia.[1-3] The concomitant use of a light general anesthetic is suggested by some authors.[3] In some cases, the addition of a general anesthetic may pose additional risk to the patient and may actually be unnecessary. Because several factors place preterm infants at increased risk from general anesthesia,[4] a regional technique alone may be preferable to the combination of regional with light general anesthesia.

Spinal anesthesia has been recommended by some authors as an alternative to general anesthesia in high-risk infants.[5,6] In infants, this technique involves occasional difficulty in locating the subarachnoid space,[5] and has a relatively short duration of anesthetic effect.[5,6] We evaluated the efficacy of caudal epidural anesthesia in seven consecutive, awake, high-risk infants undergoing lower body surgical procedures and report our experience with this technique.

MATERIALS AND METHODS

Seven consecutive patients were retrospectively studied. All were given no feeding for approximately 6 h and received no premedication. Intraoperative monitoring consisted of precordial stethoscope, ECG, pulse oximeter, and automated blood pressure cuff. An intravenous cannula was placed and an infusion of 5% dextrose in 0.45% saline was started (4 ml · $kg^{-1} \cdot h^{-1}$). Each patient was then placed in the lateral position and the back was cleansed with 10% povidone-iodine solution. A 22-gauge short-beveled needle was placed into the caudal epidural space using an accepted technique.[3] The needle was aspirated for evidence of blood or cerebrospinal fluid before local anesthetic injection. Bupivacaine 0.25% with epinephrine 1:200,000 was given in 1.0-ml increments, to a total dose of 2.5–3.25 mg/kg (1.0–1.3 ml/kg). The needle was then removed and the patient positioned for surgery. All caudal injections were performed by the anesthesiology resident rotating on the pediatric anesthesia service. Sensory levels were estimated by assessing facial grimace and aversive response to a manual pinch. Midazolam was used for sedation in four patients (table 1).

RESULTS

All patients were ASA physical status II or III and were classified as high-risk infants, based on the presence of bronchopulmonary dysplasia (patients 3, 4, and 7), cardiomyopathy (patient 6), chronic diarrhea with failure to thrive (patient 5), or postconceptual age less than 53 weeks (patients 1 and 2). The mean gestational age at birth was 29 (±4) weeks (range 25–36 weeks), with a mean birth weight of 1114 (±607) grams (range 635–2500 g). At the time of surgery, the patient's mean age was 7 (±4) months (range 3–13 months), and mean body weight was 4.5 (±1.3) kilograms (range 2.2–6.3 kg). All infants were awake and responsive during the caudal injection and during the operation. Patient 1 became restless and cried during deep inguinal dissection. The pain was relieved following a supplemental ilioinguinal/iliohypogastric nerve block performed by the surgeon. The child later became restless during traction of the spermatic cord. The discomfort was alleviated with 0.06 mg/kg of intravenous midazolam. No other patient showed any evidence of discomfort. The level of sensory analgesia achieved in five patients is shown in table 1. Supplemental oxygen was administered only if it was part of the preoperative therapy, except in patient 1. In this infant, a brief period of apnea occurred immediately following intravenous midazolam administration during which oxygen saturation decreased to 93% and heart rate decreased from 128 to 100 bpm, both of which responded immediately to tactile stimulation. This child experienced no further apnea but was given supplemental oxygen for the remainder of the procedure. Apnea was not seen in any other patient. Oxygen saturation remained 97–100% in all other patients. Except for the transient decrease in heart rate in patient 1, there were no clinically significant differences in heart rate or arterial blood pressure following caudal anesthesia in any patient, either in the operating room or recovery room. We have had no

* Instructor.
† Assistant Professor

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Address reprint requests to Dr. Spear: Director of Pediatric Intensive Care, UCSD Medical Center, H-814, 225 Dickinson Street, San Diego, California 92103.

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TABLE 1. Caudal Anesthesia Data in High-risk Infants

Patient	Underlying Disease	Surgical Procedure	Duration of Surgery (Min)*	Bupivacaine (mg/kg)	Sensory Level (t)	Sedation Prior to Caudal (mg/kg)	Sedation Following Caudal (mg/kg)
1	Premature	BIH, orchiopexy	90	2.5	T11 (90)	Midazolam 0.15 iv	Midazolam 0.05 iv
2	Premature	BIH	60	3.0	T1 (60) T4 (120)	Midazolam 0.75 PR	Midazolam 0.3 iv
3	BPD, paralyzed diaphragm	Removal of groin catheter	25	2.75	NM	None	None
4	BPD, seizures	Femoral vein cutdown	60	2.9	NM	None	None
5	Premature	Proctoscopy to 10 cm	35	2.75	T6 (35)	Midazolam 0.22 iv	Midazolam 0.06 iv
6	Cardiomyopathy, myopathy	Leg muscle biopsy	60	2.5	T10 (60)	None	None
7	BPD, apnea	BIH, circ	90	3.25	T2 (90)	Midazolam 0.75 PR	None

t = time in minutes following caudal injection that sensory level was measured; BIH = bilateral inguinal herniorrhaphy; PR = per rectum; circ = circumcision; NM = not measured; BPD = bronchopulmonary dysplasia.

* Length of operation from injection of caudal until surgery completed.

patient require general anesthesia following caudal anesthesia.

DISCUSSION

Caudal epidural anesthesia is a common technique utilized by pediatric anesthesiologists, both as an adjunct to general anesthesia and as an effective means of providing postoperative pain relief.[3] We utilized this technique in awake and sedated infants who were at substantial risk of respiratory complications from general anesthesia. Caudal anesthesia is a technically simple procedure to perform in infants and children as identification of the sacral hiatus and puncture of the sacrococcygeal membrane are easily accomplished. Its safety has been demonstrated in a large series[7] and is supported by studies of subarachnoid and epidural blockade in infants and small children in which minimal changes in heart rate and blood pressure occurred despite high-thoracic sensory blockade.[8,9]

Based on information derived from adults, investigators may have been reluctant to attempt or recommend caudal anesthesia for high-risk infants because of the impression that the intensity of the sensory block achieved with caudal epidural bupivacaine 0.25% would not be sufficient as the sole anesthetic for operative procedures.[10] The intensity of the sensory block achieved in infants with bupivacaine 0.25% might be greater than that seen in adults. In six of our seven patients, bupivacaine 0.25% with epinephrine 1:200,000 provided complete surgical anesthesia. We also noted a lack of lower extremity motor activity in our patients. Although we loosely restrained the lower extremities in our patients, no leg or pelvic movement was noted during the operations. Furthermore, relaxation was adequate for inguinal hernia repair as long as the child was not crying. A recent study in children has shown that 0.25% bupivacaine does indeed cause motor blockade.[11] Furthermore, sensory blockade adequate for postoperative pain relief is achieved with 0.125% bupivacaine.[11] Armitage suggested using a volume of 1.0 ml/kg of bupivacaine 0.25% when a block involving the lower thoracic nerves was necessary (*e.g.*, inguinal herniorrhaphy) and using 1.25 ml/kg when a block of the midthoracic nerves was desired (*e.g.*, umbilical herniorrhaphy).[12] We used 1.0–1.3 ml/kg (2.5–3.25 mg/kg) of bupivacaine 0.25% with epinephrine 1:200,000 and achieved adequate sensory levels in six of seven patients (table 1). As would be expected, our highest sensory levels correlated with higher volumes (ml/kg) of local anesthetic. In patients 2–7, there was no evidence of discomfort at any time during the operation. In retrospect, had we used a larger volume of caudal, local anesthetic (*e.g.*, 1.3 ml/kg) in patient 1, a higher block likely would have resulted in this patient.

Although large studies evaluating serum bupivacaine concentrations following caudal epidural anesthesia in infants are not available, data suggest that the dose we used (2.5–3.25 mg/kg of bupivacaine) would result in levels less than 4 μg/ml, a level above which systemic toxicity is believed to occur.[10] In a study of caudal anesthesia using bupivacaine 0.5% with epinephrine 1:200,000 at a bupivacaine dose of 3.7 mg/kg, peak serum bupivacaine concentrations averaged 0.67

μg/ml.[13] Ecoffey *et al.*[14] used 2.5 mg/kg of plain bupivacaine for caudal anesthesia and showed average peak serum bupivacaine concentrations of 1.25 μg/ml. Epinephrine may be responsible for the lower serum levels, despite a larger bupivacaine dose, by reducing systemic absorption. We believe epinephrine is necessary as an early indicator of inadvertent intravascular injection. We give incremental injections, aspirating intermittently, and monitor for changes in heart rate and arterial blood pressure. We did not observe any central nervous system or cardiovascular signs of local anesthetic toxicity in our patients.

In summary, we performed caudal anesthesia easily and safely in seven consecutive, awake or sedated, high-risk infants. An adequate level of block was obtained using 1.0–1.3 ml/kg of bupivacaine 0.25% with epinephrine 1:200,000, although one patient required a supplemental ilioinguinal/iliohypogastric block for deep exploration of the inguinal area on one side. Our observations indicate that caudal epidural anesthesia is a useful anesthetic technique for lower extremity, anorectal, and inguinal procedures in high-risk infants and obviates the necessity for general anesthesia and endotracheal intubation.

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Comparison of Lidocaine and Prilocaine for Intravenous Regional Anesthesia

ANGELA M. BADER, M.D.,* MERCEDES CONCEPCION, M.D.,† RONALD J. HURLEY, M.D.,*
G. RICHARD ARTHUR, PH.D.†

Intravenous regional anesthesia (IVRA) is an effective method of producing anesthesia of an extremity with rapid onset and recovery. There has been considerable controversy regarding the most appropriate drug for IVRA.[1,2] Lidocaine is probably the local anesthetic most commonly chosen for this technique in the United States.

Prilocaine is better tolerated in terms of systemic toxicity than lidocaine.[3,4] Circulating prilocaine concentrations are less than those of lidocaine when equal doses of the two agents are administered for regional blockades.[5] This would suggest that prilocaine may be of particular advantage in an anesthetic technique in

* Instructor in Anesthesia.
† Assistant Professor of Anesthesia.
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Address reprint requests to Dr. Bader: Brigham and Women's Hospital, 75 Francis Street, Boston, Massachusetts 02115.
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