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Dosage of Lidocaine for Caudal Anesthesia in Infants and Children

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For determination of dosage for caudal anesthesia in children, Speigel¹ has proposed an empirical formula based on the distance from the spinous process of the seventh cervical vertebra to the sacral hiatus (D). However, unnecessarily high levels of anesthesia are sometimes attained, especially in infants,² and it may be difficult to determine the distance "D" in daily practice. Schulte-Steinberg and Rahlfs³ proposed a formula for dosage based on age, but their study involved only a small number of children. The purpose of the present study was to re-evaluate dose requirements for caudal anesthesia in a large series of infants and children.

METHODS

Caudal anesthesia for surgical or diagnostic procedures was performed on 250 children, newborn to 7 years of age. Patients requiring epidural catheterization for continuous analgesia were not included in this study. Informed consent had been obtained from the parents. Children more than 1 month old undergoing elective procedures received secobarbital, 6.5 mg/kg (not exceeding 100 mg), and atropine, 0.015 mg/kg, intramuscularly one hour prior to induction of anesthesia. Further sedation with meperidine, 1 mg/kg, intramuscularly, was given to 120 of the children.

To ensure a motionless and unconscious patient for placement of the intravenous cannula and the epidural needle, general anesthesia was induced with halothane, nitrous oxide and oxygen by mask, using a nonbreathing technique. After infusion of 5 per cent dextrose in water or lactated Ringer's solution (10 mg/kg/hr) through an intravenous cannula, the inhalational anesthetic agents were discontinued to assess analgesic level accurately. Prior to caudal puncture, 29 patients were given thiamylal, 2 to 3 mg/kg, iv, while 18 received halothane anesthesia

during the caudal puncture, after which the halothane was discontinued. To perform caudal anesthesia, the patient was placed in a modified lateral decubitus position, the upper leg flexed, and the body rotated 45 degrees over the limb. After careful skin preparation and draping, the sacral cornua was identified, and a 21-gauge short-bevel, winged needle with tubing was inserted through the skin overlaying the sacral hiatus pointing in an upward direction at an angle of 65 to 70 degrees relative to the plane of the skin. This direction was held until the sacrococcygeal membrane was perforated; the needle was then advanced for 5 to 8 mm inside the sacral conus. After demonstration of inability to aspirate blood or CSF, or to produce crepitus following injection of 2 to 3 ml of air, lidocaine hydrochloride with freshly added epinephrine, 1/200,000, was injected. One per cent lidocaine was used for infants less than 8 kg in body weight, 1.5 per cent lidocaine for larger children. In each case, the dosage given was determined by multiplying the desired number of segments by the volume in ml of local anesthetic needed per segment [$\text{ml/segment} = 0.078 \times \text{body weight (kg)} - 0.17$], a formula that had been empirically derived from a prior study.² No test dose was used. The solution was injected as a single dose at a rate of 0.15 ml/sec, and the volume of deadspace of the needle and tubing was replaced.

Following injection of lidocaine and removal of the needle, the child was turned supine. Onset and spread of cutaneous analgesia were observed at 3- to 5-minute intervals using pinprick to delineate the upper margin of analgesia as evidenced by the absence of protective movement in response to painful stimulation.³ The last pinprick test was made on each side 20 minutes after injection. In most of the cases the upper limit of analgesia had remained stable from 10 to 20 minutes after caudal injection. The segmental dose requirement was defined as:

Dose of analgesic solution injected (ml)

Number of analgesic dermatones observed

The heart and breath sounds were monitored in all cases with a precordial stethoscope. Blood pressure was measured by sphygmomanometry using cuffs of a size appropriate to the child's age.

The distribution of the most important variables was analyzed graphically and by digital computer.¶

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TABLE 1. Operations Performed with Caudal Peridural Anesthesia and Levels of Sensory Block Proposed

Operation	Number of Patients	Level of Analgesia Attempted
Inguinal herniorrhaphy or hydrocelectomy	174	T7-T10
Orthopedic operations on lower extremities	30	T12
Gastrointestinal operations	16	T5
Catheterization (cardiac)	10	T10
Plastic operations of penis and urethra	7	T10
Anoplasty and rectal muscle biopsy	7	L1
Umbilical herniorrhaphy	6	T8

RESULTS

The desired upper levels of sensory block ranged from T5 to L1, depending upon the operation to be performed (table 1). Our results show that the segmental dose requirements for caudal anesthesia increase with increases in body weight (fig. 1); this linear relationship is highly significant ($r = 0.932$, $P < 0.001$). The resultant regression equation states that the dose requirements (ml/spinal segment) of lidocaine, 1 or 1.5 per cent, is equal to $[0.05608 \times \text{body weight (kg)} - 0.00204]$. The relationship between increasing dose requirements and age was also highly significant, $P < 0.001$; this correlation coefficient, however, was 0.867, less than that for dose requirements and body weight.

In no case did convulsions follow local anesthetic injection, nor was a pressor agent needed to treat a decrease in arterial blood pressure. The patients were well sedated by the medication administered preoperatively and had apparently adequate analgesia for the surgical procedures. However, 18 per cent of these patients appeared apprehensive or moved their upper extremities unexpectedly during the surgical procedures; these were managed with incremental intravenous doses of thiamylal (12.5 mg). In the course of this study no block was obtained in three cases.

DISCUSSION

In this study the correlation between dose requirement and body weight ($r = 0.93$) was better than the correlation between dose requirement and age ($r = 0.87$). Schulte-Steinberg and Rahlfs,³ however, reported that dose requirements had a better correlation with age ($r = 0.94$) than with body weight ($r = 0.90$).³ Their regression equation was dose (ml/spinal segment) = $0.0558 + 0.09729 \times \text{age in years}$.

This equation is quite similar to that of Bromage,⁴ which was based on data from 25 subjects aged 4 to 20 years receiving lumbar peridural analgesia. Using our equation $\text{ml/segment} = 0.056 \times \text{body weight (kg)} - 0.002$ may be disregarded in actual calculation), the dosage for a 1-year-old child weighing 9.5 kg is 0.530 ml/spinal segment, as opposed to 0.153 ml/segment obtained by the equation of Schulte-Steinberg and Rahlfs. We believe that the difference between our results and those of Schulte-Steinberg and Rahlfs is a result of different patient age distributions and methods. They studied 52 patients with a relatively wide age range from 7 weeks to 12 years.³ In our study, more than half of the children studied (163/250) were less than 2 years of age. We confirmed that the relationship between age and body weight is nonlinear for children less than 4 years of age.⁵ They made the caudal injection at about 1 ml/sec, whereas we used a very slow speed of injection (0.15 ml/sec), because the majority of our patients were very small and would have very small epidural cavities.⁴ This slow speed of injection might be expected to avoid a low-intensity, unnecessarily high level of block² or an uneven scattering of block⁴ due to wide spread of solution into epidural space; this seems to be an important reason why our study resulted in larger segmental dosages. Furthermore, since they checked analgesic level after the surgical procedure the difference in the time elapsing from caudal injection of lidocaine to determination of analgesic level may be responsible in part for the difference in results between their study

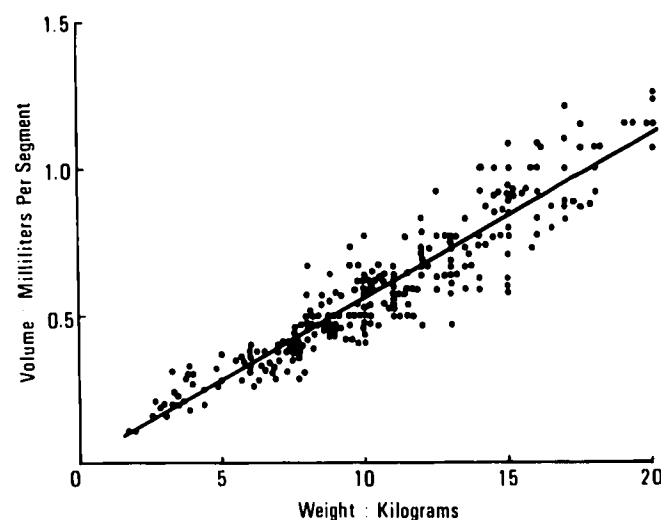


FIG. 1. Scattergram of the relationship of body weight and dose requirement per spinal segment. The regression equation is $y = 0.05608x - 0.00204$ ($r = 0.932$, $P < 0.001$).

and ours. In our study, however, the possibility that the last pinprick test was done before the fixation of sensory block occurred seems unlikely, since the upper limit of analgesia had remained stable from 10 to 20 minutes after injection. In addition, halothane-nitrous oxide anesthesia during operation in their study might affect their ability to assess accurately the exact level of caudal anesthesia. Similarly, we cannot exclude the possibility that variations in preoperative medication and the residual effects of the inhalation anesthesia introduced at the onset of the procedure modified, to some extent, the observed analgesic levels. It is, consequently, likely that our patients had more intense blocks than Shulte-Steinberg and Rahlfs', since in most of the patients in their study caudal anesthesia was supplemented by halothane and nitrous oxide during surgical procedures.³

For procedures requiring analgesic levels above T10, using lidocaine, 1.5 per cent, the total dose calculated from our formula will exceed 10 mg/kg; this has been reported to be the maximal dosage for lidocaine solution with epinephrine in adults,⁶ and presumably applies to children.^{3,7} More than 60 per cent of our patients were given lidocaine (with epinephrine) in doses of more than 10 mg/kg, without observed convulsions or other signs of gross toxicity. We acknowledge, however, that the absence of convulsions is a gross measure of nontoxicity. Therefore, we do not recommend caudal anesthesia above T10 using lidocaine, 1.5 per cent, according to our formula (table 2).

In summary, we conclude that the dose requirements for caudal peridural anesthesia in children can be easily and accurately calculated from patient's

TABLE 2. Dosages Administered with Equal Volume Injection According to the Equation:
 $\text{ml/segment} = 0.056 \times \text{body weight (kg)} - 0.002$

Desired Level of Analgesia	Dosage of Lidocaine with epinephrine (1/200,000)	
	1 Per Cent Lidocaine	1.5 Per Cent Lidocaine
T6	9.4 mg/kg	14.1 mg/kg
T10	7.2 mg/kg	10.8 mg/kg
L1	5.6 mg/kg	8.9 mg/kg

body weight. Our data demonstrate that for children ranging in age from newborn to 7 years, segmental dose requirements correlate better with body weight than with age.

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