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Spinal Anesthesia with Isobaric Bupivacaine in Infants

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Previous studies have reported the efficacy of spinal anesthesia with hyperbaric tetracaine in infants.^{1,2} In adults, isobaric 0.5% bupivacaine is an appropriate local anesthetic for spinal anesthesia.³ The addition of epinephrine to intrathecally administered bupivacaine does not significantly increase the duration of analgesia.⁴ However, there is no information on the use of intrathecal bupivacaine alone or with epinephrine in infants.⁵ The aim of this study was to evaluate in infants under 6 months of age the efficiency and the hemodynamic effects of spinal anesthesia with isobaric 0.5% bupivacaine alone and combined with epinephrine (1:200,000).

MATERIALS AND METHODS

Twenty-eight infants undergoing inguinal hernia repair were studied after approval by the Institutional Investigation Committee and parental consent. Sixteen infants 2.7 ± 1.3 months of age (mean \pm SD) (range 1.5-5 months), weighing 4.8 ± 1.0 kg (range 3.5-6.6 kg) received isobaric 0.5% bupivacaine (group I), and 12 infants 2.3 ± 1.2 months of age (range 1-5 months), weighing 4.5 ± 1.3 kg (range 1.6-6.8 kg), received isobaric 0.5% bupivacaine with epinephrine 1:200,000 (group II). They were not premedicated, and had fasted for 4 h before anesthesia. Heart rate was continuously recorded from the ECG and arterial pressure measured

with an automated blood pressure cuff every 5 min. After insertion of a venous cannula for infusion of 5% dextrose in 0.18% NaCl ($4 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$), lumbar puncture was performed at L4-L5 interspace using a pediatric lumbar puncture needle (22-gauge, 4 cm) while the infant was awake and in lateral or sitting position with the chin held upward.⁶ When free flow of cerebrospinal fluid was obtained, bupivacaine was injected using a 1-ml syringe over a 20-s period. The dose of 0.5% bupivacaine administered depended on the infant's weight: 1.25 mg (0.25 ml) under 2 kg, 3.75 mg (0.75 ml) between 2 and 5 kg, and 5 mg (1 ml) above 5 kg. Mean dose of bupivacaine was $0.80 \pm 0.2 \text{ mg} \cdot \text{kg}^{-1}$ in group I and $0.86 \pm 0.1 \text{ mg} \cdot \text{kg}^{-1}$ in group II. After injection, the infant was placed in the supine position.

Measurements recorded during this study were: 1) onset and duration of motor blockade by observation of the movements in the lower limbs, 2) cutaneous analgesia assessed every 5 min by dermatome level of subjective change to pinprick, 3) heart rate and blood pressure recorded before insertion of the venous cannula, 5, 10, 15 min after intrathecal bupivacaine administration and 30 s after surgical incision (22 ± 6 min), and 4) respiratory function monitored during the first four postoperative hours by Respirace⁷ in four of the 28 infants who were premature and were 37, 46, 48, and 50 weeks conceptual age at the time of surgery. Apnea was defined as the cessation of breathing for longer than 20 s or a shorter period associated with bradycardia, cyanosis or pallor.⁸ Respirace showed the abdominal, the rib cage, and the sum movements. Central apnea is the absence of chest wall movements on trend event recordings, whereas obstructive apnea is the absence of sum movements, despite respiratory efforts indicated by paradoxical movements of rib cage and abdominal compartments.

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TABLE 1. Systolic (SBP) and Diastolic (DBP) Blood Pressure and Heart Rate (HR) Before and 5, 10, and 15 Min after Spinal Anesthesia and at the Time of Incision (Mean \pm SD).

	Before Spinal Anesthesia	After Spinal Anesthesia			
		5 Min	10 Min	15 Min	Incision
Bupivacaine without epinephrine					
SBP (mmHg)	100 \pm 11	86 \pm 13*	81 \pm 12†	81 \pm 15†	85 \pm 10*
DBP (mmHg)	64 \pm 13	53 \pm 13*	50 \pm 11†	47 \pm 11†	47 \pm 14†
HR (beat/min)	160 \pm 16	164 \pm 23	156 \pm 26	146 \pm 22*	146 \pm 24*
Bupivacaine with epinephrine					
SBP (mmHg)	92 \pm 17	79 \pm 15*	81 \pm 14*	76 \pm 16†	79 \pm 16*
DBP (mmHg)	60 \pm 12	44 \pm 11†	42 \pm 13†	40 \pm 9†	41 \pm 11†
HR (beat/min)	167 \pm 22	155 \pm 17	145 \pm 18*	135 \pm 14†	136 \pm 13†

* $P < 0.01$, † $P < 0.001$ versus before spinal anesthesia.

All values are expressed as mean \pm SD; statistical analysis was performed using ANOVA followed by a t test for paired data. Differences between the two groups were tested with the use of the t test for unpaired data.

RESULTS

No significant differences were found between infants in the two groups in relation to age, weight, and hemodynamic control values. The onset of motor blockade was less than 2 min in all infants. The maximum level of cutaneous analgesia was reached at 10 min in all infants in both groups and ranged between T1 and T6: T3.2 \pm 1.3 in group I, and T3.3 \pm 1.9 in group II. All infants in both groups had complete motor blockade. In group I, the duration of motor blockade was 70 \pm 25 min (range 20–110 min). In group II, the duration of motor blockade was 81 \pm 18 min (range 50–115 min). The duration of motor blockade was not significantly longer in group II as compared to group I. One infant in group I needed halothane anesthesia by mask during surgery because of the short duration of the block (20 min).

After onset of the blockade, systolic and diastolic arterial blood pressure decreased significantly and to the same extent in each group (table 1). The maximum decrease in systolic blood pressure was observed at 12 \pm 6 min in group I and at 10 \pm 5 min in group II, and averaged 24 \pm 13% and 23 \pm 11%, respectively. The decrease in systolic blood pressure was not treated in 24 of 28 infants. Four infants had a decrease in systolic blood pressure greater than 40%. In these infants, lactated Ringer's solution was given iv: 10 ml \cdot kg⁻¹ in 20 min. Heart rate decreased in both groups after spinal anesthesia (table 1). Maximum decrease in heart rate was observed at 16 \pm 5 min in group I and at 17 \pm 4 min in group II, and averaged 10 \pm 13% and 19 \pm 11%, respectively; this decrease was delayed and more prolonged than the decrease in arterial blood pressure. None of the four premature infants who had respira-

tory monitoring during the first four postoperative hours showed apnea longer than 20 s.

DISCUSSION

Spinal anesthesia with isobaric 0.5% bupivacaine produces adequate anesthesia in infants under 6 months of age undergoing short surgical procedures below the umbilicus. Duration of analgesia in infants with 0.5% bupivacaine alone and with epinephrine is shorter than in adults. Hemodynamic changes observed were statistically significant but spontaneously reversible in most cases.

To obtain a similar upper level of cutaneous analgesia, the dose needed (mg \cdot kg⁻¹) was greater in children than in adults. Duration of analgesia is shorter in children than in adults (0.3 mg \cdot kg⁻¹).³ The same results were obtained with the use of tetracaine in infants.^{1,2,9} Dohi *et al.*⁹ found a correlation between age and duration of motor blockade after spinal analgesia with hyperbaric tetracaine in infants and adults, and possible reasons for this may relate to age-related physical and physiologic differences among adults and children (*e.g.*, amount of cerebrospinal fluid, diameter and surface area of the spinal cord and nerve roots, and rate of absorption of local anesthetics from the subarachnoid space).

In infants, Abajian *et al.*¹ found that the duration of spinal anesthesia with tetracaine plus epinephrine averages 32% longer than the mean duration with tetracaine without epinephrine; Warner¹⁰ demonstrated that addition of epinephrine 1:200,000 to 0.25% bupivacaine in caudal anesthesia produces prolonged postoperative analgesia from 12–24 h in children aged less than 5 yr. In our study, following spinal bupivacaine anesthesia, the addition of epinephrine did not significantly change the duration of analgesia. Moreover, in adults, Chambers *et al.*⁴ found that the addition of epinephrine to a solution of 0.5% hyperbaric bupivacaine administered for spinal anesthesia produces only a small, insignificant increase in duration of anesthesia.

These authors concluded that vasoconstrictors probably have different effects on different local anesthetic agents when administered intrathecally.

In our study, we observed acute and transient decreases in arterial blood pressure and moderate changes in heart rate after intrathecal administration of bupivacaine with and without epinephrine. Harnik *et al.*² reported one case of decrease in systolic blood pressure from 90 to 75 mmHg, which corrected itself spontaneously in 10 min. In other series, the authors reported little change in heart rate and blood pressure in infants undergoing spinal anesthesia.^{1,2,5,9,11} Hemodynamic changes are thought to be due to control values for heart rate and arterial blood pressure that are higher than normal values for this age.¹² We did not use premedication. Berkowitz and Greene¹¹ and Blaise and Roy⁵ found no change in arterial blood pressure because they sedated their infants who, consequently, had normal, not elevated, arterial pressures before anesthesia was administered. Some infants were crying before the insertion of the venous cannula, due to the lack of premedication. A high upper level of sympathetic blockade may also account for our finding hemodynamic changes. Dohi *et al.*⁹ obtained the same levels of anesthesia, but the onset of the blockade was slower than in our study, averaging 15 min. This slower onset of anesthesia can, perhaps, explain the difference in hemodynamic tolerance.¹³ The rapid reversal in the decrease of arterial blood pressure might be due to an increase in vascular resistances in the upper limbs, as previously reported during caudal anesthesia in infants.¹⁴ Harnik *et al.*² proposed the use of spinal anesthesia for premature infants under 46 weeks of conceptual age who were undergoing minor surgery below the umbilicus because they felt that this technique might avoid the increased incidence of postoperative respiratory complications associated with general anesthesia.⁸ Despite the absence of postoperative apnea in our study, the number of premature infants studied is too small to allow us to decide whether spinal anesthesia causes less postoperative apnea than does general anesthesia. Therefore, we believe continuous respiratory monitoring for at least 12 h postoperatively is mandatory in these infants.

In conclusion, spinal anesthesia with isobaric 0.5% bupivacaine alone and with epinephrine is efficacious in

infants under 6 months of age, but has a shorter duration of action than in adults. We observed acute yet transient changes in heart rate and arterial pressure in most cases.

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