Complications during Spinal Anesthesia in Infants: High Spinal Blockade

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During the first half of this century, spinal anesthesia was commonly used for pediatric surgery.1-4 With improved general anesthetic techniques, the practice of spinal anesthesia, in children in particular, fell into disuse. In the past decade, however, a resurgence in the use of spinal anesthesia in infants and children has occurred.5-9

As the use of a procedure increases, so does the incidence of side-effects and complications. We report our experience with four former premature infants in whom the intrathecal administration of hyperbaric tetracaine (0.5-0.6 mg/kg) resulted in a high sensory and motor block. One infant required pharmacologic intervention for the treatment of bradycardia and hypotension, an extremely uncommon event in this age group; two required ventilatory support; and the fourth infant exhibited a high block that did not require intervention. These cases are of particular interest in light of the 0.2-1.3-mg/kg range of doses for intrathecal tetracaine that has been reported in the recent literature.5-7,9-13 They also identify some of the pitfalls of the technique that, when ignored, can lead to complications.

CASE REPORTS

Case 1. This 4.8-kg, 10-week-old male infant who was born after a 34-week gestation presented for repair of a right inguinal hernia after an 8-h fast. For this infant and the subsequent three children, an intravenous infusion was started, supplemental oxygen was provided, and the following monitors were placed: precordial stethoscope, automated blood pressure cuff, pulse oximeter, and continuous ECG. Without sedation and with the infant in the sitting position, a lumbar puncture was performed in the L3-4 interspace with a 22-G, 1.5-inch spinal needle. Tetracaine without epinephrine was slowly injected over 6-8 s (0.5 mg/kg; 2.5 mg in a volume of 0.5 ml). He was maintained in a sitting position until his legs became flaccid. After he was placed supine, the circulating nurse noted that the electrocautery grounding pad had become loose and raised the infant by the ankles to secure it. Within 30 s, the infant was flaccid and apneic, while his blood pressure, pulse, and oxyhemoglobin saturation (SpO2) remained stable. Controlled ventilation via mask with 100% oxygen was instituted immediately, and the infant's trachea was intubated. The lungs were ventilated with 50% N2O and 0.4% isoflurane in oxygen. On completion of the 50-min procedure, the infant was breathing spontaneously and moving the upper extremities. The trachea was extubated, and he recovered without problem.

Case 2. This 5.3-kg, 5-week-old male infant who was born after a 36-week gestation presented for bilateral inguinal hernia repair after a 5-h fast. The incarcerated hernia had been reduced 12 h before surgery. He was placed in the lateral position, and intrathecal sedation was provided with thiopental in divided doses to a total of 5 mg/kg. A 22-G, 1.5-inch spinal needle was placed with ease in the L3-4 interspace, and cerebrospinal fluid (CSF) flowed freely from the hub. Tetracaine with epinephrine (0.6 mg/kg; 3.2 mg in 0.64 ml) was injected in 2 or 3 s from a 1-ml syringe. Minutes after the infant was placed supine, a nurse briefly lifted the infant by the ankles to place a grounding pad on the buttocks. Within several minutes, his heart rate abruptly decreased from 140 to 95 beats per min, and blood pressure decreased from 95/65 to 50/35 mmHg. Atropine (0.12 mg) was given with 5 ml/kg iv fluid. Also noted were a paradoxical respiratory pattern and flaccid arms. His heart rate and blood pressure returned to normal within 90 s, and throughout this time, the infant appeared well perfused and SpO2 was 100%. The infant's condition remained stable during surgery, and within 30 min he was in the recovery room moving his arms. Recovery was uneventful.

Case 3. This 4.3-kg, 6-week-old male infant was scheduled for bilateral inguinal herniorrhaphy. He was one of twins born after an uneventful 36-week gestation. The infant, who had been fasted for 4 h, was sedated with thiopental in divided doses (6 mg/kg iv) and placed in the lateral decubitus position. Lumbar puncture was performed at the L3-4 interspace with a 25-G, 1-inch spinal needle. Tetracaine with epinephrine was injected over 8-10 s (0.6 mg/kg; 2.5 mg in volume of 0.5 ml). The grounding pad was applied to the back, and care was taken not to raise the infant's legs. A motor block was evident within 30 s of injection. The infant tolerated the surgical procedure well, and all vital signs remained stable. In the recovery room, the infant was noted to have a weak cry. Gentle pinching of the skin revealed a C2 sensory block, and observation of the infant's movements suggested a C5 motor block. The block dissipated over the ensuing 60 min, and the infant did well. An identical anesthetic for bilateral inguinal herniorrhaphy resulted in a T4 block in the infant's twin brother.

Case 4. This 3.8-kg, 10-week-old female infant who was born after a 34-week gestation was admitted for repair of bilateral inguinal hernias. She had been fasting for 3½ h. The infant was positioned in the left lateral decubitus position, and 10 ml/kg Ringer's lactate was infused intravenously. No sedation was administered. A lumbar puncture was performed with a 25-G, 1-inch spinal needle in the L3-4 interspace without difficulty. Tetracaine with epinephrine (0.5 mg/kg; 2.2 mg in a volume of 0.44 ml) was injected over 10-15 s. The needle was then removed, the grounding pad applied to the back of the infant in lateral position, and the infant carefully log-rolled to a neutral supine

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position. It was noted immediately that the infant had a weak cry, limited movement of all extremities, and progressively weaker respiratory efforts. Within 30 s of the spinal injection, the awake infant had movement of only the neck and facial muscles. Heart rate, blood pressure, and \( \text{SpO}_2 \) did not change. Assisted ventilation and oxygenation were provided via bag and mask, and the trachea was intubated. Nitrous oxide sedation was provided for the 30-min surgical repair. Vital signs remained stable, and she recovered uneventfully.

**DISCUSSION**

We have presented four cases in which a routine dose of tetracaine produced an unexpectedly high spinal block. In the year in which these high spinal blocks occurred, we performed 44 other subarachnoid blocks in infants < 4 months of age without the same complication. We briefly discuss these cases in light of several factors that may play a role in governing the height of the block in adults: baricity, position, total dose, volume of CSF, volume of the anesthetic solution, and the rate of injection.\(^4\)

When using hyperbaric solutions, position is a major determinant of the height of the block.\(^10\) In case 1, and possibly in case 2, leg raising allowed the hyperbaric solution to drift cephalad and cause total paralysis, a phenomenon reported by Bailey \textit{et al.} with a smaller dose of hyperbaric tetracaine.\(^11\) Others have used isobaric bupivacaine successfully in children,\(^8\) a solution that may be safer in infants because it should not migrate with changes in position.

The dose of agent also affects the height of the block, although, as case 3 emphasizes, height of the block may vary from patient to patient for a given dose. In general, tetracaine 0.5–0.6 mg/kg (as a hyperbaric solution of 5\% dextrose) produces a T4–6 block, while smaller doses often produce inadequate anesthesia for inguinal herniorrhopathy.\(^6,7\) For a given level of block, proportionately larger doses are required in small infants, presumably due to the difference in CSF volume to body weight ratio (4 ml/kg in infants vs. 2 ml/kg in adults).\(^1\) Doses as high as 1.3 mg/kg have been used in premature infants (2 or 3 kg) for inguinal herniorrhaphy, apparently without adverse effect.\(^12\) The length of the baby's body, rather than the weight, could be more closely related to the effective spinal anesthetic dose, but no information exists regarding this.

While the relative CSF volume is large in an infant as compared to that in an adult, the absolute volume of CSF in an infant is considerably smaller, particularly in relation to the injected volume. In a 4 or 5 kg infant, the CSF volume may be only 16–20 ml, 5–7 ml lying within the spinal canal.\(^4\) Small differences in the volume of intraspinal CSF in this age group could change the hydrodynamics of the injection such that a given volume of hyperbaric solution might occupy a greater proportion of the intraspinal canal and lead to a high block. The CSF volume in an infant may be further contracted by loss of CSF during performance of the block.

Although Bridenbaugh and Greene state that the speed of injection has no effect on the height of the block in adults,\(^4\) rapid injection may result in a higher block in infants due to the small distances between each segment. (Recommended rates of injection vary between 1 ml hyperbaric tetracaine per 5 s and the slow injection of isobaric bupivacaine over 20 s.\(^5,6\)) Because the infant spinal cord and canal are much shorter, small differences in the extent to which the solution ascends with injection could make a significant difference in the height of the block. In case 2, the height may have been affected by a rapid injection. The effect on the height of the block of either the rate of intrathecal injection or the size of needle and syringe has not been systematically investigated in infants.

Of additional interest are the cardiovascular changes that occurred in case 2. Numerous reports have documented cardiovascular stability in infants and young children with spinal blockade, a finding attributed to the immaturity of the sympathetic nervous system in these patients.\(^5,6,12,14\) In particular, Dohi \textit{et al.}\(^13\) observed no significant cardiovascular changes in response to T3–4 sensory spinal blockade in infants and in children under 5 yr of age. At the same time, Harnik\(^18\) did observe a significant decrease in blood pressure in one of 30 infants undergoing spinal block with tetracaine, and Mahé\(^9\) described moderate decreases in all 28 infants undergoing spinal anesthesia with isobaric bupivacaine. Thus, although apparently less common than in adults, hypotension and/or bradycardia may indeed occur in infants with high spinal blockade, whether due to sympathectomy, blockade of the cardiac accelerator fibers of the upper four thoracic spinal nerves, or decreased stimulation of the right atrial stretch receptors. A prolonged preoperative fast and poor oral intake during the period of the hernia's incarceration in case 2 may have increased the risk of these cardiovascular consequences of a high spinal block. This case also suggests that, since hypotension and bradycardia call for rapid administration of fluids and medications, it may not be advisable to proceed with a spinal block before securing IV access in an infant.

In summary, this report describes four former premature infants aged 5–10 weeks who developed high spinal blocks with 0.5–0.6 mg/kg tetracaine. Whereas cases 1 and 2 suggest that leg raising and rapid injection of drug may contribute to a high block, cases 3 and 4 show that a high block may occur without any apparent cause. We affirm that spinal anesthesia is not free of risk, that strict attention to detail must be maintained, and that only prompt recognition and intervention in these cases prevented further complications. We suggest caution when using hyperbaric tetracaine in doses greater than 0.5 mg/kg. Further investigation is warranted to establish
the specific roles of the many factors that determine the level of spinal blockade in the infant.

REFERENCES