circulation until the surgeon can clamp the hilar vessels and isolate the defect.10,19

In summary, we have described a case of left atrial air embolism during needle biopsy of a deep pulmonary mass. Rapid diagnosis and therapy are necessary to preserve circulation and prevent neurologic sequelae.

REFERENCES


Anesthesiology
73:345–347, 1990

CASE REPORTS

Life-threatening Apnea Following Spinal Anesthesia in Former Premature Infants


With improvements in neonatal care, an increasing number of former premature infants are presenting for surgery, particularly inguinal hernia repair. Over the past decade, there have been many reports of postoperative apnea in such patients.1–3 Several strategies have been employed to overcome this problem. These include postponing surgery for as long as possible, postoperative monitoring, use of naloxone,4 perioperative intravenous caffeine,5 and regional techniques such as spinal anesthesia.6–8 It has been suggested that spinal anesthesia results in a lower incidence of postoperative apnea in former premature infants. We report two cases of life-threatening apnea following spinal anesthesia in former premature infants.

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Key words: Anesthetic techniques: regional, spinal. Complications, postoperative: apnea. Prematurity.
CASE REPORTS

Case 1. A 57-day-old, 2.54-kg infant presented for bilateral inguinal hernia repair and orchidopexy. He had been born at 29 weeks gestation and had a postconceptional age of 37 weeks. His neonatal course was complicated by hyaline membrane disease and subsequent bronchopulmonary dysplasia. His trachea had been intubated at birth, and his lungs had been mechanically ventilated for 19 days. Following tracheal extubation, he had had episodes of apnea and bradycardia that had been treated with oral theophylline (6 mg·kg⁻¹·day⁻¹, divided 8 hourly). His preoperative serum theophylline concentration was 78 μmol/L. At the time of surgery, he was receiving very low flow oxygen via nasal prongs (approximately 1/16th of a liter of oxygen per min) and was still having one or two self-limiting episodes of apnea and bradycardia per day. A pneumographic study was not performed preoperatively.

Anesthesia for the procedure was achieved with tetracaine (0.39 mg/kg) in 10% dextrose injected intrathecally at the L3–L4 interspace. The anesthetic level was estimated to be approximately at the second thoracic dermatome as assessed by observation of the infant’s response to cold and painful stimuli. Atropine (0.04 mg) was given intravenously at the start of the procedure to reduce the risk of intraoperative vagal reflexes. Fifty percent nitrous oxide in oxygen was administered by mask for a brief period intraoperatively. The procedure was tolerated well with no episodes of bradycardia, apnea, or decreased hemoglobin saturation (SpO₂). Total anaesthetic and surgical time was 1 h and 35 min. The patient was then transferred to the intensive care unit for continuous monitoring of SpO₂, ECG, and respiratory rate. His oral theophylline therapy was continued postoperatively.

The infant demonstrated signs of being distressed by pain (e.g., excessive crying, tachycardia); therefore, two doses of codeine phosphate (1 mg/kg) were given orally, 3 and 9 h postoperatively. Shortly after the second dose of codeine, the patient began having frequent periods of apnea with associated bradycardia and decreased SpO₂. These episodes required vigorous stimulation and ventilation via a bag and mask. There was no improvement with the administration of nasal continuous positive airway pressure (CPAP) or intravenous naloxone (0.01 mg/kg) repeated four times. The episodes gradually became more prolonged and frequent, occurring every few minutes, and 14 h postoperatively the trachea was intubated and mechanical ventilation instituted. Extubation was attempted after 2 days, but reintubation occurred after 3 days because of upper airway edema. Two days later his trachea was successfully extubated. A pneumographic study 11 days postoperatively showed no episodes of apnea or periodic breathing.

Case 2. A 95-day-old, 1.65-kg infant presented for bilateral inguinal hernia repair. He had been born at 25 weeks gestation and had a postconceptional age of 38 weeks. His trachea had been intubated at birth, and he had developed severe hyaline membrane disease with subsequent bronchopulmonary dysplasia. A persistent ductus arteriosus had been ligated on day 23 of life. He had received 61 days of mechanical ventilation. At the time of surgery, he was receiving 0.5 L of oxygen per min via nasal prongs and oral theophylline (3.5 mg·kg⁻¹·day⁻¹, divided 8 hourly), but he was not having episodes of apnea or bradycardia. His preoperative serum theophylline concentration was 40 μmol/L. It had been planned to discontinue his theophylline therapy after recovering from surgery. His preoperative hemoglobin was noted to be 8 g/100 ml.

Anesthesia was achieved with tetracaine (0.42 mg/kg) in 10% dextrose injected intrathecally at the L3–L4 interspace. Sixty percent nitrous oxide in oxygen was given by mask for a brief period. No other agents were given, and the procedure was well tolerated with no episodes of hypotension, apnea, or decreased SpO₂. Combined anesthetic and surgical time was 1 h and 15 min.

The patient’s ECG, SpO₂, and respiratory rate were monitored continuously for 24 h in the intensive care unit, and no episodes of apnea or bradycardia were noted during this period. Theophylline therapy was continued perioperatively. Two doses of oral codeine phosphate (1 mg/kg) were given during the first 12 postoperative h because it was felt clinically that the infant was distressed by pain. He was then transferred to the ward.

The patient began having apneic episodes 32 h postoperatively. These initially lasted around 30 s each and recovered spontaneously. He was transferred back to intensive care for monitoring. He was noted to be hypothermic (34°C), and his hemoglobin concentration had fallen to 7.1 g/100 ml. He was placed under an overhead warmer and transfused with 15 ml/kg packed red blood cells. Despite these measures, his apneic episodes became much more frequent and prolonged, and were associated with significantly decreased SpO₂. His trachea was therefore intubated, and mechanical ventilation was begun. A workup for sepsis was performed, and he received intravenous cloxacillin and cefotaxime. The trachea was extubated 2 days later without difficulty. The urine was subsequently found to be positive for Klebsiella oxytoca, but blood cultures were negative. One other finding of note was a 1.5-cm hemorrhagic infarct of the right frontal lobe seen on computed tomographic scan 8 days after the patient’s deterioration. The rest of the patient’s recovery and hospital stay was unremarkable. No pneumographic studies were performed on this patient.

DISCUSSION

Spinal anesthesia is an attractive choice for the former premature infant undergoing inguinal hernia repair. Exposure to volatile anesthetic agents and other fixed agents can be avoided; opioids can be administered in very small doses or avoided completely. Tracheal intubation is unnecessary, which is advantageous in the presence of airway reactivity or subglottic stenosis. The technique is simple and quick to perform and provides excellent, reliable surgical conditions.6,8

A recent study by Welborn et al.7 has suggested there is a lower incidence of apnea in former premature infants when unsupplemented spinal anesthesia is used, compared with general anesthesia or spinal anesthesia with ketamine supplementation. The addition of intramuscular ketamine to a spinal anesthetic technique markedly increased the risk of postoperative apnea. However, when patients without a history of preoperative apnea were considered alone, no significant difference between patients receiving spinal anesthesia (with or without ketamine) and those anesthetized with general anesthesia was observed. The two patients presented were of similar postconceptual age to those in Welborn’s study, but they both had significant bronchopulmonary dysplasia, unlike Welborn’s patients who had no medical disorders.

Spinal anesthesia was selected in the two patients described because of previous problems we have experienced with postoperative respiratory failure and apnea in similar patients. Both patients received nitrous oxide briefly at the time of traction on the inguinal sac, and both received oral codeine phosphate in the postoperative period. The use of codeine phosphate for pain relief in the postoperative period, however, may be related to an increased incidence of postoperative apnea, although there is no clear relationship demonstrated in either of the two cases reported.
The experience with spinal anesthesia for former premature infants suggests a low incidence of postoperative apnea. Abajian et al., included 36 high-risk patients in his study who were delivered prematurely or had neonatal respiratory distress. No postoperative complications were encountered. Harnik et al., reported the use of spinal anesthesia in premature infants recovering from respiratory distress syndrome. Twenty spinal anesthetics were administered, with two pulmonary complications. One patient who was prone to frequent apnea had an anoxic spell intraoperatively requiring tracheal intubation, but no postoperative mechanical ventilation had been needed. Another patient had apnea 8 h postoperatively in relation to hypothermia. Welborn et al., demonstrated no postoperative apnea in 11 patients given an unsupplemented spinal anesthetic. Postoperative apnea has been described after caudal anesthesia in an ex-premature infant undergoing inguinal hernia repair; but this episode was short-lived and did not appear to be related to the anesthetic technique used.

We could not be certain what factors contributed most to the episode of apnea in the first patient described. He had bronchopulmonary dysplasia and was prone to episodes of apnea, although these were mild and infrequent preoperatively. Oral codeine could have been a factor precipitating his apnea, but there was no response to intravenous naloxone, which suggested that opiate-induced hypoventilation was not the primary problem. It is highly unlikely that there was residual neural blockade after 15 h.

In the second patient the most likely causes of his apnea were anemia, hypothermia, and sepsis. In addition, he sustained a small cerebral infarct at some stage during his illness, but we could not determine the relationship of the infarct to his episodes of apnea. It is unlikely that the spinal anesthetic was a primary precipitating factor leading to the apnea, particularly since apnea spells began on the second postoperative day. The last dose of codeine was administered 25 h prior to the onset of apnea spells, therefore, we did not consider the use of codeine as a factor in this patient's apnea.

Welborn et al. showed that caffeine suppresses postoperative apnea in former premature infants undergoing general anesthesia for inguinal hernia repair; they excluded patients already receiving methylxanthines in this study. We, however, find that many of our high-risk former premature infants are already receiving theophylline. It may well be that caffeine will find a useful role whether spinal or general anesthesia is selected and whether the patient is receiving theophylline. Further studies need to be undertaken to compare the results of spinal versus general anesthesia, with or without caffeine, in the former premature infant.

If faced with anesthetizing similar patients again for inguinal hernia repair, we would choose an unsupplemented spinal anesthetic technique. Preoperative risk factors, such as anemia and sepsis, should be actively sought and treated. If a patient is transferred to an unmonitored ward after 24 h in intensive care, attention should still be closely paid to such factors as temperature control. We would consider the empirical use of caffeine intraoperatively, pending the results of further studies on this agent's use in combination with spinal anesthesia. If at all possible, we would avoid the use of opioid in this type of patient.

The two cases described illustrate the multifactorial nature of apnea in former premature infants. When managing such patients in the perioperative period, not only is choice of anesthetic important but also factors such as temperature control, presence or absence of anemia, and sepsis. Theophylline has an established role in the treatment of apnea in premature infants, and it is important to maintain therapeutic serum theophylline concentrations postoperatively if the infant required theophylline preoperatively. Although there is some debate over what is an appropriate theophylline level, most authors suggest a serum concentration of 40–60 μmol/L, with adjustment of the dose according to the clinical effect. Whether spinal or general anesthesia is used for inguinal hernia repair, it is recommended that all infants at risk for postoperative apnea be monitored closely for the first 24 postoperative h, even though the incidence of apnea may be less after unsupplemented spinal anesthesia.

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