

Risk factors for spinal anesthesia in preterm infants undergoing inguinal hernia repair

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Abstract

Objectives: To investigate the risk factors and incidence of perioperative adverse effects from unsupplemented spinal anesthesia in preterm infants. Times to resumption of oral feeding and to home discharge were also evaluated.

Methods: Perioperative data were collected prospectively for all preterm and former preterm infants who underwent inguinal hernia repair with spinal anesthesia at a tertiary medical center.

Results: The study group consisted of 144 infants with a median gestational age of 30 weeks, postmenstrual age of 37 weeks, birth weight of 1,420 g, and weight at surgery of 2,140 g. Overall, six (4.2%) infants had intraoperative complications, which included apnea (2/1.4%), bradycardia (2/1.4%), and hypoxemia (4/2.8%). Postoperative complications occurred in 15 (10.4%) infants, mainly hypoxemia (3/2.1%), bradycardia (8/5.5%), and apnea (6/4.1%). Predictive factors of an unfavorable outcome (apnea, resumption of oral feeding > 6 h postoperatively, or discharge > 30 h postoperatively) were bronchopulmonary dysplasia (odds ratio [OR] = 3.2, 95% confidence interval [95%CI] 2.8-5.3; p = 0.01) and periventricular leukomalacia (OR = 2.8, 95%CI 2.1-4.9; p = 0.03).

Conclusions: Spinal anesthesia is safe and effective for inguinal hernia repair in preterm infants, with early resumption of oral feeding and short hospitalization. Bronchopulmonary dysplasia and periventricular leukomalacia may pose risks for an unfavorable outcome.

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Introduction

Spinal anesthesia has gained considerable acceptance for use during surgery in preterm infants because it is relatively simple to administer and poses a low risk for intraoperative complications.¹⁻⁸

However, evidence-based guidelines have concluded that infants with a history of continuing apnea, anemia, neurological disease, or bronchopulmonary dysplasia might be predisposed to significant postoperative apnea even after spinal anesthesia, and must be considered at

risk.⁹ Other complications such as delayed feeding and prolonged hospitalization in preterm infants undergoing spinal anesthesia were not investigated.

The aim of the present prospective cohort study was to evaluate the incidence and risk factors of perioperative adverse effects from unsupplemented spinal anesthesia in stable preterm infants treated for inguinal hernia before discharge from the neonatal unit, as well as the times to resumption of oral feeding and to hospital discharge, in order

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to help clinicians determine which comorbidities require a more careful approach.

Patients and methods

Study population

This prospective cohort study was approved by the hospital's Institutional Ethics Committee. All preterm infants (< 37 weeks gestation) who underwent successful inguinal hernia repair with unsupplemented spinal anesthesia from January 31, 2002 to December 31, 2006 were included.

Data collection

The following background and perioperative data were collected: gestational age; sex; birth weight; postmenstrual age; weight and hematocrit during surgery; prematurity-associated morbidity (congenital heart disease, bronchopulmonary dysplasia defined as oxygen requirement at 36 weeks corrected age, gastroesophageal reflux diagnosed by upper gastrointestinal imaging or pH measurements, grade III-IV intraventricular hemorrhage, and periventricular leukomalacia); history of bradycardia, hypoxemia, or apnea and time of cessation; type of surgery (unilateral or bilateral); intraoperative and postoperative adverse effects; time to first feeding after surgery; and time to hospital discharge. Bradycardia was defined as heart rate < 100 beats/min for any duration; hypoxemia, as oxy-hemoglobin saturation < 90%⁵; and clinical apnea, as cessation of respiratory airflow associated with bradycardia or with cyanosis, or hypoxemia that did not resolve spontaneously and required intervention.

Anesthesia management

Spinal anesthesia was administered as previously described.¹ Ninety minutes prior to surgery, 0.5-1 mL of EMLA® cream (Astra Sodertalje, Sweden) was applied to the midline area over L4-S1 and covered with an occlusive dressing. All patients received 1 mg.kg⁻¹ of either 0.5% hyperbaric tetracaine (a 1:1 mixture of 1% tetracaine and 10% glucose) or 0.5% hyperbaric bupivacaine, with adrenaline 1:1000 added to either medication. A 1-inch, 25-gauge Quincke spinal needle was inserted in the midline, cephalad, in an interspace between L4 and S1. Subarachnoid placement was confirmed by free flow of cerebrospinal fluid. With the needle stabilized, the local anesthetic solution was rapidly injected without aspiration and the needle removed. The patient was immediately positioned supine with a 20-30° head up tilt for 2-3 min, and then horizontally. Successful spinal anesthesia was defined as lack of sensation to pinch at the desired sensory level and paralysis of the lower limbs. A paracetamol suppository (20-25 mg.kg⁻¹) was inserted per rectum before the beginning of surgery, or 10-15 mg.kg⁻¹ of

paracetamol syrup was given *per os* postoperatively. With hands restrained to avoid interference with the surgical procedure, the patient received a dummy or gauze dipped in glucose water.

Ninety-four percent of the spinal anesthesia procedures were carried out or supervised by one of the authors (ZS); the remainder was performed by anesthesiologists whom he trained. Based on departmental policy, only stable preterm infants who were scheduled for discharge home were eligible for inguinal hernia repair.

After the procedure, all patients were transferred to the neonatal intensive care unit for monitoring and follow-up. Monitoring included continuous pulse oximetry, respiratory rate and electrocardiography measurements, as well as intermittent arterial blood pressure measurement. Oral feeding was offered to all infants immediately upon arrival to neonatal intensive care unless regurgitation, retching, or vomiting was present. Patients were discharged only after documented absence of apnea, hypoxemia or bradycardia episodes for 24 h, resumption of full oral feeding, and a normal physical examination.

Outcome measures

Study outcome measures were: rates of bradycardia, hypoxemia, and apnea during and after surgery, time to oral feeding after surgery, and time to discharge. Unfavorable outcomes were defined as episodes of postoperative apnea, resumption of oral feeding > 6 h postoperatively, or discharge > 30 h postoperatively.

Statistical analysis

Measurements are expressed as median and range, as appropriate. Multivariate logistic regression analyses were performed to adjust unfavorable outcome to the following independent variables: gestational and postmenstrual age, history of apnea, presence of hypoxemia or bradycardia and time of cessation before surgery, weight and hematocrit at the time of surgery, type of surgery (unilateral or bilateral), and co-existing morbidities that might predispose infants to an unfavorable outcome (bronchopulmonary dysplasia, gastroesophageal reflux, severe intraventricular hemorrhage, periventricular leukomalacia, and congenital heart disease).

Results

A total of 1,582 preterm infants were born during the study period. Of these, 159 infants were diagnosed with inguinal hernia, and a decision to perform hernioplasty before their discharge home from the neonatal unit was made. Infants in whom spinal anesthesia failed and who required general anesthesia (n = 5) and patients requiring emergency surgery (n = 10) were excluded from the results.

The study group included 144 infants. Their demographic and background characteristics are shown in Table 1, and the intra- and postoperative data, in Table 2. The spinal anesthesia success rate was 96%. The overall rates of intraoperative and postoperative complications were 4.2 and 10.4% respectively. Eighty-four percent resumed feeding within 6 h after surgery and 83% were discharged home within 30 h after surgery (Table 2). In logistic regression analysis, the only variables with an independent effect on the risk of unfavorable outcome were bronchopulmonary dysplasia (OR [odds ratio] = 3.2, 95% confidence interval

[95%CI] 2.8-5.3; $p = 0.01$) and periventricular leukomalacia (OR = 2.8, 95%CI 2.1-4.9; $p = 0.03$).

Discussion

The present study confirms earlier findings of a high success rate^{2,7} and low rates of intraoperative^{2,3,7} and postoperative^{1,4,7,8} apnea, hypoxemia, and bradycardia in preterm infants undergoing inguinal hernia repair with unsupplemented spinal anesthesia. Additionally, we showed that spinal anesthesia is associated with a low rate of airway/pulmonary and other complications, rapid resumption of

Table 1 - Patients' characteristics (n = 144)

Value	Characteristic
30 (24-37)	Gestational age (weeks)
1,420 (537-2,376)	Birth weight (grams)
37 (34-42)	Postmenstrual age (weeks)
2,140 (1,845-3,050)	Weight at surgery (grams)
92/52	Sex (male/female), (n)
42 (29)	Comorbidity, n (%)*
39 (27)	History of preoperative apnea/hypoxemia/bradycardia, n (%)
46 (23-82)	Time from last preoperative apnea/hypoxemia/bradycardia episode to surgery (days)
52/92	Unilateral/bilateral hernia repair, (n)

* Bronchopulmonary dysplasia (n = 16), gastroesophageal reflux (n = 6), grade III or IV intraventricular hemorrhage (n = 8), periventricular leukomalacia (n = 10), hemodynamically significant congenital heart disease (n = 4).

Table 2 - Adverse effects for premature infants (n = 144) undergoing inguinal hernia repair with spinal anesthesia

Value	Adverse effect
6 (4.2)	Intraoperative, n (%)
2 (1.4)	Apnea
2 (1.4)	Bradycardia
4 (2.8)	Hypoxemia
15 (10.4)	Postoperative, n (%)
4 (2.8)	Upper airway/respiratory distress
6 (4.1)	Apnea
8 (5.5)	Bradycardia
3 (2.1)	Hypoxemia
3.8 (1.2-24)	Time to oral feeding (h)
25 (24-152)	Time to discharge (h)
120 (83)	Early discharge, n (%)*

* ≤ 30 h postoperatively

oral intake after surgery, and early hospital discharge. Analysis of the various factors that could potentially affect the occurrence of adverse effects, as well as delay oral feeding and home discharge, found a significant independent effect only for disorders associated with prematurity, namely bronchopulmonary dysplasia and periventricular leukomalacia.

In a large study of spinal anesthesia in this age group (1,554 surgeries, including 855 for inguinal hernia repair), Williams et al. reported rates of intraoperative bradycardia and hypoxemia very similar to the results reported here, 1.6% and 0.6%, respectively.² However, both term and preterm infants were included in the study and 24.1% received intraoperative sedation. No postoperative follow-up information was provided. In another prospective study, Frumiento et al. examined the perioperative parameters of 259 preterm infants undergoing inguinal hernia repair. Although 21.4% of the patients required supplementation with systemic anesthesia, only 1.5% had intraoperative bradycardia, similar to our rate, and none had apnea or hypoxemia. Postoperatively, their overall rates of bradycardia and apnea were 3.1% and 4.9%. When the 21.4% of patients who received systemic supplementation were excluded, the apnea rate decreased to 4.2%.⁷ The true postoperative complication rate in that study is difficult to assess because 40% of the infants were discharged home soon after surgery.⁷

In line with our findings that bronchopulmonary dysplasia and periventricular leukomalacia were the only significant risk factors predictive of an unfavorable outcome after spinal anesthesia, a review study reported that postoperative apnea in preterm infants was associated with bronchopulmonary dysplasia, apnea episodes at home, neurological disease, and anemia.⁹

The present study provides new clinically significant information compared to previous reports. The study group was restricted to preterm infants who did not require systemic anesthesia supplementation and for whom post-anesthesia and perioperative follow-up data were available. However, the high success rate of 96% excludes any bias in our results. In addition to the routine postoperative parameters of hypoxemia, bradycardia, and apnea, we analyzed airway and pulmonary complications, and times to resumption of oral feeding and to home discharge. In one of the few studies that evaluated postoperative outcomes other than apnea, bradycardia, and hypoxemia, Somri et al.¹⁰ observed that spinal anesthesia was associated with shorter postoperative hospitalizations and a decreased rate of postoperative apnea compared to general anesthesia. However, the postoperative apnea rate was high (20%), possibly because spinal anesthesia was supplemented with sedation or general anesthesia in six of the 20 patients in the spinal anesthesia group.¹⁰

It should be noted that the rate of postoperative apnea, hypoxemia, or bradycardia in our study might have been higher had we based it on analysis of monitoring recordings,¹¹ or used nasal airflow thermistors or capnograph probes.^{5,12} This is true for other studies,^{11,12} and the clinical relevance of nonsignificant apnea episodes is questionable. Furthermore, because we used a prospective cohort design, no comparison was made with other forms of anesthesia, such as general or caudal, precluding a definitive conclusion. Nevertheless, the present results should encourage further evaluation of the use of spinal anesthesia in preterm infants, when appropriate.

In conclusion, our study suggests that, for preterm infants undergoing inguinal hernia repair before their discharge from the neonatal unit, spinal anesthesia, in experienced hands, is associated with a high success rate, a low rate of postoperative complications, and short times to first feeding and to home discharge. Special attention should be addressed to preterm infants with bronchopulmonary dysplasia and periventricular leukomalacia, who may be prone to episodes of apnea, delayed resumption of feeding, and prolonged hospitalization, postoperatively. These findings need to be confirmed in larger prospective controlled studies in institutions where both spinal and general anesthesia are administered to high-risk preterm infants.

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