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Postoperative Outcome in Formerly Premature Infants undergoing Herniorrhaphy: Comparison of Spinal and General Anesthesia

To compare the postoperative outcome according to the type of anesthesia, formerly prematured and high-risk infants who had received and weaned ventilator care preoperatively and had undergone inguinal herniorrhaphy were enrolled in this study. Immediate pre- and post-operative respiratory data which contained the lowest respiratory rates, SpO_2, heart rates and the incidence of hypoxemia and bradycardia were collected with the incidence of ventilator care, application of continuous positive airway pressure (CPAP), application of oxygen, hospital stay, and respiratory mortality by chart review, retrospectively. Among the twenty-nine infants, fourteen received the general anesthesia (GA group), and fifteen received the spinal anesthesia (SA group). Postoperatively, the infants in the GA group had lower SpO_2 (77.1 $\pm$20.9% vs. 93.0$\pm$5.5%), higher incidence of hypoxemia (6 vs. 0), ventilator care (5 vs. 0) and application of CPAP (4 vs. 0) than the infants in the SA group. One infant in the GA group died because of acute respiratory failure caused by respiratory syncythial virus pneumonia. We concluded that spinal anesthesia reduces postoperative oxygen desaturation and respiratory morbidity in formerly prematured and high-risk infants who underwent inguinal herniorrhaphy.

Key Words : *Anesthesia, General; Anesthesia Spinal; Infant, Premature; Postoperative Complications*

Gaab Soo Kim, Jae Gyok Song, Mi Sook Gwak, Mikyung Yang

Department of Anesthesiology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

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Address for correspondence
Mikyung Yang, M.D.
Department of Anesthesiology, Samsung Medical Center, Sungkyunkwan University School of Medicine, 50 Ilwon-dong, Kangnam-gu, Seoul 135-710, Korea
Tel : +82.2-3410-2462 , Fax : +82.2-3410-0361
E-mail : mkyang@smc.samsung.co.kr

INTRODUCTION

During the period of recovery from general anesthesia, we found that formerly prematured and high-risk infants might have frequent episodes of apnea, bradycardia, and oxygen desaturation (1). Therefore, routine postoperative monitoring on the patterns of breathing, heart rate, and saturation of oxygen was recommended in these infants (2). Several studies have demonstrated that the prematured and high-risk infants, who received general anesthesia, are at higher risk of postoperative apnea than those who received spinal anesthesia during the immediate postoperative period (2-4). But there was no report whether these complications subsequently cause the reuse of mechanical ventilator in these infants during the extended postoperative period; who once weaned ventilator preoperatively. Therefore, we decided to check postoperative courses in these infants with different type of anesthesia, and to find whether it had influenced the incidence of bradycardia, hypoxemia in the immediate postoperative period and the incidence of mechanical ventilation, the length of the hospital stay, and mortality in the extended postoperative period.

MATERIALS AND METHODS

During a 7-yr period (April 1995 through April 2002), all prematured (born at less than 32 wk gestational age) and high-risk (less than 44 wk postconceptual age at the time of operation) infants who had received and weaned ventilator care preoperatively and had undergone unilateral or bilateral inguinal hernia repair were included in this study by the review of the chart. In our institution, inguinal hernia repair was usually delayed until the infant was otherwise fit for discharge from hospital. Infants who received emergency inguinal hernia repair during the course of treatment in the intensive care unit because of the risk of incarceration were excluded. Gestational age, postconceptual age, body weight at birth, body weight at operation, Apgar scores at one and five min, and the time length of operation were obtained. Infants from whom we could not find the above information were excluded.

There were 29 infants who met the above criteria during the period mentioned above. Fourteen of them had received general anesthesia (GA), while fifteen of them had received spinal anesthesia (SA). In both groups, Hartmann's solution was administered intravenously at a rate of 5 mL/kg/hr using an infusion pump (IVAC 591 Volumetric pump, San Diego, CA, U.S.A.). Atropine 0.02 mg/kg was given to all infants, and the temperature of the operating room was maintaining steadily at 28℃ as warming blankets and heat lamps were used for all patients.

All blocks in the SA group were performed to the patient in the lateral decubitus position with the neck extended to prevent airway obstruction. Electrocardiographs and SpO_2 monitors were attached to the infant prior to positioning. A pacifier was used to soothe the restless infants, and ketamine 1 mg was given intravenously as demanded. There was no fluid preloading prior to spinal anesthesia. The back of the infant was cleansed with 10% povidone iodine solution. Lumbar puncture was performed with a midline approach through either the 4th or 5th lumbar interspace, using a 22 gauge, 1.5 inch Quincke needle (Becton Dickinson, Franklin Lakes, NJ, U.S.A.). When a free flow of cerebrospinal fluid was obtained, hyperbaric bupivacaine (Marcaine® Spinal 0.5% Heavy, AstraZeneca Södertälje, Sweden) 0.6 mg/kg+0.1 mL was injected by using a 1 mL syringe. The spinal block was regarded as successful, if there was almost immediate loss of tone in the lower limbs. The attempt of lumbar puncture was allowed three times at maximum frequency. Two infants who received general anesthesia because of unsuccessful lumbar puncture were included into the GA group. Infants who had converted to general anesthesia during the operation because of inadequate spinal anesthesia were excluded from this study. Sedation of the infants was done by intermittent injection of ketamine 1 mg, if necessary. Eleven of the fifteen infants received ketamine, and the average dose was 4.4 mg per patient. Oxygen supply was done via nasal prong (0.1-0.5 L/min) in two infants who received oxygen application preoperatively. Loose restraints were applied to the upper limbs of the infant to prevent abrupt movement. There was no intraoperative hemodynamic instability. Nor did episode of hypoxemia occur.

In the GA group, anesthesia was induced by injection of thiopental 5 mg/kg intravenously. Tracheal intubation was facilitated by vecuronium 0.1 mg/kg, followed by intermittent positive pressure ventilation with enflurane 1.5-3% and N_2O/O_2 (50/50%). If the spontaneous respiration was restored at the end of the surgery, neuromuscular blockade was reversed with pyridostigmine 0.3 mg/kg and glycopyrrolate 0.008 mg/kg. If not, we waited for about 30 min in the operating room for the infant to recover with repeated tactile stimulation and then recommended the use of ventilator in infants whose respiration was still too weak to breathe alone.

Preoperative treatment of surfactant, aminophylline, or antibiotics were assessed and the existence of respiratory distress syndrome (RDS) and the incidence of ventilator care, the application of continuous positive airway pressure (CPAP) and oxygen were reviewed. The lowest value of respiratory rates, SpO_2, and heart rates and the incidence of hypoxemia and bradycardia were obtained by review of the flow sheet of the intensive care unit during the period of 24 hr before the operation and 24 hr after the operation, respectively. The respiratory rates, SpO_2, and heart rates had been recorded at an hour interval in the flow sheets. Bradycardia was defined as a heart rate less than 100 beats/min and hypoxemia was defined as SpO_2 less than 90%. Hypoxemia was divided into three grade according to its severity: 1) SpO_2 80-89%, 2) 70-79%, and 3) less than 70%. The incidence of ventilator care, applications of CPAP and oxygen, length of the hospital stay, and respiratory mortality were assessed during the periods from the end of the operation to the discharge or death.

Comparison between the different variables (gestational age, birth weight, conceptual age, body weight at operation, and Apgar scores) in both groups was performed by using Student's t-test. Comparison of the differences in the preoperative treatment of surfactant, aminophylline, antibiotics, the existence of RDS, the incidence of application of ventilator, CPAP and oxygen, the incidence of hypoxemia, bradycardia, and respiratory mortality in both groups was performed by using Fischer's exact test. Wilcoxon Rank Sum test was used to analyze the lowest values of respiratory rates, SpO_2, heart rates, and hospital stay in both groups. A p value of 0.05 or less was considered to be statistically significant. The statistical program used in this study was Jandel SigmaStat (version 2.0, Jandel Corporation, San Rafael, CA, U.S.A.). Data are presented as mean±SD or number of patients.

RESULTS

There were no statistically significant differences in the mean gestational age, birth weight, postconceptual age, body weight at the operation, Apgar scores, and the operating time between the two groups (Table 1). There were no statistically significant differences in the preoperative treatment of surfactant, aminophylline, antibiotics, the existence of RDS, and the incidence of ventilator care, applications of CPAP and oxygen between the two groups (Table 2). There were also no statistically significant differences in the lowest values of respiratory rates, SpO_2, heart rates and the incidence of hypoxemia and bradycardia between the two groups (Table 3).

Postoperatively, infants in the GA group had lower SpO_2, higher incidence of hypoxemia, ventilator care, and application of CPAP than infants in the SA group (Table 4, 5). Five infants from the GA group required postoperative mechanical ventilation; one infant for one day, one infant for three days, and three infants for more than two weeks (15, 23, 78 days). One infant in the GA group died because of acute respiratory failure caused by respiratory syncythial virus pneumonia.

Table 1. Demographic Data

	GA Group (n=14)	SA Group (n=15)
Gestational age (wks)	27.8±1.7	27.5±1.9
Birth weight (g)	1156±327	982±235
Postconceptual age (wks)	40.2±2.6	41.1±2.8
Body weight at operation (g)	2,806±541	2,937±755
Apgar score at 1 min	4.4±2.1	3.6±2.1
Apgar score at 5 min	6.4±1.5	5.2±1.9
Operating time (min)	65.4±15.6	66.3±17.0

GA: general anesthesia, SA: spinal anesthesia. Values are mean±SD. There were no significant statistical differences between the two groups.

Table 2. Preoperative respiratory data (I)

	GA Group (n=14)	SA Group (n=15)
Surfactant	5	4
Aminophylline	1	5
Antibiotics	2	2
RDS	4	2
Ventilator care	14	15
CPAP	8	10
Oxygen	11	15

CPAP: continuous positive airway pressure, GA: general anesthesia, RDS: respiratory distress syndrome, SA: spinal anesthesia. Values are numbers of patient. There were no significant statistical differences between the two groups.

Table 3. Preoperative respiratory data (II) (during 24 hr before the operation)

		GA Group (n=14)	SA Group (n=15)
Respiratory rates (/min)		34.8±6.0	34.3±12.9
SpO_2 (%)		90.1±8.2	90.7±8.9
Incidence of	SpO_2 80-89	5	2
hypoxemia (<90%)	SpO_2 70-79	3	2
	SpO_2 <70	0	0
Heart rates (beats/min)		125.6±9.6	127.1±19.1
Incidence of bradycardia (<100/min)		0	1

GA: general anesthesia, SA: spinal anesthesia. Values are number of patient or mean±SD. Respiratory rates, SpO_2, and heart rates are the lowest values during the observation period. There were no significant statistical differences between the two groups.

Three infants from the SA group required postoperative application of oxygen (0.1-0.5 L/min via nasal prong), but none needed postoperative mechanical ventilation or application of CPAP in the SA group. There was no significant difference in the length of the hospital stay between the two groups.

DISCUSSION

An increasing number of premature infants who survived beyond the immediate neonatal period due to advances in neonatology require surgical intervention for a variety of problems, most commonly inguinal hernias. Inguinal hernias are present in 13% of infants born at less than 32 weeks of gestational age (5). Early repair of these inguinal hernias might prevent incarceration, but the associated apnea after general anesthesia can be a significant source of morbidity in these infants. The present study revealed that spinal anesthesia reduces postoperative hemoglobin oxygen desaturation and respiratory morbidity in formerly prematured, high-risk infants who underwent inguinal herniorrhaphy.

In the GA group, five infants (36%) required postoperative mechanical ventilation, four received the application of CPAP, and eight needed application of oxygen. All of five infants received ventilator care immediately after the operation and two of these received secondary ventilator care after the weaning once in the postoperative period. On the contrary, none in the SA group required postoperative mechanical ventilation or application of CPAP; only three infants needed application of oxygen.

Table 4. Postoperative respiratory data (I) (during 24 hr after the operation)

		GA Group (n=14)	SA Group (n=15)
Respiratory rates (/min)		30.3±9.8	34.3±7.1
SpO_2 (%)		77.1±20.9	93.0±5.5*
Incidence of	SpO_2 80-89	8	4
hypoxemia (<90%)	SpO_2 70-79	5	0*
	SpO_2 <70	6	0*
Heart rates (beats/min)		108.1±29.7	124.6±15.2
Incidence of bradycardia (<100/min)		3	0

GA: general anesthesia, SA: spinal anesthesia. Values are number of patient or mean±SD. Respiratory rates, SpO_2, and heart rates are the lowest values during the observation period. *: $p<0.05$ compared with the GA group.

Table 5. Postoperative respiratory data (II)

	GA Group (n=14)	SA Group (n=15)
Ventilation	5	0*
CPAP	4	0*
Oxygen	8	3
Hospital stay (days)	32.6±58.4	10.7±14.1
Respiratory mortality	1	0

CPAP: continuous positive airway pressure, GA: general anesthesia, SA: spinal anesthesia. Values are numbers of patient or mean±SD. *: $p<0.05$ compared with the GA group.

Many studies have reported that prematured, and formerly prematured infants of less than 60 weeks of postconceptual age experience respiratory complications more frequently following general anesthesia than other infants with full-term conception (6, 7). Postanesthesia apnea may occur because of diminished central respiratory drive, easily incurred diaphragmatic fatigue, airway obstruction, hypothermia, and residual effect of muscle relaxant and inhaled anesthetic agents (8). In our study, five of the fourteen infants (36%) in the GA group developed postoperative apnea and were required to postoperative mechanical ventilation. The incidence of postoperative respiratory complications following general anesthesia in our study was similar to that reported by Welborn et al. (2). They found a 31% apnea rate in premature infants who underwent herniorrhaphy under general anesthesia. While there is no consensus on the exact incidence of apnea in premature infants who received general anesthesia, the rate is likely to be between 11 to 37% (1).

A study by Abajian et al. (9) in 1984 provoked an interest in spinal anesthesia as an alternative to general anesthesia in this high-risk population. Thereafter, many studies including ours examined the risk of apnea in premature infants after receiving spinal anesthesia (4, 10, 11). But most and other studies were concerned about the incidence of apnea, the necessity of routine postoperative respiratory monitoring (12), feasibility of outpatient surgery (13), and the cost effectiveness (4) in the immediate postoperative period. There were few reports whether the general anesthesia in this population increases the chance of the reuse of mechanical ventilation as well as the risk of hypoxemia in the immediate postoperative period. Besides, there was a report to support the routine use of general anesthesia for repair of asymptomatic inguinal hernia in medically stable premature infants because of the technical difficulty, lack of reliability, and the inconclusive effectiveness of spinal anesthesia (14). Therefore, we decided to prove that there still remains high risk of postoperative complication after general anesthesia, and it could be removed by spinal anesthesia. Restarting mechanical ventilation in infants who had experienced marked difficulty in the weaning of mechanical ventilation, can be very hazardous and even fatal. The infant who expired 145 days after the operation had weaned ventilator care once and needed the reuse of mechanical ventilation after general anesthesia. Although there were no significant differences in the durations of the hospital stay and the rates of incidence of mortality between the two groups in this study, we thought that the death of this infant in the GA group in particular should not be regarded as trivial. So we recommend considering the delay of the surgery, when it is technically impossible to obtain spinal anesthesia in case of the infants who had marked difficulty in the weaning of mechanical ventilation.

We chose the infants of less than 44 weeks of postconceptual age rather than of 60 weeks. It is because Malviya et al. (15) reported that ex-preterm infants younger than 44 weeks of postconceptual age are at greater risk for apnea after general anesthesia than are the infants older than 44 weeks of postconceptual age. Webster et al. (11) suggested that spinal anesthesia in these infants reduces but does not eliminate the risk of respiratory instability, and that supplementary anesthesia is often necessary to provide satisfactory operating conditions. In our study, three of the fifteen infants in the SA group required application of postoperative oxygen because of low SpO_2 but none showed SpO_2 less than 80% level. As mentioned earlier, infants who needed supplementary anesthesia was excluded from this study.

Welborn et al. (2) reported that spinal anesthesia without ketamine sedation was not associated with postoperative apnea, whereas infants receiving either general anesthesia or spinal anesthesia plus ketamine sedation experienced a 31% and 89% incidence rates of postoperative apnea, respectively. Despite of the high incidence of apnea in spinal plus ketamine group in their study, our infants in the SA group did not show troublesome that demanded ventilation assistance during the operation. The discrepancy between two studies may be related to the differences in the amount of dose and the route of ketamine and in the difference of the monitoring method. They gave intramuscular ketamine 1-2 mg/kg and monitored apnea using an impedance pneumograph, while we gave intravascular ketamine 1 mg intermittently and reviewed the lowest SpO_2 and the incidence of hypoxemia. Because they did not monitor the SpO_2, it was not certain that the apnea resulted in hypoxemia in every case without the spontaneous return of respiration.

There are several reports that confirmed the cardiovascular stability of children aged five years and less after spinal block because of the immaturity of the sympathetic nervous system and the small proportions of the lower extremities (16, 17). In our review, there were no episodes of hypotension or bradycardia. No case of high spinal (18) was found, and there were no episodes of hypoxemia intraoperatively.

Conclusively, we can suggest that spinal anesthesia for inguinal herniorrhaphy in formerly premature, high-risk infants can reduce the risk of postoperative hypoxemia and the need for postoperative mechanical ventilation.

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