Original Article

Does Spinal Anesthesia Affect Huff Cough Strength in Parturient Under Elective Cesarean Section?

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Background: Spinal anesthesia in parturients that undergo cesarean section is a method of choice, but some patients complain about shortness of breath after surgery. This might be due to spinal block may have effect on huff cough strength resulting in the difficulty to expel the mucus from the lungs. The Mini-Wright Peak Flow Meter, the surrogate device of huff cough strength, is a bedside equipment used to assess exhalation force by its peak expiratory flow rate (PEFR). As a result, the investigators would like to know if the spinal block affected the parturient huff cough strength.

Objective: To evaluate the spinal anesthesia during cesarean section effect on the parturient huff cough strength and to find the factors that influence the difference of PEFR beside the spinal block.

Materials and Methods: The PEFR was recorded three times in 161 healthy term pregnant women at 38 to 42 weeks of gestational age that were scheduled for elective cesarean section, at preoperative, immediate after spinal block, and before discharge from the recovery room. The measurement was performed in all parturients with 15 degree left lateral tilt position and the highest PEFR achieved in three successive attempts. The spinal anesthesia with 10.75 to 11 mg of 0.5% hyperbaric bupivacaine and 0.15 to 0.2 mg morphine was performed under the standard anesthetic care.

Results: One hundred sixty-one patients successfully completed the present study. The PEFR appeared to decrease significantly after spinal block from 285.53±55.21 L/minute to 238.70±49.69 L/minute ($p<0.001$) and seemed to sustain till the time of discharge from the recovery room at 235.40±47.29 L/minute ($p=0.493$). These implied that though the patients fulfilled the discharge from recovery criteria, the level of sensory blockade was not yet improved. Interestingly, these values were comparable and showed no correlation with age, BMI, and solid sensory blockade.

Conclusion: Spinal anesthesia might affect huff cough strength in parturients that underwent elective cesarean section as evidenced by the decrease of PEFR even at the time of discharge from the recovery room.

Keywords: Bupivacaine; Cesarean section; Huff cough strength; Parturient; Peak expiratory flow rate; Spinal anesthesia

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Previously, cesarean section was not an interesting issue because of the risk of postpartum hemorrhage(1). However, with the advancement of surgical techniques and instrumentation as well as the complexities of vaginal deliveries, operating delivery has been increasing in about 30% of all deliveries(2).

Parturients under surgical delivery are manipulated with either general or regional anesthesia. The former yields a higher maternal morbidity/mortality such as intubation failure and pulmonary aspiration, while the latter including epidural or spinal block shows increasing popularity since conscious mother can merrily participate in the delivery of her infant(3).

Nevertheless, the regional anesthesia, particularly spinal block, is not without adverse effects. After intrathecal block, most patients complain about shortness of breath. Furthermore, the spinal block may impair the patient's ability to cough forcefully to clear the airways. A study reported that these parturients had 14% pulmonary atelectasis area as verified by chest-computed tomography(4). The level of blockade might have direct effect upon abdominal and intercostal muscle weakness followed by decreasing functional residual capacity and expiratory reserve volume. In addition, the uterine distension and elevation of the

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diaphragm result in reduced huff cough strength[5,6].

The huff cough is like exhaling onto a mirror or windowpane to steam it up[7]. It involves taking a breath in, holding it, and actively voluntarily exhaling. Though huff cough is not so forceful as a conventional cough, it helps to expectorate the mucus from the lungs effectively[8].

The Mini-Wright Peak Flow Meter is a handheld, bedside device used to measure the peak expiratory flow rate (PEFR), which reflects the patency of the airways. The higher the PEFR is, the more open the airways are. One can achieve the PEFR by breathing in slowly, holding the breath as long as possible, and then forcing the air out through the mouthpiece of the device. Concurrently, the PEFR values can indicate huff cough strength[7].

Normally, the PEFRs vary in different individuals according to race, for example, Asians have lower PEFRs than the Europeans[9]. In addition, positioning, such as supine or sitting, has particular impacts on PEFRs[8,10]. So far, the baseline values of PEFRs have not been well established in normal pregnant women[9-19].

There are conflicts between the dosage of spinal block and the PEFRs reduction in parturient in those studies[20-26]. As a result, the authors would like to study whether spinal anesthesia in the present study dosage range affected huff cough strength and PEFRs in parturient that underwent elective surgical delivery, and the factors influencing this outcome.

Materials and Methods

The present study protocol was approved by the Siriraj Institutional Review Board (SIRB), Mahidol University, Thailand (COA: 763/2560EC4) and registered via Thai Clinical Trials Registry (TCTR20180507003). Written informed consents were obtained from all parturient.

The present study was a single group, non-blinded, prospective study. The sample size (n=170) was calculated using standard deviation (SD) from Ungern-Sternberg et al in the study on impacts of spinal anesthesia and obesity on maternal respiratory function during elective cesarean section[20]. The 10% difference in the PEFR at α of 0.05 and power 90% were determined.

Inclusion criteria were healthy term pregnant women at 38 to 42 weeks of gestational age, receiving elective cesarean section between March 20 and October 16, 2018. Exclusion criteria were patients with body mass index (BMI) greater than 30 kg/m², pre-existing respiratory and cardiovascular diseases, non-singleton pregnancy, history of smoking, and signs of true labor pain or fetal distress before the date of elective surgery. Termination criteria were patients refusing to join the study at any time, those that failed the spinal procedure and switched to general anesthesia, or those that developed severe hypotension or heart failure.

The day before surgery

A co-researcher visited and explained the project in detail as well as demonstrated the practical way to blow the Mini-Wright Peak Flow Meters (Micropeak®, Basingstoke, United Kingdom) at 15 degrees, left lateral tilt position to the participant. After the participants became familiar with the process, they would blow the device in three successions on the absence of labor pain with numeric rating scale or NRS at 3 or lower. The highest PFER was recorded as PEFR1.

On the day of surgery

All parturient were administered with 50 mg ranitidine intravenously or 0.3M sodium citrate 30 mL orally, 30 to 60 minutes before the transfer to the operating theater. Prior to commencing spinal anesthesia, patients were monitored with non-invasive blood pressure, percutaneous oxygen saturation (SpO_2) and electrocardiogram (EKG). Then an anesthetist placed a patient in left lateral position and performed the intrathecal block at the L3-L4 or L2-L3 level with 10.75 to 11 mg of 0.5% hyperbaric bupivacaine and 0.15 to 0.2 mg morphine. Subsequently, the patient was arranged in the supine position with 15-degree left lateral tilt and supported by a wedged pillow under the right hip for preventing aortocaval compression. Additionally, 6 mg ephedrine or 4 mcg norepinephrine was pushed intravenously whenever the blood pressure showed a 20% decrease from the baseline.

The level of sensory impairment was assessed by using gauze in 0.5% chlorhexidine solution. When the block became solid, the patient blew the device once and the resulting PEFR was noted as PEFR2. Afterwards, the surgery and anesthesia ensued in usual timely manner.

In the recovery room

A registered nurse took care of the postoperative participant for nearly 1.5 hours with standard monitoring. She administered narcotics intravenously to relieve the patient's pain to keep NRS at 3 or lower. When the discharge criteria were fulfilled, the nurse asked the patient to blow the device for the last time and the PEFR was recorded as PEFR3.

Statistical analysis

Data were expressed as mean and standard deviation by means of IBM SPSS Statistics, version 21 (IBM Corp., Armonk, NY, USA). All PEFRs were analyzed by the paired t-test, Kolmogorov-Smirnov test and Pearson's correlation. A p-value of less than 0.05 was considered statistically significant at the 95% confidence interval.

Results

One hundred sixty-one out of 170 parturient accomplished the present study, as nine switched to general anesthesia. Patients characteristics including age at 34±4.5 years, BMI at 26.2±2.4 kg/m², gestational age at 270±3.1 days, time to solid blockade at 8.6±2.4 minutes, time from skin incision to delivery at 10.3±5.4 minutes, and duration of surgery at 51.5±14.8 minutes were recorded (Table 1).

The height of sensory blockade was between the levels of T6 and T3. Postoperative narcotics were not administered in all patients. Approximately 80% of the parturient required vasopressors for the treatment of intraoperative hypotension.

The PEFR2 at 238.7±49.7 L/minute appeared to decrease significantly after the block from PEFR1 at 285.5±55.2 L/minute ($p<0.001$); however, it was comparable to PEFR3 at 235.4±47.3 L/minute ($p=0.493$) at the time of discharge from the recovery room (Table 2).

The differences of PEFR1 to PEFR2 and PEFR1 to PEFR3 did not correlate with age, BMI, and solid sensory blockade (Table 3).

Discussion

After spinal anesthesia in the operating theatre and in the recovery room, PEFRs showed significant decreases from the baseline. Interestingly, these values were comparable and showed no correlation with age, BMI, and solid sensory blockade.

There were plausible explanations about the PEFRs decreased after spinal anesthesia.

Firstly, blockade up to the level of T4 can affect abdominal and intercostal muscle strength, resulting in decreased huff cough strength. These muscles are necessary for stabilizing the end-expiratory rib cage position, the ventilation of dependent lung field, and the functional residual capacity[21,22]. This was consistent with Harrop-Griffiths et al in a study on regional anesthesia and cough effectiveness, explaining the extensive motor block of abdominal and intercostal muscles produced during regional anesthesia for cesarean section might impair the patient's ability to cough effectively and thereby clear the airways[23]. In addition, Geng et al in an article regarding pulmonary effects of bupivacaine and ropivacaine in parturients undergoing spinal anesthesia for elective cesarean delivery described that the high-level blockade needed for surgery would reduce the lung volumes and respiratory drives of patients by affecting abdominal muscles and intercostal muscles[24].

PEFRs is an essential indicator for the huff cough strength. Adequate huff cough postoperatively plays an important role in preventing respiratory complications.

However, Lirk et al in a randomized controlled study on pulmonary effects of bupivacaine, ropivacaine, and levobupivacaine in parturient

Table 1. Demographic characteristics (n=161)

	mean±SD
Age (year)	34±4.5
BMI (kg/m²)	26.2±2.4
Gestational age (day)	270±3.1
Time to solid blockade (minute)	8.6±2.4
Time from skin incision to delivery (minute)	10.3±5.4
Duration of surgery (minute)	51.5±14.8

BMI=body mass index; SD=standard deviation

Table 2. Comparison between the PEFR1, PEFR2, and PEFR3 in parturient receiving spinal anesthesia for elective cesarean section

	PEFR (L/minute); mean±SD	p-value
PEFR1	285.5±55.2	<0.001
PEFR2	238.7±49.7	
PEFR1	285.5±55.2	<0.001
PEFR3	235.4±47.3	
PEFR2	238.7±49.7	0.493
PEFR3	235.4±47.3	

PEFR=peak expiratory flow rate; SD=standard deviation

p<0.05, statistical significance

Table 3. Correlation of age, BMI, and solid sensory blockade with differences of PEFR values from the baseline

Difference of PEFR	Age	BMI	Solid sensory blockade
PEFR1-PEFR2	0.152	0.017	0.108
PEFR1-PEFR3	0.147	0.101	0.004

PEFR=peak expiratory flow rate; BMI=body mass index undergoing spinal anesthesia for elective cesarean delivery showed that the PEFRs did not decrease after a spinal block with 10 mg bupivacaine differed from 12.5 mg in those studies[20,23,25-27]. Furthermore, Geng et al in a study on pulmonary effects of bupivacaine and ropivacaine in parturient undergoing spinal anesthesia for elective cesarean delivery, reported that there was no significant deterioration in PEFRs after a spinal block with 9 mg bupivacaine[24]. These disparities may be explained by different doses of bupivacaine.

Secondly, parturients with high BMIs showed reduced respiratory function. Higher BMIs resulted in elevated work of breathing, respiratory muscle inefficiency, and diminished respiratory compliance. Furthermore, decreased functional residual capacity and expiratory reserve volume are associated with the closure of peripheral lung units, ventilation to perfusion ratio abnormalities and hypoxemia, especially in the supine position[28,29]. This was supported by Lirk et al in a randomized controlled study on pulmonary effects of bupivacaine, ropivacaine and levobupivacaine in parturient undergoing spinal anesthesia for elective cesarean delivery. They reported that higher BMIs appeared to predispose patients undergoing spinal anesthesia to more severe reductions in lung functions[25]. In addition, Ungern-Sternberg et al in a study on the impacts of spinal anesthesia and obesity on maternal respiratory function during elective cesarean section explained that obesity predisposed to the formation of atelectasis and contributed to postoperative compromised respiratory function[20].

Finally, the cephalad shifting of the diaphragm is caused by the expanding uterus. This affected the lung volume especially the functional residual capacity and tended to increase pulmonary atelectasis. However, no previous studies reported the impacts of spinal anesthesia on the diaphragm[22,30]. This agreed with Meira et al in a study on atelectasis observed by computerized tomography after cesarean section, who reported that the diaphragm elevation secondary to uterine volume increase impaired the distribution of ventilation during pregnancy[4]. Furthermore, LoMauro A, et al in an article on respiratory physiology of pregnancy explained that the enlarged uterus, which displaced the diaphragm upwards, was leading to an earlier closure of the small airways with consequent reduction of the functional residual capacity and expiratory reserve volume[5].

The limitation of the present study was that parturients were not able to force peak expiratory flow as much as usual. However, the investigators measured patients' PEFRs three times and took the best one. Moreover, this was a single-group study. A blinded, randomized controlled trial regarding the relationship between the intrathecal bupivacaine dosage and the huff cough strength in parturients undergoing cesarean section should be conducted.

Conclusion

The huff cough strength in parturients scheduled for elective cesarean section could reduce immediately after spinal anesthesia until the time of discharge from the recovery room. Although most of these patients are not sedated from intraoperative period until discharged to ward, anesthesiologists should beware and pay concern to prevent the aspiration risk.

What is already known on this topic?

The different dosage of spinal anesthesia in previous studies has made the controversy of parturient huff cough strength reduction.

What this study adds?

Spinal anesthesia of the present study dosage might affect huff cough strength in parturients that underwent elective cesarean section until the time of discharge from the recovery room.

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Conflicts of interest

The authors declare no conflict of interest.

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