Original Article

Significance of Expiratory Muscle Strength in Gynecologic Patients after Spinal Anesthesia

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Background: The spinal block has become a favorable technique for gynecologic surgery. However, the level of sympathetic blockade results in weak diaphragm and respiratory muscles as well as cough impairment. Investigators were curious to assess patients' respiratory functions after spinal anesthesia.

Materials and Methods: One hundred forty-five gynecologic patients undergoing elective, exploratory laparotomy with spinal anesthesia were included. The blowing practice of a Mini Wright Peak Flow Meter was performed until patients became comfortable with it. A given patient blew the device three times, and the best value was chosen to assess peak expiratory flow rates (PEFRs): prior to surgery (P1), after the spinal block (P2), and in the recovery room (P3).

Results: At the thoracic blockade level as T was 4 or less and T was greater than 4, PEFR at P1, P2 and P3 were 285.9±5.9, 222.3±4.9, and 216.4±6.4 mL, and 302.8±7.7, 224.9±6.4, and 203.4±8.4 mL, respectively. The PEFRs showed no significant differences among the levels of blockade at the ward (p=0.082), the operating theater (p=0.744), and the recovery room (p=0.211). Though P3 seemed to fall, there was no marked difference between P2 and P3 (p=0.224). However, either P2 or P3 appeared to decrease sharply (p<0.001) in comparison with P1.

Conclusion: A Mini Wright Peak Flow Meter can be used as a bedside device to measure PEFRs. The substantial decrease of PEFR was related to the level of sympathetic blockade after spinal anesthesia.

Keywords: Anesthesia, Spinal block, Peak expiratory flow rate, Gynecology

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Annually, the Department of Anesthesiology takes care of 52,023 patients, about 30% of whom engage in regional anesthesia[1].

Spinal block, a technique of providing anesthetics intrathecally, is commonly used for regional anesthesia where the operative field is below the thoracic level, particularly in gynecologic patients. The criteria for spinal anesthesia are compulsory. Normally, spinal block is carried out for patients with difficult ventilation, difficult intubation, or irritable airway[2].

After the administration of local anesthetics to the subarachnoid space, drugs dissociate into ionized and non-ionized forms. Those without ions (lipid-soluble) can disperse freely through nerve membranes and determine the onset of actions. Then drugs are once split into ionized and non-ionized form. This time it is the ionized form that interacts with the internal sodium channel. Consequently, patients experience solid sensory and motor blockade and can tolerate surgery for hours[3].

However, spinal anesthesia has some adverse effects. By and large, the sympathetic block results in mild hypotension, weakness of the diaphragm and respiratory muscles, as well as cough impairment. If the blockade level was high, referred to as high or total spinal anesthesia, profound hypotension, severe bradycardia, respiratory muscle paralysis, and even cardiac arrest could result, so anesthesia personnel

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need to be alert. Apparently, respiratory function impairment varies with the level of sympathetic blockade[4,5].

Clinically, physicians have been using Mini Wright Peak Flow Meter since 1950 as a bedside device to measure peak expiratory flow rates (PEFRs)[6]. The flow meter is a small, light weighted handheld plastic cylinder. During the measurement, the patient blows forcefully via the mouthpiece of the device.

PEFR is a quick test for the amount and rate of air that can be powerfully exhaled, and it is mostly used in patients who suffer from asthma[7]. Investigators are curious about its facility to assess patients' respiratory functions before and after spinal anesthesia. Is PEFR related to the level of sympathetic blockade? Can one predict respiratory effects after spinal anesthesia?

Materials and Methods

After the Siriraj Institutional Review Board approval 764/2560 (EC4), the present trial was registered via the Thai Clinical Registry (TCTR20180921002), and written informed consent forms were obtained from all subjects. This prospective interventional study was performed between March 2018 and May 2019.

To calculate the sample, the test significance level α=0.010, 1- or 2-sided test=1, the null hypothesis correlation was P_0=0.500, the alternative correlation was P_1=0.700, the power (%)=90, therefore, the number of subjects required was n=132. After adding 10% for drop-out, the required number of patients was 145. The inclusion criteria were gynecologic patients, aged 18 to 65, ASA class I-II, undergoing elective, exploratory laparotomy for non-cancer under spinal anesthesia, including total abdominal hysterectomy and salpingo-oophorectomy.

The exclusion criteria were patients with body mass indices (BMIs) of over 30 kg/m^2, history of pulmonary, cardiovascular, and end-stage renal diseases, pregnancy, heavy smoking, and participants with an abnormal chest wall, kypho-scoliosis, or those using anti-psychotic or regular sedative drugs.

Withdrawal criteria were patients who were unhappy to continue under the study project and those with unstable vital signs or interventional failure.

On the day of admission

A co-researcher invited recruited patients and explained the project in detail. Besides giving an overview information of the surgical procedure and the spinal anesthesia technique, the blowing practice of a Mini Wright Peak Flow Meter was performed until patients felt comfortable doing it. Measurement should start after full-lung inhalation. When the informed consent was obtained, the patient intentionally blew the device three times. The best value of the first PEFR at the ward was then verified as P1.

On the day of surgery

The patient was examined with standard monitoring, such as electrocardiography (EKG), SpO_2, and non-invasive blood pressure (NIBP). An anesthesiologist performed the regional blocking, using an alcohol pad to verify cold sensation every 1 to 2 minutes until the level of blockade was solid. Then the second PEFR after the spinal block administration was noted as P2.

After the operation, the patient was transferred to the recovery room under conventional nursing care. When the discharge criterion was met, the final PEFR prior to discharge was measured as P3.

Statistical analysis

Descriptive statistics were used to analyze the demographic characteristics such as age and gender. Quantitative data were presented as mean ± standard deviation, or median (percentile 25, percentile 75), and qualitative data were presented as frequency.

To test the differences in quantitative variables with and without normal distribution between two groups (spinal blockade level independent t-test and Mann-Whitney U test as T as 4 or less and T as greater than 4) were applied, respectively. The Pearson's chi-square test or Fisher's exact test measured the difference in qualitative variables between the two groups.

The repeated-measure ANOVA was applied to compare PEFRs at the ward (P1), after the spinal block (P2), and prior to discharge (P3) between the two groups. Bonferroni adjustment was also used for multiple comparisons. The PEFR was presented as mean ± standard error of mean (SEM)

All statistical analyses were performed using PASW Statistics, version 18.0 (SPSS Inc., Chicago, IL, USA). A p-value of less than 0.05 was considered statistically significant at 95% confidence interval.

Results

One hundred forty-five female patients were recruited in the present study. Their demographic data regarding age, weight, height, BMI, the American Society for Anesthesiologists (ASA) classification, underlying diseases, volume of uterus, diagnosis,

Table 1. Demographic data of all participants (n=145) undergoing gynecologic surgery after spinal anesthesia

Patients' characteristic	All (n=145) n (%)	≤T4 (n=92) n (%)	>T4 (n=53) n (%)	p-value
Age (year); mean±SD	43.42±8.05	43.10±8.26	43.98±7.70	0.526
Weight (kg); mean±SD	58.35±9.22	59.22±8.93	56.85±9.60	0.136
Height (cm); mean±SD	157.53±5.51	157.91±4.71	156.87±6.68	0.318
BMI (kg/m^2); mean±SD	23.44±3.22	23.63±3.08	23.12±3.46	0.364
ASA classification				0.500
ASA I	90 (62.1)	59 (64.1)	31 (58.5)	
ASA II	55 (37.9)	33 (35.9)	22 (41.5)	
Underlying disease				
Anemia	11 (7.6)	8 (8.7)	3 (5.7)	0.746
Diabetes mellitus	5 (3.4)	4 (4.3)	1 (1.9)	0.653
Hypertension	21 (14.5)	14 (15.2)	7 (13.2)	0.741
Dyslipidemia	16 (11.0)	10 (10.9)	6 (11.3)	0.933
Allergy	3 (2.1)	3 (3.3)	-	0.299
Volume of uterus (cm^3); median (p25, p75)	504 (153, 1,091)	640 (160, 1,485)	420 (140, 840)	0.290
Operation time (minute); median (p25, p75)	115 (90, 130)	120 (95, 143)	110 (80, 125)	0.057
Diagnosis				0.530
Myoma uteri	114 (78.6)	75 (81.5)	39 (73.6)	
Ovarian tumor	13 (9.0)	7 (7.6)	6 (11.3)	
Both	18 (12.4)	10 (10.9)	8 (15.1)	
Operation				
Total abdominal hysterectomy	107 (73.8)	69 (75.0)	38 (71.7)	0.663
Bilateral salpingo-oophorectomy	41 (28.3)	25 (27.2)	16 (30.2)	0.698
Bilateral salpingectomy	34 (23.4)	24 (26.1)	10 (18.9)	0.323
Salpingo-oophorectomy	26 (17.9)	15 (16.3)	11 (20.8)	0.501
Salpingectomy	14 (9.7)	8 (8.7)	6 (11.3)	0.606
Oophorectomy	16 (11.0)	10 (10.9)	6 (11.3)	0.933
Myomectomy	24 (16.7)	14 (15.2)	10 (18.9)	0.569
Incision				0.844
Pfannenstiel	115 (79.3)	72 (78.3)	43 (81.1)	
Low midline	28 (19.3)	19 (20.7)	9 (17.0)	
Midline incision	2 (1.4)	1 (1.1)	1 (1.9)	

SD=standard deviation; BMI=body mass index; ASA=American Society for Anesthesiologists

operation time, and surgical technique were recorded (Table 1).

The spinal anesthesia characteristics including the site of each spinal block, spinal needle gauge, anesthetic agent, anesthesia personnel, level of sensory blockade, and regression were clarified (Table 2). The study showed substantial correlation between the level of spinal blockade, the volume of anesthetic agent (Table 2), and the PEFR (Table 3).

At the thoracic blockade level as T was 4 or less and T was greater than 4, PEFR at P1, P2, and P3 were 285.9±5.9, 222.3±4.9, and 216.4±6.4 mL, and 302.8±7.7, 224.9±6.4, and 203.4±8.4 mL, respectively. The PEFRs showed no significant differences between the levels of blockade at the ward (p=0.082), the operating (p=0.744), and the recovery room (p=0.211) (Table 3). Though P3 seemed to decline, there was no significant difference between P2 and P3 (p=0.224).

However, either P2 or P3 appeared to decrease significantly (p<0.001) in comparison with P1 at all pairwise (Figure 1).

Table 2. Spinal anesthesia characteristics of all participants (n=145) undergoing gynecologic surgery

Patients' characteristic	All (n=145) n (%)	≤T4 (n=92) n (%)	>T4 (n=53) n (%)	p-value
Anesthesia personnel				0.189
Staff	11 (7.6)	10 (10.9)	1 (1.9)	
1st-year resident	48 (33.1)	27 (29.3)	21 (39.6)	
2rd-year resident	34 (23.4)	21 (22.8)	13 (24.5)	
3rd-year resident	52 (35.9)	34 (37.0)	18 (34.0)	
Spinal needle				0.229
Quincke	132 (91.0)	86 (93.5)	46 (86.8)	
Whitacre	13 (9.0)	6 (6.5)	7 (13.2)	
Needle gauge (G)				0.361
25	13 (9.0)	6 (6.5)	7 (13.2)	
26	15 (10.3)	9 (9.8)	6 (11.3)	
27	117 (80.7)	77 (83.7)	40 (75.5)	
Site of block				0.060
L2 to L3	5 (3.4)	1(1.1)	4 (7.5)	
L3 to L4	139 (95.9)	90 (97.8)	49 (92.5)	
L4 to L5	1 (0.7)	1(1.1)	-	
Anesthetic agent				0.366
Bupivacaine with morphine	144 (99.3)	92 (100)	52 (98.1)	
Bupivacaine	1 (0.7)	0 (0.0)	1 (1.9)	
Volume of anesthetics (mL); median (p25, p75)	3.3 (3.2, 3.4)	3.4 (3.2, 3.5)	3.2 (3.2, 3.4)	0.026*
Time to T4 to T6 (minute)				0.190
1	129 (89.0)	84 (91.3)	45 (84.9)	
2	13 (9.0)	7 (7.6)	6 (11.3)	
3	1 (0.7)	1 (1.1)	0 (0.0)	
4	2 (1.4)	0 (0.0)	2 (3.8)	

* p<0.05 as significance

Table 3. Comparison of PEFRs at the ward (P1), after the spinal block (P2) and prior to discharge (P3) among all gynecologic patients (n=145)

Level of blockade	PEFR (mL)			p-value
	P1	P2	P3	
T≤4	285.9±5.9	222.3±4.9	216.4±6.4	<0.001
T>4	302.8±7.7	224.9±6.4	203.1±8.4	Pairwise comparison
p-value	0.082	0.744	0.211	P1-P2 <0.001, P1-P3 <0.001, P2-P3 0.025

p<0.05 as significance

There were no complications due to high spinal block such as desaturation, dyspnea, or hypotension in the present study.

Discussion

The PEFRs after the spinal block and prior to discharge from the recovery room showed sharp decreases in comparison to those at the ward. Though the anesthesia regression was noted approximately two hours before discharge, PEFRs showed no significant improvement. This seemed to agree with Regli et al[8] in a trial on the impact of spinal

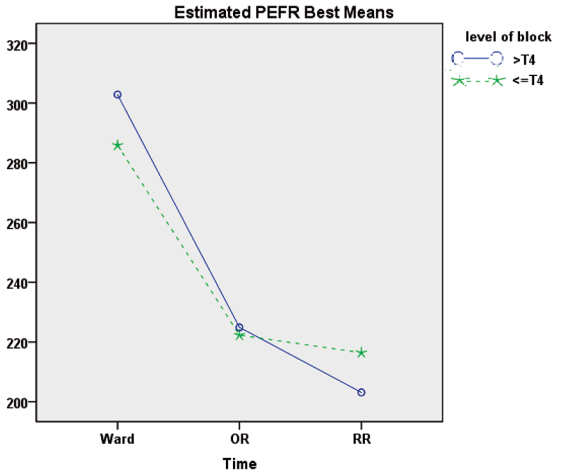

Figure 1. Peak expiratory flow rate (PEFRs) at the ward, after spinal block in the operating room (OR) and prior to discharge from the recovery room (RR) among all gynecologic patients (n=145).

anesthesia on peri-operative lung volumes in obese and morbidly obese female patients, which concluded that the diminished lung volume remained constant for two hours, and spirometric parameters showed marked improvement in all patients three hours after the surgery. This confirmed a sharp decrease in respiratory functions after a spinal block.

The Mini Wright Peak flow meter was widely used as a bedside tool to evaluate the expiratory capacity. Shahane and Jiandani supported its application to evaluate airway obstruction in patients with chronic respiratory diseases[9]. Moreover, Ishida et al, in a study on the correlation between peak expiratory flows and abdominal muscle thicknesses, claimed that the abdominal muscles, the firmness of the external oblique muscles at the end of relaxed expiration, were most strongly associated with PEFRs during forced expiration[10].

The PEFRs have served as a surrogate measure of cough and huff strength. It is the highest point of inspiration in the flow volume maneuver. Thus, the level of sensory and motor blockade after spinal anesthesia might considerably involve chest and abdominal muscles, resulting in less strenuous expiratory efforts, particularly the blowing of the Mini Wright Peak Flow Meter in the supine position. The present study finding was consistent with Jyothi and Kumar[11] in a study on flow rates and effects of different postures on peak expiratory and peak inspiratory flow rates on healthy individuals. They found that the standing position increased the sensitivity for assessing the effects on upper airway patency.

In addition, the level of spinal block affecting pulmonary function tests was discussed in many studies. Oğurlu et al, in a study on the effects of spinal anesthesia on pulmonary function tests in elderly patients, concluded that high level of spinal block influenced pulmonary function tests, predominantly in the elderly[12]. Conn et al, in a study on changes in pulmonary function tests during spinal anesthesia for cesarean section, reported that the changes in forced vital capacity, forced expiratory volume and PEFRs after spinal anesthesia decreased the ability to cough effectively[13].

The reasons for this were given by Kelly et al in a study on respiratory effects of spinal anesthesia for cesarean section. They described that an intra-operative deterioration in pulmonary function tests occurred as a result of the motor block that accompanied the sensory block of spinal anesthesia[14]. Geng et al[15] also found that the decrease in maternal pulmonary function tests were similar following spinal anesthesia with local anesthetics for cesarean section. However, the clinical maternal effects of these alterations appeared negligible.

The study limitation, investigators did not record the time of P3 measurement prior to discharge from the recovery room. In addition, the investigators could not determine causal relations between PEFR and timing of sympathetic blockade regression at ward.

Conclusion

A Mini Wright Peak Flow Meter can be used as a bedside device to measure PEFRs. The substantial decrease of PEFR was related to the level of sympathetic blockade after spinal anesthesia.

What is already known on this topic?

Spinal blocking has become a preferred technique in most gynecologic patients. However, the level of sympathetic blockade results in weak diaphragms and respiratory muscles as well as cough impairment for some time after surgery. Unfortunately, these adverse events are hardly assessed by anesthesia personnel at the point of care.

What this study adds?

The Mini Wright Peak Flow Meter has been used as a bedside device to measure PEFRs the patient could powerfully exhale. Investigators applied its facility to assess patients' respiratory efforts before and after spinal anesthesia.

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Conflicts of interest

The authors declare no conflict of interest.

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