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Effect of waist circumference and body mass index on the level of spinal anesthesia

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Abstract

Background: We aimed to determine the effects of waist circumference and body mass index on spinal anesthesia levels. In total, 120 surgical patients who were between 18 and 65 years old and in the American Society of Anesthesiologists' (ASA) I–III risk groups enrolled in this study. Patients were classified into three groups, depending on their weight. After a spinal block, we noted the time needed for the sensory block to reach the T10 level, the maximum sensory block level, the time needed for the sensory block to reach the maximum sensory block level, the time needed before the start of the motor block, and the Bromage scale for each patient.

Results: We observed no significant demographic differences in age, gender, or ASA risk class between the groups; however, we found a statistically significant difference between the groups' BMIs and waist circumferences. For the time needed for the spinal block to reach the T10 level, we observed a statistically significant difference between groups I, II, and III, and we also found a statistically significant difference between the groups' comparing Bromage scales. Moreover, we found a statistically significant difference between the groups' time needed (in minutes) for the block to reach the maximal upper dermatomal block level and, as BMIs and waist circumferences increased, the time needed to reach the maximal upper dermatomal block level. We also noted a statistically significant difference in waist circumference variability.

Conclusions: This study shows that body mass index and waist circumference can be used and interpreted as independent parameters reflecting the increasing incidence of obesity.

Keywords: Spinal anesthesia, Waist circumference, Body mass index, Obesity

Background

Spinal anesthesia has gained popularity over the last decade (Fettes, Jansson, and Wildsmith 2009). It is a regional anesthesia method that provides a reversible block in the spinal nerve root by injecting a local anesthetic drug. It offers many advantages, such as keeping the patients awake with spontaneous breathing, preserving such protective reflexes as coughing during operations, early mobilization, minimal lung complications, continuing analgesia, and shortened hospital stays during the postoperative period (Atkinson, Rushman, Davies, Lee, and Atkinson 1993; Collins 1993). Spinal anesthesia is mainly used for operations involving the inguinal, urogenital, rectal, and lower abdominal areas, as well as the extremities (Kayhan 2004).

The main goal of spinal anesthesia is a sensory and motor block, but sympathetic denervation that generally provokes systemic disturbances can be regarded as a side effect (Liu and McDonald 2001). Alongside the advantages of spinal anesthesia, some complications—such as hypotension, headache, lumbago, neurological sequelae, nausea, vomiting, meningitis, urinary retention—are associated with the method (Kayhan 2004).

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Obesity has been affecting all facets of health in the modern era (Hurt, Kulisek, Buchanan, and McClave 2010). Over the last three decades, morbid obesity rates have tripled. The World Health Organization declared in 2005 that 1.6 billion people are overweight (BMI 25–30), and 400 million people are obese (BMI > 30). In 2015, 2.3 billion people were estimated to be overweight, and 700 million were estimated to be obese (National Clinical Guideline 2014). As the incidence of obesity and morbid obesity (BMI > 40) increases, medical comorbidities—such as type 2 diabetes mellitus, hypertension, obstructive sleep apnea syndrome, cardiopulmonary diseases, and venous thromboembolism—have also increased (Şahin and Doğru 2013).

The World Health Organization defines classifications for BMI: *low weight* (BMI < 18.5), *normal* (BMI 18.5–24.9), *overweight* (grade 1 obesity, BMI 25–29.9), *obese* (grade 2 obesity, BMI 30–30,9), and *morbid obesity* (BMI > 40). ("Body mass index, 1998").

It is recommended that abdominal obesity should be considered together with BMI to define health risks. ("Waisted: abdominal obesity and your health," 2009) Waist circumferences larger than 102 cm in male patients and 88 cm in female patients have been defined as *abdominal overweight* and associated with a high risk of morbidity and mortality despite a normal BMI (Şahin and Doğru 2013).

In our study, we aimed to determine the effects of waist circumference and BMI on spinal anesthesia levels.

Methods

With ethical committee approval (2016/10/01/10) and written consent from each patient, our study recruited 120 patients who were undergoing surgical operations at the Department of Anesthesiology and Intensive Care using spinal anesthesia. Patients who were in risk-scoring groups I–III of the American Society of Anesthesiologists (ASA) and aged 18–65 were included in the study.

We excluded from the study patients who were over 65 years old or under 18 years old, had ASA IV scores or higher, had a contraindication for regional anesthesia, had undergone a failed spinal block, had a central nervous system disease (mental retardation, non-cooperated speech disorder, or psychiatric disease), were under 150 cm or over 185 cm in height, or had experienced an operation lasting more than 2 h.

Before patients' operations, their weight and height were measured. The patients were divided into three groups of 40: group I—*normal* (BMI 18.5–24.9); group II—*overweight* (BMI 25.0–29.9); and group III—*obese* (BMI 30.0 and higher).

Before patients' anesthesia and operations began, their waist circumference was measured with a nonflexible measuring tape. Before each operation, an intravenous line was introduced from the dorsum of each patient's left hand with a 20-gauge intricate for all patients transferred to the induction room, and an infusion of 0.9% NaCl was started at a rate of 10 ml/kg/h. Before receiving an injection of spinal anesthetic, all patients were monitored for three-line electrocardiography, non-invasive blood pressure (NIBP), and peripheral oxygen saturation (SpO_2). Spinal anesthesia was performed with patients in a sitting position by introducing a gauge 26 Quincke needle into the subarachnoid space at the L4–5 level. After sterile cerebrospinal fluid became visible, 3 ml (15 mg) of bupivacaine HCl (Marcaine spinal, 0.5% Heavy 5 mg/ml, AstraZeneca) was injected.

Before and during the patients' surgeries, NIBP, SpO_2, and heart rate were measured and recorded every 5 min. During operations, every 5 min, each patient's sensory level was evaluated with a pin-prick test (Kersten 2004) (a method to detect pain areas using needle pricks), and motor block levels were evaluated with a modified Bromage scale (0—patients can easily move their legs, feet, and knees; 1—patients just able to flex knees with free movement of feet; 2—patients unable to flex knees, but with free movement of feet; 3—patients cannot move their feet and knees).

After performing a routine spinal block, the time needed for the block to reach up to the T10 level (in minutes), the maximal sensory block level, the time needed to reach the maximum sensory block level (in minutes), and the relief time from the motor block (in minutes) were recorded for each patient. Moreover, every 5 min during the perioperative period, each patient's heart rate, NIBP, and SpO_2 were evaluated and recorded. At the end of their operations, all patients were transferred to a recovery room and then transported to their wards after experiencing relief from their motor block and a stable hemodynamic system.

Statistical analysis

To transfer our data to a digital platform for analysis, we used the PASW Statistics Windows program package. To normalize the data, we used a Shapiro-Wilk test. Three or more parameters showing normal distribution were compared with a variance analysis (ANOVA) test. The subgroups were compared with Tukey's or Tamjane test. Three or more non-showing or non-normal distribution parameters were compared with a Kruskal-Wallis test, and their subgroups were compared with a Mann-Whitney *U* test. Categoric data were compared with a chi-square test. The results were expressed as means, standard deviations (minimum-maximum values), or marginal or cross tables. All p values lower than 0.05 were considered statistically significant.

Table 1 Demographic data of cases (mean ± SD)

	Group I (n = 40)	Group II (n = 40)	Group III (n = 40)	p
Age (years)	43.23 ± 12.15	44.23 ± 12.78	43.50 ± 7.80	0.918*
BMI	22.14 ± 1.83	27.59 ± 1.35	32.92 ± 1.99	0.000*
Male (n = 60)	20	20	20	
Female (n = 60)	20	20	20	
ASA I	11	11	11	
ASA II	28	28	28	
ASA III	1	1	1	

BMI body mass index, *ASA* American Society of Anesthesiologists, *SD* standard deviation
*ANOVA test

Results

This study included 120 patients aged between 18 and 65 who were in the I–III ASA risk score groups. Comparing the three groups' demographic data (age, gender, and ASA score), we found no statistically significant differences; however, we observed a strongly significant difference in BMI between the three groups (Table 1).

In comparing the times needed for blocks to reach the T10 level, we identified the following values: group I = 8.63 ± 3.20 min, group II = 6.38 ± 2.26 min, and group III = 5.50 ± 1.51 min. We observed a statistically significant difference between groups I, II, and III in times needed for blocks to reach the T10 level ($p < 0.05$; Table 3). In comparing the time needed for the block to reach the T10 level between groups II and III, we found no statistically significant difference (Table 2).

Comparing the starts of the motor block level (Bromage scale), we found a statistically significant difference ($p < 0.05$). Between groups I, II, and III, a statistically significant difference was observed in the time needed for blocks to reach a Bromage score of 3 (Table 3). For group I, the time needed for blocks to reach a Bromage score of 3 was longer than the corresponding times for groups II and III. Group I's BMI was also lower.

We observed a statistically significant difference between the groups' maximum upper dermatomal block levels (thoracic vertebra (T); min): group I = 9.30 ± 0.75, group II = 8.23 ± 1.05, and group III = 7.25 ± 1.21 ($p < 0.05$; Table 4). As BMI increased, maximal upper dermatomal block levels increased.

We recorded the following durations for the maximal upper dermatomal block (min): group I = 14.25 ± 2.89, group II = 13.75 ± 2.94, and group III = 13.75 ± 2.94 (Table 5).

Waist circumference (cm) was measured as follows: group I = 83.48 ± 10.00, group II = 99.68 ± 9.30, and group III = 112.70 ± 7.16 (Table 6). From group I to group III, BMI increased proportionally with waist circumference. A statistically significant difference was observed in this regard between the three groups ($p < 0.05$).

Discussion

Morbid obesity incidence has tripled around the world over the last 30 years due to technological developments (Hurt et al. 2010). Obesity—and especially morbid obesity (BMI > 40 kg/m^2)—has increased alongside medical comorbidities, such as type 2 diabetes mellitus, hypertension, obstructive sleep apnea, cardiopulmonary disease, and venous and psychosocial diseases (Jehan et al. 2018). For obese patients, regional anesthesia has become more popular than general anesthesia. Regional anesthesia offers some advantages over general anesthesia for these patients (Ingrande, Brodsky, and Lemmens 2009).

Since regional anesthesia decreases perioperative opioid requirements, it is very important for patients who tend toward postoperative pulmonary complications. Still, the limitations of regional anesthesia, as well as its technical difficulties for obese patients and complications, should be considered (Ingrande et al. 2009).

For obese patients, increased intraabdominal pressure increases pressure in the vena cava inferior (VCI), which provokes distention in the lumbar plexus; this distention reduces cerebrovascular volumes (Depauw et al. 2019).

Table 2 Time to reach the T10 level for each group (min)

	Group	Mean ± s.d.	Min–max value (min.)	Group comparison	p
Time to reach T10 level (min.)	**I (n = 40)**	8.63 ± 3.20	5–15	**I–II**	**0.000***
	II (n = 40)	6.38 ± 2.26	5–10	**I–III**	**0.000***
	III (n = 40)	5.50 ± 1.51	5–10	**II–III**	**0.244***

T10 10th thoracal vertebra
*Kruskal-Wallis test

Table 3 Time to reach Bromage score 3 (min)

	Group	Mean ± s.d.	Min–max value (min)	Group comparison	*p*
Time to reach Bromage score 3 (min)	**I (*n* = 40)**	12.25 ± 3.19	10–20	**I–II**	**0.001***
	II (*n* = 40)	9.75 ± 2.25	5–15	**I–III**	**0.000***
	III (*n* = 40)	9.00 ± 3.43	5–20	**II–III**	**0.506***

*Kruskal-Wallis test

Consequently, the dilution of a local anesthetic reduces, affecting the level and duration of a block. Secondary to obesity, adipose tissue in the epidural space, dilatation of the epidural veins, and increased epidural pressure raise the block level (Barclay, Renegar, and Nelson 1968; Gülhaş et al. 2006).

Hogan et al. (1996) have found vast individual variability in cerebrovascular fluid volumes using magnetic resonance images. As intraabdominal pressure increases—as in the cases of obesity and pregnancy—cerebrovascular fluid volumes decrease local anesthetic dilution, so fluid decreases, and all of these effects can cause a large neural blockage (Hocking and Wildsmith 2004). The soft tissue moves inward into the intervertebral foramen, replacing the cerebrovascular fluid and reducing cerebrovascular fluid volumes. Lim et al. (2004). reported that reduced local anesthetic doses provide sufficient anesthesia during shorter procedures, and the local anesthetic's concentration in the reduced cerebrovascular fluid volume increases.

Saravanakumar et al. (2006) reported that pregnancy increases intraabdominal pressure as much as obesity, and in both cases, pressure on the vena cava inferior is caused by both epidural venous congestion and epidural space pressure. For obese pregnant patients, as the reduced subarachnoid space causes a higher spinal block, reduced epidural space volume causes local anesthetics to affect a larger area, resulting in a higher sensory block level (Saravanakumar et al. 2006).

Önal et al. (2003) researched the parameters that affect extension levels in combined spinal-epidural anesthesia, citing the effect of a given epidural space volume on cephalic extension levels due to the subarachnoid space's compression and a correlation between BMI and cephalic-extension levels. They found a positive correlation between BMI and cephalic extension, noting that compression over the subarachnoid space increases cephalic extension.

Gülşah et al. (2006) classified 90 patients between 15 and 65 years old who were undergoing elective urological operations into three groups regarding their BMI in three groups (*normal weight*, *weighted*, *overweighted*). These researchers performed spinal anesthesia from the same space and injected the same volume of local anesthetic for all patients. They found that the same volume of local anesthetic had extended effects, depending on the patients' BMI. Unlike that previous study, we also measured the waist circumference in addition to BMI, and we found that both parameters increased block levels at the same time. We conclude that waist circumference is as valuable as BMI in evaluating spinal block levels.

Çakır (Çakır 2009) compared 50 pregnant patients' various BMI values, spinal anesthesia levels, and durations (group I [*n* = 25] BMI 25–30; group II [*n* = 25] BMI 30–35, obese pregnant). With patients in a sitting position, 15 mg of levobupivacaine was injected into the L4–5 space. In the obese group, a significantly higher sensory level was reached, and the time need to reach the Bromage 3 level was shorter among obese patients. In our study, similarly, waist circumference proportionally increased sensory block levels and times needed to reach the Bromage 3 level.

Kuok et al. (2016) researched waist circumference's effect on sensory block levels in spinal anesthesia performed for 40 pregnant patients. They intrathecally injected 0.5% hyperbaric bupivacaine (2 ml, 2.2 ml, or 2.4 ml), depending on the patients' height (consecutively, 156–160 cm, 161–165 cm, and 166–170 cm). Five minutes after their spinal anesthesia application, pregnant patients with larger waist circumferences had a higher tendency of raising the sensory blockage higher. In our study, the higher patients' waist circumference, the higher their sensory block level.

Wei et al. (2017) examined the effects of abdominal circumference and vertebral column. They measured the

Table 4 Maximal upper dermatomal block level (T)

	Group	Mean ± s.d.	Min–max value (T)	Group comparison	*p*
Maximal upper dermatomal block level	**I (*n* = 40)**	9.30 ± 0.75	8–10	**1–2**	**0.000***
	II (*n* = 40)	8.23 ± 1.05	5–10	**1–3**	**0.000***
	III (*n* = 40)	7.25 ± 1.21	5–10	**2–3**	**0.000***

T thoracal vertebra
*Kruskal-Wallis test

Table 5 Duration of the maximal upper dermatomal block (min)

	Group	Mean ± s.d.	Min–max value (min)	Group comparison	*p*
Duration of maximal upper dermatomal block (min)	**I (*n* = 40)**	14.25 ± 2.89	10–20	**I–II**	**0.726***
	II (*n* = 40)	13.75 ± 2.94	10–20	**I–III**	**0.726***
	III (*n* = 40)	13.75 ± 2.94	10–20	**II–III**	**1.000***

T thoracal vertebra
*Kruskal-Wallis test

spread of intrathecal hyperbaric bupivacaine in 126 pregnant patients by intrathecally injecting 10 mg of 0.5% hyperbaric bupivacaine into the L3–4 space under ultrasonographic assistance for combined spinal-epidural anesthesia. They showed that abdominal circumferences and vertebral columns could be measured as predictors of spinal spread by multiple linear regression analysis ($p < 0.01$; $p < 0.01$). Consequently, larger abdominal circumferences and vertebral columns were distinct predictors of spinal anesthesia prognoses with hyperbaric bupivacaine at birth.

Zhou et al. (2014) researched the extension of spinal anesthesia 30 min after the injection of 15 mg of isobaric bupivacaine into the L3–4 space. They measured the abdominal circumferences and vertebral columns for 114 patients in ASA groups I and II who were undergoing orthopedic surgeries for their lower extremities. Unlike our study, they also used a vertebral column measure as a parameter. We instead used BMI as an independent parameter. The result of the Zhou et al. study was that abdominal circumference and vertebral column measurements served as key predictors of spinal anesthetics' cephalic spread by multiple regression analysis ($p < 0.01$; $p < 0.01$).

In our study, we found a statistically significant difference in waist circumference measurements between our three patient groups ($p < 0.000$). As we had expected, the waist circumference measurement was parallel and linearly proportional to BMI for groups I–III. The results of the previous studies by Kuok et al. (2016) Wei et al. (2017), and Zhou et al. (2014) prove this correlation. We conclude that waist circumference measurements are a simple, non-invasive, and valuable measure.

Conclusions

In this study, we examined the anesthesia levels and related undesired effects related to waist circumference and BMI in spinal anesthesia. We found that waist circumference can serve as an independent parameter like BMI in detecting spinal anesthesia levels. Especially for obese and morbidly obese patients, waist circumference measurements should be taken and considered alongside BMI since anesthesia levels could be higher for these patients, such that local anesthetic doses should be reduced to prevent potential complications.

Table 6 Waist circumferences (cm)

	Group	Mean ± s.d.	Min–max value (cm)	Group comparison	*p*
Waist circumference (cm)	**I (*n* = 40)**	83.48 ± 10.00	68–106	**1–2**	**0.000***
	II (*n* = 40)	99.68 ± 9.30	79–130	**1–3**	**0.000***
	III (*n* = 40)	112.70 ± 7.16	98–130	**2–3**	**0.000***

*ANOVA test

Abbreviations

BMI: Body mass index; ASA: American Society of Anesthesiologists; NIBP: Non-invasive blood pressure; SpO2: Peripheric oxygen saturation

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Not applicable.

Authors' contributions

MG designed the study, performed the analysis, and wrote and critically revised the manuscript. CA revised the literature, performed the analysis, and critically reviewed the manuscript. CM designed the study, revised the literature, performed the analysis, followed the patients, measured the vital data, recorded the respiratory mechanics data, and wrote the manuscript. OB and BT revised the literature, followed the patients, collected the data, performed the analysis, and critically reviewed the manuscript. All authors approved the final version of the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Approval from the research ethical committee of the Faculty of Medicine, Namık Kemal University, was obtained (code number: Namık Kemal University 2016/10/01/10), and written informed consent was obtained from the patients after the description of the procedure and its potential complications.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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