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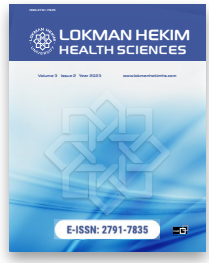

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ORIGINAL ARTICLE

Effects of Body Mass Index on Intra-abdominal Pressure and Regional Cerebral Oxygen Saturation in Lumbar Spine Surgery in the Prone Position

Prone Pozisyonunda Lomber Omurga Cerrahisinde Vücut Kitle İndeksinin İntraabdominal Basınca ve Bölgesel Serebral Oksijen Satürasyonuna Etkisi

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Abstract

Introduction: This study aimed to investigate whether the prone position could affect near-infrared spectroscopy (NIRS) values in patients with a high body mass index (BMI).

Methods: A total of 40 patients with the American Society of Anesthesiology physical status I–III who underwent lumbar disc hernia repair for one or two levels were included in this prospective study. NIRS monitorization was performed on all patients after routine monitoring. The patients were allocated equally to two groups according to BMI: Group I (BMI ≥30 kg/m^2) and Group II (BMI <30 kg/m^2).

Results: The mean intra-abdominal pressure (IAP) measured at the prone position was higher in Group I (p=0.005). There was a statistically significant positive correlation between BMI and IAP values at the prone position (r=0.471, p =0.002). A total of 8 patients suffered a ≥20% decrease in regional cerebral oxygen saturation, with 6 in Group I and 2 in Group II.

Discussion and Conclusion: Intragroup IAP values increased over time and were significantly higher in obese patients. Regional cerebral oxygen saturation dropped in both groups until the 20th minute of the prone positioning and then was stabilized. These findings might be used for anesthetic management of patients undergoing lumbar surgeries within the first 20 min

Keywords: Anesthesia; Body mass index; Intra-abdominal pressure; Lumbar surgery; Oxygenation; Prone

The prone position has been used in posterior lumbar spine surgery since the 1930s.[1] The considerations for positioning patients prone during various surgeries include cardiovascular effects, respiratory compromise, surgical conditions, and intraoperative blood loss.[2] Whereas arterial pressure remains stable when turning the patient

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into a prone position, cardiac output decreases due to a reduction in venous return.[3] Since the abdomen and chest are restricted during prone positioning, placing an anesthetized patient into a prone position requires continuous monitoring of respiratory status.[4] On the other hand, turning patients from supine to prone during anesthesia results in an increase in the oxygenation index and a decrease in the intra-abdominal pressure (IAP).[5]

Obesity, as measured by the body mass index (BMI), leads to lung mechanics and functional abnormalities. Patients with obesity should be closely monitored to control these respiratory mechanics, which lead to impaired oxygenation during surgery. Studies have focused on improving oxygenation in obese patients during the perioperative period.[6–9] Han et al.[9] claimed that BMI affects IAP in the prone position than in the supine position during lumbar spinal surgery. The authors stated a significant negative correlation between the oxygenation index and BMI and a significant positive correlation between IAP and BMI in the prone position.

Near-infrared spectroscopy (NIRS) is a noninvasive method used to determine tissue oxygenation based on spectrophotometric quantitation of oxy- and deoxyhemoglobin within a tissue.[10] Thus, NIRS can provide information about muscle oxygen saturation, muscle oxygen consumption, and regional blood flow. This study aimed to investigate whether the prone position could affect NIRS values in patients with a high BMI.

Materials and Methods

First, the study protocol was approved by the Ethics Committee of Dr. Abdurrahman Yurtaslan Ankara Oncology Training and Research Hospital (date: 05/03/2014, approval no: 2014-2/82). All patients were informed about the objectives of the study in detail, and they provided written informed consent. The study was conducted in line with the Declaration of Helsinki, revised in 2013.

A total of 40 patients with the American Society of Anesthesiology (ASA) physical status I–III who underwent lumbar disc hernia repair for one or two levels were included in this prospective study. Patients younger than 18 and older than 70 years and those with ASA IV physical status, documented carotid stenosis, prior neck surgery, cervical stenosis, or a history of stroke, neurologic event, myocardial infarction, spinal cord injury, or sudden vision loss were excluded from the study. Patients' demographics such as age, gender, height, weight, BMI, smoking status, and preexisting medical conditions were recorded.

Anesthesia Protocol

A standard anesthesia protocol was performed in all patients. Routine intraoperative monitoring consisted of electrocardiography, automatic noninvasive arterial blood pressure, pulse oximetry, capnography, and cerebral tissue oxygen saturation through NIRS. Two noninvasive NIRS sensors (INVOS 5100, Somanetics) were placed bilaterally to the frontotemporal area with the medial margin 1 cm above the eyebrow, thus avoiding the temporalis muscle. Frontal lobe oxygenation was monitored continuously and recorded every 5 min. After 1 min, a preoperative regional cerebral tissue oxygen saturation (rSO_2) baseline was measured and recorded for both hemispheres. Patients were maintained with sevoflurane after anesthetization. Ventilation was controlled to maintain end-tidal pCO_2 between 32 35 mmHg. Normothermia was maintained throughout the study.

The NIRS monitoring system was set to alarm with rSO_2 decreases of 20% or greater from baseline. The cerebral desaturation episodes were treated with a protocol that included ephedrine (5 mg), fluid bolus, and an increased fraction of inspired oxygen to avoid cerebral vascular injury. Hypotension was accepted as a >20% decrease in the basal measurement of SAP or SAP <90 mmHg and treated with boluses of less ephedrine as needed. Bradycardia was accepted as a heart rate <50 beats/min and was treated with atropine.

Measurement of IAP

Before positioning patients on the operating table, a Foley catheter was placed. IAP was measured in the following positions in all patients: (1) in the supine position after intubation and (2) in the prone position before the skin incision. We measured IAP indirectly and used a Foley catheter to measure urinary bladder pressure.

Before statistical analysis, the patients were allocated equally to two groups according to the World Health Organization Guideline of BMI: Group I (BMI ≥30 kg/m^2) and Group II (BMI <30 kg/m^2).

Statistical Analysis

The data obtained in this study were statistically analyzed using SPSS version 23.0 (SPSS, Statistical Package for Social Sciences, IBM, Inc., Armonk, USA). The normality of the variables was evaluated using the Kolmogorov–Smirnov test. Comparison of the normally distributed parameters was made using Student's t test, while skewed data were evaluated using the Mann–Whitney U test. Results of the statistical variables were expressed as mean±standard deviation, minimum (min)–maximum (max), and n (%). Variance anal-

Table 1. Demographic characteristics of the patients

	Group I (n = 20)	Group II (n = 20)	p
Age (years)	50.65±12.07 (31–75)	49.30±11.20 (34–70)	0.716
Height (cm)	167.45±8.32 (155–182)	170.85±10.60 (150–195)	0.266
Weight (kg)	93.00±12.31 (72–120)	75.85±11.04 (60–98)	<**0.001**
BMI (kg/m^2)	33.18±4.03 (30–45)	25.96±2.45 (20.26–29.41)	<**0.001**
ASA (I/II/III)	8(40)/9(45)/3(15)	11(55)/9(45)/0(0)	0.099
Gender (M/F)	6(30)/14(70)	12(60)/8(40)	0.057
Operation time (min)	100.00±33.05 (55–160)	102.75±31.52 (60–165)	0.789

BMI: Body mass index; ASA: American Society of Anesthesiology.

ysis was performed for the assessment of heart rate, mean arterial pressure (MAP), oxygen saturation (SpO_2), end-tidal carbon dioxide ($EtCO_2$), and rSO_2 values had a normal distribution. In cases where the variance analysis results were statistically significant, Bonferroni correction comparative test was used to determine the time at which the results caused the statistical significance. The relationship between rSO_2, IAP, and BMI was evaluated with Pearson's or Spearman's correlation analysis test. Results between 0 and 0.49 were rated as weak correlation, 0.5 and 0.74 as mild correlation, and 0.75 and 1 as high correlation. A value of $p<0.05$ was considered statistically significant.

Results

A total of 40 patients undergoing lumbar disc hernia repair were included. The patients were divided into two groups based on BMI: Group I (BMI ≥30 kg/m^2) and Group II (BMI <30 kg/m^2). The mean age was found to be 50.65±12.07 years in Group I and 49.30±11.20 years in Group II. No statistically significant difference was found between both groups in terms of age (p=0.716). The M/F ratio was 6/14 in Group I and 12/8 in Group II. The difference was close to statistical significance (p=0.057). The mean BMI value was calculated as 33.18±4.03 kg/m^2 in Group I and 25.96±2.45 in Group II (p<0.001). Operation time was measured as 100.00±33.05 min in Group I and 102.75±31.52 min in Group II (p>0.05). The demographic features of the groups are summarized in Table 1.

Changes in the mean MAP, SpO_2, and $EtCO_2$ values over time were similar in both groups at all sampling times. The IAP values measured at the supine position were similar in both groups (p>0.05). However, the mean IAP measured at the prone position was higher in Group I (p=0.005). The intragroup comparison of the mean IAP measurements showed a statistically significant increase in IAP when the patients were turned to prone from the supine position in both groups (p<0.0001, p<0.005, respectively) (Table 2). There was a statistically significant positive correlation between BMI and IAP values at the prone position (r=0.471, p=0.002) (Fig. 1).

Table 2. Intragroup changes of the mean IAP values when turning to prone from the supine position

	Group I (n = 20)	Group II (n = 20)	p
Supine IAP	10.58±3.44 (7–22)	8.73±2.56 (5–15)	0.061
Prone IAP	17.18±5.14 (8–29)	12.93±3.82 (6–20)	**0.005**

IAP: Intra-abdominal pressure.

Table 3. Number of patients suffering a 20% decrease in rSO_2 according to the groups

	rSO_2 % change				χ^2	p
	>20%		<20%			
	n	%	n	%		
Group I	6	30.0	14	70.0	1.406	0.235
Group II	2	10.0	18	90.0		

The percent changes in the rSO_2 values of the patients measured throughout the operation are shown in Figure 2.

The number of patients who experienced a 20% or more reduction in rSO_2 was 8. Although there was no statistical difference between the groups, the number of patients with cerebral desaturation was higher in Group I (6 in Group I vs 2 in Group II) (Table 3). In addition, episodes of cerebral desaturation were higher in Group 1 (6.1 episodes in Group I vs 3.0 episodes in Group II).

The data show that if the BMI value of a patient is ≥30.2 kg/m^2, the patient has a higher risk of a 20% or higher fall in rSO_2 (AUC=0.74, p=0.038, 95% GA: 0.55–0.93, cutoff: BMI >30.2 kg/m^2) (Fig. 3).

Discussion

During spinal surgery, the prone position is commonly used to access the posterior head, neck, and spine. Pelvic and abdominal compression causes increased IAP, direct pressure on inferior vena cava and venous pooling, and

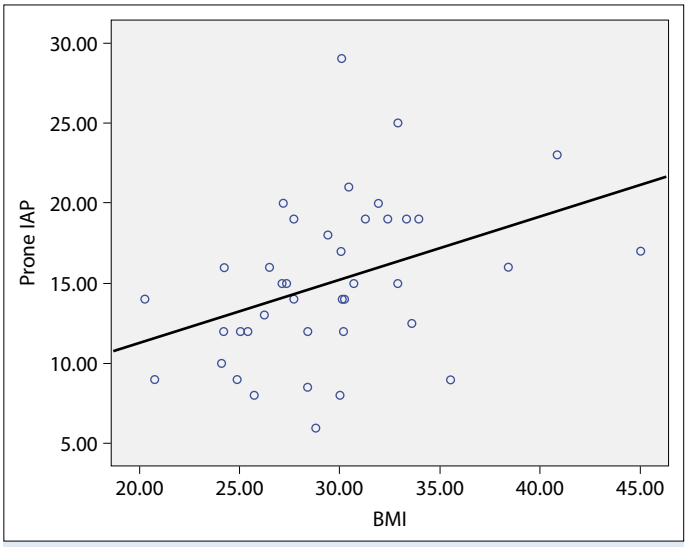

Figure 1. Correlation between body mass index and intra-abdominal pressure values at the prone position.

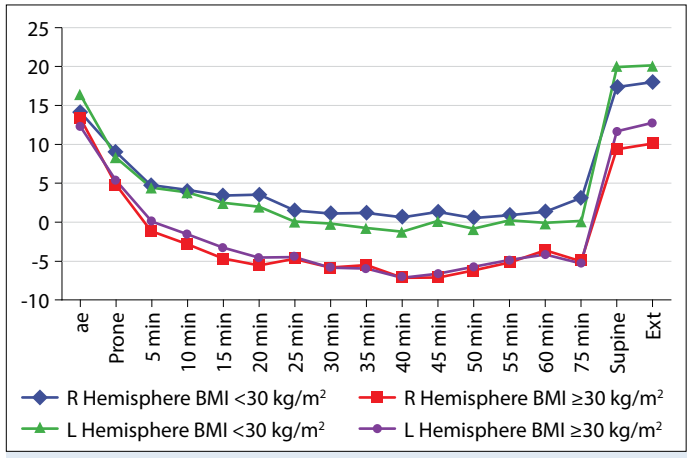

Figure 2. Percent changes in the rSO_2 values of the patients measured throughout the operation.

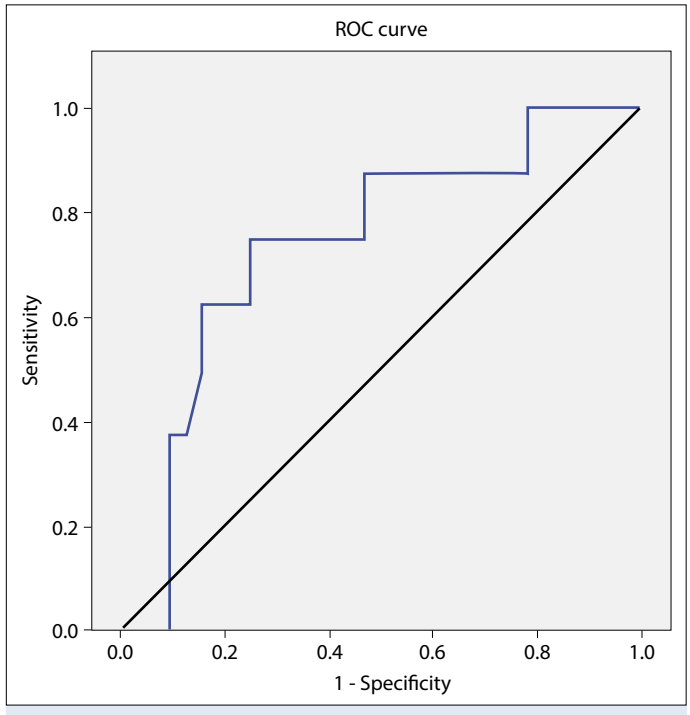

Figure 3. Risk of a 20% or higher fall in rSO_2.

decreased venous return.[2] In parallel, when patients are turned to the prone position, significant hemodynamic changes are seen, such as an increase in systemic vascular resistance and a decrease in cardiac index and cardiac output. It is possible that these hemodynamic changes affect cerebral blood flow and thus cerebral oxygenation. BMI correlates with IAP, and therefore IAP values are higher in obese people.[11] Park[12] measured IAP changes for the first time in patients undergoing lumbar surgery. Han et al.[9] suggested that BMI affects IAP more in prone than supine positions. In the present study, we investigated the effects of BMI on IAP and rSO_2 in lumbar spine surgery. Our hypothesis is that in obese patients in the prone position, hemodynamic changes due to abdominal compression will be greater than in weak patients, and cerebral desaturation may be more common. We found that although the mean IAP value was similar between obese and nonobese patients in the supine position, this value was significantly higher in obese patients compared with nonobese ones in prone positioning. Limited studies have been published regarding the effect of obesity on prone position, mostly case series or case reports. Fusco et al.[13] stated that prone positioning seems safe in obese patients and may improve oxygenation more than in nonobese patients. Panitchote et al.[14] reported that in moderate to severe ARDS patients with obesity, prone position ventilation significantly decreased 28-day and 90-day mortality. Smit et al.[15] showed that BMI was a better predictor of IAP in cardiothoracic surgery patients. In this regard, our findings are consistent with the previous studies in the literature.

In the present study, no statistically significant difference was found between the two groups in terms of rSO_2 monitored by NIRS, which is a noninvasive technique used to measure cerebral oxygen saturation. Notably, after 20 min from the prone position, the percentage changes of the rSO_2 values were stabilized similarly in both groups. Soeding reported that dynamic coupling between cerebral arterial, venous, and cerebrospinal fluid volumes may influence oximetric readings during postural changes.[16] Deiner et al.[17] have found more cerebral desaturation episodes and demonstrated that cerebral desaturation is independent of arterial hypotension. Closhen et al.[18]

detected less than 5% of patients undergoing orthopedic surgery and reported that the prone position might be considered safe in terms of maintaining cerebral oxygenation. Keles et al.[19] reported that posterior stabilization surgery did not pose an additional risk to the patients in terms of spinal and oxygen saturation. In our study, the lack of significant difference between obese and nonobese patients in terms of cerebral oxygenation suggests that the prone position does not pose an additional risk to obese patients undergoing lumbar spine surgery.

Study Limitations

The main limitation of the study was limited number of patients included from a single center, making the generalization of the findings difficult. Finally, other parameters such as peripheral tissue oxygenation could be included. However, given the rarity of studies on this issue in the literature, we believe our results will encourage future studies.

Conclusion

The principal cause of hemodynamic changes at the prone position is abdominal compression, increasing IAP. In our study, intragroup IAP values increased over time and were significantly higher in obese patients. We believe that the increase in abdominal compression is dominant in obese patients due to the difficulty in positioning and the increased visceral fat mass. Although no statistically significant difference was found between obese and nonobese patients in terms of cerebral oxygenation, rSO_2 dropped in both groups until the 20th minute of the prone positioning and then stabilized. These findings might be used for anesthetic management of patients undergoing lumbar surgeries within the first 20 min. However, our findings should be confirmed with furthermore comprehensive studies.

Peer-review: Externally peer-reviewed.

Ethics Committee Approval: The Dr. Abdurrahman Yurtaslan Ankara Oncology Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 05.03.2014, number: 2014-2/82).

Authorship Contributions: Concept: ÖŞ; Design: ÖŞ; Supervision: ÖŞ; Materials: ÖŞ, DK; Data Collection or Processing: ÖŞ, DK, SÜ, TK, KKY; Analysis or Interpretation: ÖŞ, DK; Literature Search: ÖŞ; Writing: ÖŞ; Critical Review: ÖŞ.

Conflict of Interest: None declared.

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