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ARAŞTIRMA YAZISI / RESEARCH ARTICLE

OBEZ HASTALARDA LAPAROSKOPİK CERRAHİLERDE FARKLI PEEP UYGULAMALARININ OPTİK SİNİR KILIF ÇAPINA ETKİSİNİN DEĞERLENDİRİLMESİ

EVALUATION OF THE EFFECT OF DIFFERENT PEEP APPLICATIONS ON OPTIC NERVE SHEATH DIAMETER IN OBESE PATIENTS UNDERGOING LAPAROSCOPIC SURGERY

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ÖZET

AMAÇ: Alveollerin açık kalmasını sağlayarak oksijenasyonu düzeltmek amacıyla kullanılan positive end-expiratory pressure (PEEP) uygulaması obez hastalarda pnömoperitonyum sırasında intrakranyal basınçta (İKB) ek bir artışa neden olabilir. Bu çalışmada laparoskopik cerrahi yapılacak obez hastalarda farklı PEEP uygulamalarının optik sinir kılıf çapına (OSKÇ) etkisi değerlendirildi.

GEREÇ VE YÖNTEM: Çalışmaya ters trendelenburg pozisyonunda laparoskopik cerrahi uygulanacak Amerikan Anesteziyologlar Derneği Fiziksel Statü Sınıflandırmaları (ASA) 1-2 grubunda 18- 65 yaş arası Vücut Kitle İndeksi (VKİ) 30 ve üzeri obez 26 hasta dahil edildi. Anestezi indüksiyonu sonrası hastalar PEEP 5 grubu ve PEEP 8 grubuna randomize edilerek ayrıldı. Hastaların cinsiyet, yaş, VKİ'leri, ASA sınıflaması, vaka sırasında belirli aralıklarla kaydedilen hemodinamik verileri ve OSKÇ değerleri karşılaştırılırıldı.

BULGULAR: Çalışmayı 22 hasta tamamladı. Cinsiyet dışında (p=0,020), gruplar arası demografik ve hemodinamik verilerde farklılık yoktu. Hastaların OSKÇ'larında ölçülen tüm zamanlarda iki grup arasında farklılık gözlenmemiştir. OSKÇ'larını grup içi karşılaştırdığımızda, PEEP 5 grubunda grup içi farklılık gözlenmezken PEEP 8 grubunda pnomoperitonyum sonrası 5.dk (T2), 30.dk (T3) ve cerrahi bitişteki (T4) ölçümler bazal ölçümlerinden (T1) anlamlı bir şekilde yüksek bulunmuştur (p=0,010, p=0,003, p=0,012).

SONUÇ: PEEP 8 ve PEEP 5 uygulamasının İKB artışına benzer etkileri olsa da PEEP artışlarının ultrasonografi ile OSKÇ ölçülerek yapılmasının daha güvenli olacağını düşünmekteyiz.

ANAHTAR KELİMELER: Obezite, Laparoskopi, OSKÇ, PEEP, Ultrasonografi.

ABSTRACT

OBJECTIVE: Positive end-expiratory pressure (PEEP) application, which is used to improve oxygenation by keeping the alveoli open, may cause an additional increase in intracranial pressure (ICP) during pneumoperitoneum in obese patients. In this study, the effect of different PEEP applications on the optic nerve sheath diameter (ONSD) in obese patients undergoing laparoscopic surgery was evaluated.

MATERIAL AND METHODS: The study included 26 patients with a Body Mass Index (BMI) of ≥ 30 and the American Society of Anesthesiologists (ASA) I-II status undergoing laparoscopic surgery in the reverse Trendelenburg position. After anesthesia induction, the patients were randomly allocated to either the PEEP 5 group or the PEEP 8 group. The patients were compared with respect to age, gender, BMI, ASA status, operations performed, and the hemodynamic data and ONSD values recorded intraoperatively at regular intervals.

RESULTS: 22 patients completed the study. Except for gender (p=0.020), there was no difference in demographic and hemodynamic data between the groups. No difference was observed between the groups in respect of ONSD measurements at all times. In the intra-group comparisons, there was no difference in the ONSD values within the PEEP 5 group, whereas in the PEEP 8 group, the measurements at 5 minutes (T2) and 30 minutes (T3) after pneumoperitoneum, and at the end of surgery (T4) were significantly higher than the basal measurements (T1) (p=0.010, p=0.003, p=0.012).

CONCLUSIONS: Although PEEP 8 and PEEP 5 applications have similar effects to ICP increase, we thought that it would be safer to apply PEEP increments by measuring ONSD via ultrasonography.

KEYWORDS: Obesity, Laparoscopy, ONSD, PEEP, Ultrasonography.

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INTRODUCTION

Obesity, which is now a global epidemic, is accepted as a complex and multifactorial disease that negatively affects health. An increase in intra-abdominal pressure (IAP) is associated with obesity, and it has been reported that IAP increases as waist circumference increases in obese patients (1).

Laparoscopic surgery, as an alternative to open surgery, is widely applied because of advantages such as decreased bleeding and postoperative pain, less hospital stay, and enhanced cosmetic results. However, using carbon dioxide (CO2) pneumoperitoneum (PNP) is necessary for laparoscopy to improve the operator's visual area, which can cause undesirable effects affecting many systems, including the respiratory and central nervous systems (2). Atelectasis and a reduction in functional residual capacity (FRC) caused by general anesthesia are further increased by abdominal CO2 insufflation, and increased IAP and atelectasis reduce lung compliance. Partial arterial oxygen pressure (PaO2) also decreases due to atelectasis, decreased FRC, ventilation/perfusion disorder, and pulmonary shunts. In obese patients, the decrease in FRC is greater during anesthesia, and there is a linear relationship between Body Mass Index (BMI) and FRC. Obese patients are more vulnerable to atelectasis (3). A lung protective ventilation strategy consisting of low tidal volume and positive end-expiratory pressure (PEEP) ventilation is known to evolve postoperative respiratory outcomes in patients at high surgical risk, including patients undergoing laparoscopic surgery (4).

Evaluation of optic nerve sheath diameter (ONSD) with non-invasive ultrasonography has been shown to be proper in defining raised intracranial pressure (ICP) as it reflects pressure changes in the subarachnoid space and variations in cerebrospinal fluid in the optic nerve sheath (5). While consensus has not yet been reached in the literature regarding ONSD baseline for increased ICP, in one recent study, ONSD of 5mm was defined as an indicator of high ICP, while ONSD >5.5 mm was considered significant in obese patients (6).

Although there are studies investigating the relationship between obesity and ICD in laparoscopic bariatric surgery in the literature, the number of studies comparing PEEP is limited (6). The purpose of this study was to interpret the effect of different PEEP applications on optic nerve sheath diameter in obese patients who were planning to undergo laparoscopic surgery under general anesthesia.

MATERIAL AND METHODS

This randomized clinical study prospectively enrolled 26 patients, aged 18-65 years, with American. Society of Anesthesiologists physical status (ASA) I-II and a Body Mass Index (BMI) of ≥30, who were undergoing laparoscopic general surgery (obesity, cholecystectomy, hiatal hernia repair). Patients with chronic obstructive pulmonary disease (COPD), severe heart failure, hypertension, seizures, glaucoma, eye and eyelid infection, patients with a history of disease that may cause increased intracranial pressure (intracranial mass, edema, hematoma, abscess, presence of cyst, hydrocephalus), and pregnant patients were not included in the study. Cases which were converted from laparoscopy to open surgery and those who were hypertensive intraoperatively were excluded from the study.

Entering the operation room, standard anesthesia monitoring (peripheral oxygen saturation (SPO2), electrocardiogram (ECG), non-invasive arterial blood pressure (BP), and end-tidal carbon dioxide (ET-CO2)) was applied to all patients. After preoxygenation, the patients were intubated by applying standard general anesthesia induction (Aritmal 1mg/kg, Propofol 2mg/kg, Fentanyl 2mcg/kg, Rocuronium 0.6 mg/kg). Anesthesia was continued with 1 MAC Desflurane in a 50% oxygen/air mixture, 1 mcg/kg fentanyl, and 0.1 mg/kg rocuronium at 30 min intervals. All patients were ventilated with an Avance anesthesia machine (GE Healthcare, Madison, WI, USA) (Datex-Ohmeda, Inc, Madison WI 53707-7550 USA9). Using numbered sealed envelopes, the patients were randomly separated into two groups: the PEEP 5 group (n=13) and the PEEP 8 group (n=13). In both groups, the inspiratory to expiratory time ratio was 1:2, and the inspired oxygen fraction (FIO2) was 0.5 (balanced with air).

Ventilator settings in Group PEEP 5 were a tidal volume of 6 ml/kg according to Ideal Body Weight (IBW) and PEEP set at 5 cm H2O. In Group PEEP 8, tidal volume was 6 ml/kg (IBW) and PEEP was set to 8 cm H20. The respiratory rate was corrected to keep ETCO2 between 30-40 mmHg in both groups.

At the end of the surgical operation, suggammadex (2mg/kg, iv) was administered to reverse neuromuscular blockade and patients were extubated and taken to the recovery room. *(Propofol, Fentanyl, and Rocuronium were administered according to lean body weight (LBW), and Sugammadex was administered according to IBW* (7). *IBW was calculated using the formula "45.5 + 0.91 x (Height (cm) – 152.4)" for females, and "50 +0.91 x (Height (cm) – 152.4)" for males and LBW=IBWx1.2)*

Age, gender, weight, BMI, ASA classification, type of surgery, and operation time were recorded for each patient. Hemodynamic parameters of non-invasive mean arterial pressure, heart rate, peripheral O2 saturation, and ETCO2 were recorded at regular intervals intraoperatively.

Optic Nerve Sheath Diameter (ONSD) Measurement

In the ONSD measurements, a thick layer of sterile water-soluble gel was applied to the closed upper eyelid, and then a linear 12 MHz ultrasound probe (Philips Xperius Ultrasound HC795101, 4-12 MHz) was carefully placed on the upper eyelid over the gel. Without applying excessive pressure, the entrance of the optic nerve to the orbital globe was viewed on the monitor in 2D mode.

ONSD measurements were taken from the area between the hyperechoic dural sheaths located at the edge of the hypoechoic subarachnoid area surrounding the optic nerve. The image with the most suitable contrast was identified, then the image was frozen and the diameter of the ONSD was measured 3 mm behind the optic disc using an electronic caliper in both eyes and the mean value was used in the analysis **(Image 1)**. After the measurement was finished, the gel applied to the eyelid was wiped with a clean napkin. The ONSD measurements were taken by a single anesthesiologist, 4 times in total throughout the surgery; prior to PNP (baseline, T1), during insufflation at 5 minutes (supine, T2) and 30 minutes (reverse-Trendelenburg, T3), and after deflation of PNP (supine, T4). The pneumoperitoneum was main-

Imge 1: The diameter of the ONSD was measured 3 mm behind the optic disc using an electronic caliper

Ethical Committee

Ethics committee approval was obtained from the Ethics Committee of Afyonkarahisar Health Sciences University , Faculty of Medicine (June 17, 2019 with a codenumber 2011-KAEK-2/2019-224).

Statistical Analysis

The sample size was determined regarding original research articles in the literature (6). The primary end-point of the study was defined as an increase in ONSD values of 10% (ONSD in obese patients was mean 5.5 mm, the standard deviation was 0.5 mm (6). Using G-Power 3.1.9.2 software, the sample size was determined to be 22 patients to produce a significant difference with an effect size of 0.5, α = 0.05, and power =80%. Considering a drop-out rate of 15%, it was planned to include 26 patients. Statistical analyses were performed using SPSS software (SPSS version 20; SPSS, Inc., Chicago, IL, USA). Descriptive analyses were assessed as mean and standard deviation values for normally distributed variables, and median and (minimum–maximum) values for non-normally distributed variables. The Mann-Whitney U-test and Student's t-test were used to compare continuous variables, and the Chi-square test was used to compare categorical variables. The Paired Samples test was used to compare preoperative and postoperative variables. A value of $p< 0.5$ was considered statistically significant.

RESULTS

Initially 26 patients aged 18-65 years with a BMI of ≥30, in the ASA 1-2 group who underwent laparoscopic surgery in the reverse

Trendelenburg position were enrolled. The study was completed with 12 patients in the PEEP 5 group and 10 patients in the PEEP 8 group; one patient from each group was hypertensive during the surgery and two patients in the PEEP 8 group were converted from laparoscopic surgery to open surgery. So these 4 patients were not included for study. There was no difference in demographic data between the groups in terms of age, BMI, comorbidity and ASA **(Table 1)**.

Table 1: Demographic data of patients, and distribution of surgeries according to the groups

	Group PEEP 5 (n=12)	Group PEEP 8 (n=10)	Total (n=22)	p
Gender, F/M, n (%)	7 (58.3) / 5 (41.7)	10 (100) / 0	17 (77.3) / 5 (22.7)	0.020&
Age (years)	39.75 ± 13.72	46.10 ± 11.79		0.264*
BMI, kg/m2	36.82 (30.42 - 46.67)	34.18 (30.20 - 48.40)		0.895#
ASA, I/II, n (%)	7 (58.3) / 5 (41.7)	2 (20) / (80) 8	9 (40.9) / 13 (59.1)	0.069&
Additional disease, none/yes, n (%)	8 (66.7) / 4 (33,3)	4 (40) / 6 (60)	12 (54.5) / 10 (45.5)	0.211&
Type of surgery				
Laparoscopic cholecystectomy/ Bariatric surgery/ Hiatal hernia	6 (50) / 3 (25) / 3 (25)	7 (70) / 3 (30) / 0	13 (59.1) / 6 (27.3) / 3 (13.6)	0.232&
Duration of Surgery (minutes)	75 (49-155)	65.5 (51-130)	68 (49-155)	0.923#

*Student's t-test, #Mann Whitney U-test, &Chi-Square test
BMI; Body mass index, F/M; female/male
Data are defined as number of patients (percentage), mean ± standard deviation, and median (minimum-maximum) values.

The gender difference between the groups was significant with a total of 17 female (77.3 %) and 5 male (22.7 %) patients (p=0.020). There was no significant difference between the groups in terms of the type of operations performed and their duration (p=0.232; p=0.923, (Table 1). Non-invasive mean arterial pressure (MAP) and heart rate of the patients were similar in both groups intraoperatively **(Figure 1a-1b)**.

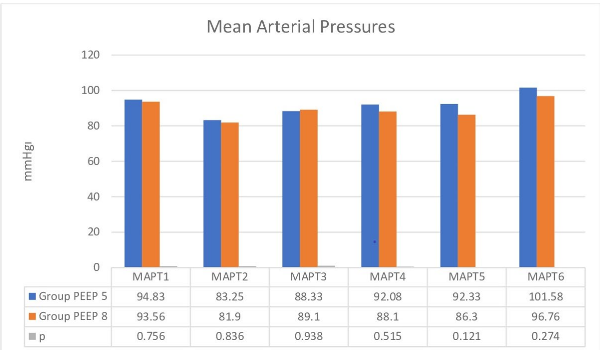

Figure 1a: Mean arterial pressures of patients
T1; prior to induction (baseline),
T2; 5 minutes after induction
T3; during insufflation at 5minutes (supine) ,
T4; 30 min (reverse-Trendelenburg),
T5; after deflation of PNP (supine)
T6; post extubation

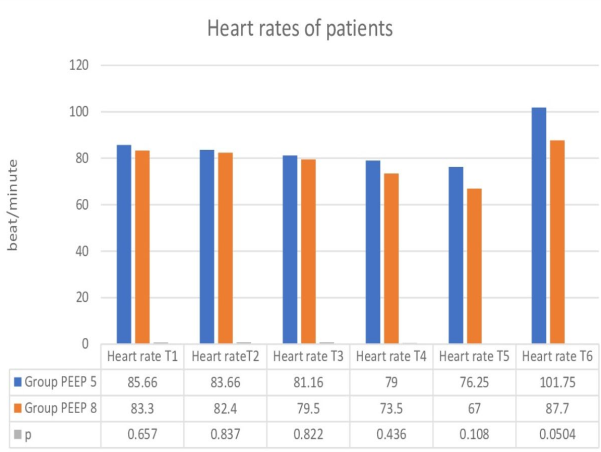

Figure 1b: Heart rates of patients
T1; prior to induction (baseline),
T2; 5 minutes after induction
T3; during insufflation at 5minutes (supine) ,
T4; 30 min (reverse-Trendelenburg),
T5; after deflation of PNP (supine)
T6; post extubation

The ETCO2 and P peak levels of the patients were similar in both groups intraoperatively **(Table 2)**.

Table 2: Comparisons of intraoperative ETCO2 and P peak levels of the patients

	Group PEEP 5 (n=12)	Group PEEP 8 (n=10)	p
ETCO2 T1, mmHg	34.66 ± 2.34	35.00 ± 3.43	0.790*
ETCO2 T2, mmHg	35.83 ± 2.36	37.30 ± 2.26	0.156*
ETCO2 T3, mmHg	36.25 ± 2.52	35.80 ± 1.93	0.650*
ETCO2 T4, mmHg	34.33 ± 2.30	33.40 ± 1.57	0.292*
P peak T1, cmH20	19.50 (15-30)	19 (15-30)	0.894#
P peak T2, cmH20	25.25 ± 4.80	27.10 ± 3.72	0.333*
P peak T3, cmH20	26.00 ± 4.43	25.00 ± 4.66	0.612*
P peak T4, cmH20	22.00 ± 2.89	22.20 ± 4.13	0.895*

*Student's T-test, #Mann Whitney U-test, ETCO2; end tidal carbondioxide
T1; 5 minutes after anesthesia induction, T2; 5th minute of pneumoperitoneum, T3; 30th minute of pneumoperitoneum, T4; end of surgery,
Data are defined as mean ± standard deviation, and median (minimum-maximum) values.

The ONSD values were compared between and within the groups **(Table 3, Table 4a - 4b)**.

Table 3: Comparisons of ONSD values between the groups

	Group PEEP 5 (n=12)	Group PEEP 8 (n=10)	p*
ONSD, mm T1	5.55 ± 0.54	5.46 ± 0.48	0.705
ONSD, mm T2	5.64 ± 0.34	5.84 ± 0.68	0.417
ONSD, mm T3	5.60 ± 0.39	5.86 ± 0.63	0.258
ONSD, mmT4	5.44 ± 0.45	5.88 ± 0.73	0.101

*Student -T test,
T1; prior to PNP (baseline),
T2; during insufflation at 5 (supine) ,
T3; 30 min (reverse-Trendelenburg),
T4; after deflation of PNP (supine)
Data are defined as mean ± standard deviation values.

Table 4a: Comparisons of ONSD values in Group PEEP 8

Group PEEP 8, n=10	**P***
T1 (5.46 ± 0.48) / T2 (5.84 ± 0.68)	0.010
T1 (5.46 ± 0.48) / T3 (5.86 ± 0.63)	0.003
T1 (5.46 ± 0.48) / T4 (5.88 ± 0.73)	0.012
T2 (5.84 ± 0.68) / T1 (5.46 ± 0.48)	0.010
T2 (5.84 ± 0.68) / T3 (5.86 ± 0.63)	0.841
T2 (5.84 ± 0.68) / T4 (5.88 ± 0.73)	0.776
T3 (5.86 ± 0.63) / T1 (5.46 ± 0.48)	0.003
T3 (5.86 ± 0.63) / T2 (5.84± 0.68)	0.841
T3 (5.86 ± 0.63) / T4 (5.88 ± 0.73)	0.843
T4 (5.88 ± 0.73) / T1 (5.46 ± 0.48)	0.012
T4 (5.88 ± 0.73) / T2 (5.84 ± 0.68)	0.776
T4 (5.88 ± 0.73) / T3 (5.86 ± 0.63)	0.843

* Paired Samples test
T1; prior to PNP (baseline),
T2; during insufflation at 5 (supine) ,
T3; 30 min (reverse-Trendelenburg),
T4; after deflation of PNP (supine)
Data are defined as mean ± standard deviation values.

Table 4b: Comparisons of ONSD values in Group PEEP 5

Group PEEP 5, n=12	P*
T1 (5.55 ± 0.54) / T2 (5.64 ± 0.34)	0.396
T1 (5.55 ± 0.54) / T3 (5.60 ± 0.39)	0.585
T1 (5.55 ± 0.54) / T4 (5.44 ± 0.45)	0.313
T2 (5.64 ± 0.34) / T1 (5.55 ± 0.54)	0.396
T2 (5.64 ± 0.34) / T3 (5.60 ± 0.39)	0.722
T2 (5.64 ± 0.34) / T4 (5.44 ± 0.45)	0.056
T3 (5.60 ± 0.39) / T1 (5.55 ± 0.54)	0.585
T3 (5.60 ± 0.39) / T2 (5.64 ± 0.34)	0.722
T3 (5.60 ± 0.39) / T4 (5.44 ± 0.45)	0.069
T4 (5.44 ± 0.45) / T1 (5.55 ± 0.54)	0.313
T4 (5.44 ± 0.45) / T2 (5.64 ± 0.34)	0.056
T4 (5.44 ± 0.45) / T3 (5.60 ± 0.39)	0.069

* Paired Samples test
T1; prior to PNP (baseline),
T2; during insufflation at 5 (supine) ,
T3; 30 min (reverse-Trendelenburg),
T4; after deflation of PNP (supine)
Data are defined as mean ± standard deviation values.

No significant difference was found between the two groups in respect of the ONSD measurements at all times (Table 3). In the intra-group comparisons, the measurements of the patients in Group PEEP 8 during insufflation at 5 min (supine, T2) and at 30 mins (reverse-Trendelenburg, T3), and immediately after deflation of PNP (supine, T4) were found to be significantly higher than the basaline ONSD measurements (p=0.010, p=0.003, and p=0.012, respectively) (Table 4a). The ONSD measurements of the Group PEEP 5 patients did not differ significantly at any of the time points (Table 4b).

The ONSD values were then evaluated by separating the patients into 3 groups according to BMI (Group 1: BMI=30-30.4, Group 2: BMI = 35-39.9, Group 3: BMI ≥ 40), and no statistically significant difference was observed between the groups. In Group 1 and Group 2, the increases at T2 and T3 almost returned to baseline values at T4, and in Group 3, the increase at T2 and T3 remained high at T4 **(Table 5a)**.

Then we compared the mean ONSD values of group of patients with BMI≥ 40 at **Table 5b**. The mean ONSD values were similar between the groups.

Table 5a: Comparisons of ONSD values according to patient BMI values

	BMI=30- 34.9 (n=10)	BMI=35–39.9 (n=5)	BMI ≥ 40 (n=7)	p*
T1	5.46 ± 0.41	5.65 ± 0.70	5.48 ± 0.53	0.796
T2	5.76 ± 0.45	5.68 ± 0.50	5.74 ± 0.68	0.964
T3	5.66 ± 0.46	5.70 ± 0.43	5.82 ± 0.68	0.824
T4	5.56 ± 0.48	5.54 ± 0.42	5.82 ± 0.91	0.670

*ANOVA, BMI; body mass index
T1; prior to PNP (baseline),
T2; during insufflation at 5 (supine) ,
T3; 30 min (reverse-Trendelenburg),
T4; after deflation of PNP (supine)
Data are defined as mean ± standard deviation values.

Table 5b: Comparisons of ONSD values of patients' with BMI≥ 40 between two groups

	Group PEEP 5 (n=3)	Group PEEP 8 (n=4)	p*
T1	5.23 ± 0.58	5.67 ± 0.47	0.319
T2	5.30 ± 0.21	6.07 ± 0.75	0.153
T3	5.43 ± 0.37	6,12 ± 0.75	0.212
T4	5.23 ± 0.27	6,26 ± 1.01	0.151

*Student T test, BMI; body mass index
T1; prior to PNP (baseline),
T2; during insufflation at 5 (supine) ,
T3; 30 min (reverse-Trendelenburg),
T4; after deflation of PNP (supine)
Data are defined as mean ± standard deviation values

DISCUSSION

PEEP application, which is used to improve oxygenation by keeping alveoli open, may cause an additional increase in intracranial pressure ICP by compressing cerebrospinal flow outflow and cerebral venous drainage during pneumoperitoneum in obese patients undergoing laparoscopic surgery (6, 8). There are studies in literature investigating whether PEEP application increases or does not affect ICP (6, 9, 10). However, no study could be found investigating the effect of different PEEP applications on ONSD in obese patients who underwent laparoscopic surgery in reverse Trendelenburg position. The most important findings of this study were, 1) no significant difference was found between the two groups in the measurements performed at the 5th minute after PNP in the supine position (T2) or at the 30th minute in the reverse Trendelenburg position (T3) (p=0.417, p=0.258), 2) in the within group comparisons, all measurements (T2, T3, T4) during PNP in the group applied with 8 cmH_2O PEEP were significantly higher than the basaline ONSD measurements (T1) whereas the ONSD measurements of Group PEEP 5 patients did not differ significantly in all positions, 3). When the patients were compared according to BMI, it was observed that the increases in ONSD after PNP continued, was terminated in patients with BMI ≥ 40.

Morbidly obese patients are more prone to improve atelectasis due to decreased lung compliance and FRC. A minimal level of PEEP (3-5 cm H_2O) is applied to help patients maintain their normal FRC, while not stretching the normally ventilated alveoli. There are three clinically applicable levels of PEEP: Minimum or physiological PEEP: Minimum levels of PEEP (3 – 5 cm H_2O) are administered to help maintain the patient's normal FRC. It does not cause complications as a very small amount of pressure is applied with minimum PEEP. Moderate PEEP: Its limits are 5 – 15 cm H_2O. It is the most commonly used therapeutic PEEP range. Maximum PEEP: Values above 15 cm H_2O are considered high PEEP acceptable. It is useful in some special diseases (ARDS etc.). We used 5 cm H_2O minimal PEEP and 8 cm H_2O moderate PEEP as in the study done by Chin et al. (10). Fahry et al. showed a decrease in thorax and lung compliance during laparoscopic surgery and reported that this may be important, especially in obese or pulmonary pathology patients (11). Muench et al. examined the effects of different PEEP levels on ICP, cerebral oxygenation, regional cerebral blood flow, and systemic hemodynamic variables, and examined the effects of PEEP levels ranging from 0 to 20 cm H_2O, and found that increased PEEP pressures caused a significant decrease in MAP and cerebral blood flow (12). However, the change in cerebral blood flow was stated to be mainly due to the change in MAP, and that cerebral perfusion was not impaired when stable MAP was maintained. In the current study, the mean arterial pressures of the patients were within normal ranges in both groups, and there was no statistically significant difference between the groups. During the operation, the patients were followed up with $EtCO_2$ monitoring, which was attempted to be kept within a certain range. In this way, it was tried to prevent the increase in CO_2 that would cause an increase in ICP.

Although invasive methods are the gold standard for ICP measurement, non-invasive imaging methods such as CT and MR are also used. However, real-time measurements cannot be made precisely with these imaging methods, and they take time to perform and repeat (13). The method of determining increased ICP by measuring the ONSD with the help of ocular ultrasonography is becoming widespread and when it is compared with pressure measurements using intraparenchymal or intraventricular devices, results with ultrasound have been shown to have high consistency and correctness (14, 15). As yet, there is no definitive consensus on the normal values of ONSD, but it has been stated that changes in ICP are strongly correlated with changes in ONSD and any increase in ONSD can be used to determine increased ICP. Ultrasonographic measurement requires experience and there is a risk of operator-related subjective data measurement. However, compared to other complex ultrasonographic measurements of ONSD, it is adequately and well standardized, and the results can be easily reproduced. In previous studies comparing the gold standard methods of ICP measurement with ONSD, it was shown that ONSD values > 6.3 mm were associated with 96 % increased ICP (20 mmHg) (14). In a study of patients who underwent laparoscopic prostatectomy, Chin et al. compared the change in ONSD diameter in a group not applied with PEEP and in a group applied with 8 cmH_2O PEEP (10). The measurements at T1 time (post-anesthesia induction-pre-PNP) were found to be significantly increased in the PEEP group compared to T0 (pre-anesthesia induction, basal values) (p=0.021). After PNP, both groups showed an increase in their measurements following the baseline and PEEP application of ONSD, but no significant difference was observed between the two groups (p=0.618) (10). In the current study, no significant difference was found between the two groups in the measurements performed at the 5th minute after PNP in the supine position (T2) and at the 30th minute in the reverse Trendelenburg position (T3) (p=0.417, p=0.258). However, when compared within the groups, there was no significant difference between the measurements taken at 5 and 30 minutes after PNP application and the baseline value in the PEEP 5 group (p=0.396, p=0.583), whereas a significant difference was found in the PEEP 8 group (p=0.010, 0.003). In addition, when PNP was terminated, no difference was observed between T4 values and baseline (T1) ONSD values in the PEEP 5 group (p=0.313), while a significant difference was observed in the PEEP 8 group (p=0.012). Although we used moderate PEEP of 8 cm H2O, mean ONSD values increased during PNP. If we consider that the BMIs, operation times, and types of patients were similar in both groups, we can think that the high ONSD values may be due to high PEEP. When the patients were grouped according to BMI, it was observed that the high ONSD values persisted after PNP was terminated in patients with BMI ≥ 40. Considering the surgery and its duration, this difference may be more pronounced in patients with higher BMI in long-lasting laparoscopic cases. In the current study, although the mean ONSD values in the PEEP 8 group were higher than the PEEP 5 group, no statistical difference was found between the two groups. We thought that this similarity might be due to the small number of patients in the groups. Similarly, in a meta-analysis by Kim et al., a significant increase was seen in ONSD measurements performed in prolonged laparoscopic surgeries (16).

As there is no definite consensus about the normal breakpoints of ONSD, the effects of PNP, position and PEEP application have been examined in most studies to date by comparing the baseline values of all patients and comparing the groups. Maude et al. found a mean baseline ONSD diameter of 4.41 mm (4.25-4.7) in 136 normal subjects (17). In a study by Dip et al.., the mean initial ONSD value was found to be 4.81 mm (6). In the present study, the mean initial ONSD values measured in both groups were determined as 5.55±0.54 and 5.46±0.48 mm, respectively.

One of the indispensable components of laparoscopic surgeries is position. Head down (Trendelenburg) and head up (reverse Trendelenburg) positions are used to provide adequate vision. The effects of increased ICP due to PNP applied in both positions on cerebral perfusion have not been clearly demonstrated (18, 19). In animal experiments, it has been reported that the PNP and head-up position increase by approximately 10 mmHg (20). However, in laparoscopic surgeries performed in the head-down position, CVP and ICP have been shown to significantly increase with increasing pressure in the right atrium, and ICP has been shown to increase with the increase in MAP (21). Awad et al. examined patients who underwent laparoscopic radical prostatectomy and reported that intraocular pressure increased by approximately 13.3mmHg in relation to the duration of surgery (19). In laparoscopic cholecystectomy, hiatal hernia repair, and sleeve gastrectomy operations, the head-up position (reverse Trendelenburg) is used. In this position, the decreased venous return due to PNP may deepen, and the cardiac index may decrease with preload. Afterload may increase with increasing MAP, systemic, and pulmonary vascular resistance (22). In the current study, it was attempted to provide safe cerebral perfusion pressure by giving a position of 30°-45°. No significant increase after PNP was observed in the PEEP 5 group but in the PEEP 8 group a significant increase was observed in the measurements after PNP.

Limitations of this study could be considered to be the absence of a patient group who did not receive PEEP and the fact that the PEEP 8 group consisted of only females despite randomization. Also not excluding morbidly obese patients was one of the limitations of our study too. Although we did not exclude morbidly obese patients from the study, the median BMI of patients in our study group was 36.82 in the PEEP 5 group and 34.18 in the PEEP 8 group.

Obese patients are associated with more increased IAP and ICP compared to non-obese patients, necessitating more careful PEEP applications when PNP is applied in laparoscopic surgery. In this study, PEEP 8 and PEEP 5 applications were observed to have similar effects on ICP increase in cases of laparoscopic surgery performed in the reverse Trendelenburg position. However, as the duration of PNP increased, the ICP increase in the PEEP 8 group increased significantly. The measurement of ONSD with USG could be considered for more widespread use in laparoscopic surgeries, especially in morbidly obese patients with BMI ≥40, since non-invasive USG measurements may make PEEP increases safer.

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