ORIGINAL RESEARCH

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The Effect of the Endotracheal Cuff and Alveolar Pressures on Laryngopharyngeal Outcomes in Laparoscopic and Open Gynecological Procedure

Laparoskopik ve Açık Jinekolojik İşlemde Endotrakeal Kaf ve Alveolar Basınçların Laringofaringeal Sonuçlara Etkisi

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Abstract

Objective: High intra-abdominal pressure during laparoscopic surgery (LS) may increase endotracheal tube cuff pressure in patients. This study aimed to evaluate the effect of endotracheal tube cuff pressure and alveolar pressures on laryngopharyngeal outcomes at different time points during laparoscopic and open surgeries.

Method: Seventy patients who underwent open or LS were included in our study. The cuff pressure, peak inspiratory pressure (PIP), and plateau pressure values were measured after endotracheal intubation, at 15th, 30th, and 60th minutes after intra-abdominal carbon dioxide (CO_2) insufflation and before extubation. In addition, all patients were evaluated for sore throat using the visual analogue scale (VAS) at 1st, 12th, and 24th hours postoperatively by an observer blinded to the study groups.

Results: The patients in the LS group had statistically significantly higher cuff, PIP, and P-plateau levels at 15th, 30th, and 60th minutes after intubation and before extubation compared to those in the open surgery (OS) group (p <0.05 for all comparisons). At postoperative 12th hour, dysphagia was observed in four (10%) patients, and cough was present in 11 (30%) patients in the LS group. The VAS score for sore throat periods was significantly higher in the LS group than in the OS group at follow-up hours (p<0.05 for all comparisons). Extended operation time and cuff pressure at different time points were significantly associated with a sore throat (p<0.05 for all correlations).

Conclusion: Endotracheal tube cuff pressures and airway pressures should be monitored, especially in LS, to protect the mucosal layer of the trachea.

Keywords: Anesthesia, endotracheal, laparoscopic surgery, pneumoperitoneum, sore throat

Öz

Amaç: Laparoskopik cerrahi (LS) sırasında yüksek karın içi basıncı hastalarda endotrakeal tüp kaf basıncını artırabilir. Bu çalışma, laparoskopik ve açık ameliyatlar sırasında farklı zaman noktalarında endotrakeal tüp kaf basıncı ve alveoler basınçların laringofaringeal sonuçlara etkisini değerlendirmeyi amaçladı.

Yöntem: Çalışmamıza açık veya LS uygulanan yetmiş hasta dahil edildi. Kaf basıncı, tepe inspiratuar basınç (PIP) ve plato basınç değerleri endotrakeal entübasyondan sonra, karın içi karbonioksit (CO_2) insüflasyonundan 15, 30, 60 dakika sonra ve ekstübasyondan önce ölçüldü. Ek olarak, tüm hastalar çalışma gruplarına kör bir gözlemci tarafından postoperatif 1., 12. ve 24. saatlerde görsel analog skala (VAS) kullanılarak boğaz ağrısı açısından değerlendirildi.

Bulgular: LS grubundaki hastalarda entübasyondan 15, 30 ve 60 dakika sonra ve ekstübasyondan önce açık cerrahi (OS) grubuna kıyasla istatistiksel olarak anlamlı derecede yüksek kaf basıncı, PIP ve P-plato seviyeleri vardı (p<0,05 için tüm karşılaştırmalar). Postoperatif 12. saatte LS grubunda dört (%10) hastada disfaji, 11 (%30) hastada öksürük vardı. Takip edilen zaman dilimlerinde boğaz ağrısı için VAS skoru, takip saatlerinde LS grubunda OS grubuna göre anlamlı olarak daha yüksekti (tüm karşılaştırmalar için p<0,05). Farklı zaman noktalarında uzamış operasyon süresi ve kaf basıncı, boğaz ağrısı ile anlamlı şekilde ilişkiliydi (tüm korelasyonlar için p<0,05).

Sonuç: Trakeanın mukozal tabakasını korumak için özellikle LS'de endotrakeal tüp kaf basınçları ve hava yolu basınçları izlenmelidir.

Anahtar kelimeler: Anestezi, boğaz ağrısı, endotrakeal, laparoskopik cerrahi, pnömoperitoneum

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Introduction

Endotracheal intubation can cause upper respiratory tract complications. Tracheal mucosal injury due to decreased mucosal perfusion is one of the significant complications (1,2). In addition, the mucosal damage is associated with an increased endotracheal tube cuff pressure and is accused as the primary cause of postoperative hoarseness, dysphagia, and sore throat (1,2).

With the advances in technology and surgical experience, laparoscopic procedures have become the preferred choice by patients and surgeons due to fewer hospital stays and better postoperative outcomes (3). From the anesthesiological perspective, increased intra-abdominal pressure due to pneumoperitoneum can increase airway pressures and lung compliance (3). The high abdominal pressure may also increase endotracheal tube cuff pressure in patients undergoing laparoscopy compared to open surgery (4-6). However, there is still a lack of evidence and controversial data regarding the relationship between different endotracheal tube cuff pressures, operative time, type of surgery, and postoperative laryngopharyngeal complications. This study aimed to evaluate the effect of endotracheal tube cuff pressure and alveolar airway pressures on postoperative airway complications at different time points in laparoscopic and open surgeries for gynecological indications.

Materials and Methods

This prospective study was conducted after obtaining ethical approval from University of Health Sciences Turkey, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee of the institution where the study took place (approval number: 2020/92, date: 17.02.2020). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Between 1 April 2020 and 1 November 2020, seventy patients who underwent gynecological surgery and agreed to participate with written informed consent were included in the study. In addition, the study included patients aged 18-70 years with the American Society of Anesthesiologists (ASA) grade I-II. They were planning to undergo elective surgery due to a variety of gynecological pathologies.

The exclusion criteria included patients with tracheostomy, tracheal stricture, history of laryngeal surgery or obstruction, chronic obstructive pulmonary disease (COPD), ASA ≥4, those in whom endotracheal intubation was achieved after >2 attempts, candidates for emergency surgery, and those with oropharyngeal infection within two weeks before the planned surgery.

Patients assigned for laparoscopic surgery were defined as the LS group, and patients who would undergo open surgery were defined as the OS group (Figure 1). Demographic data of the study population were recorded. The patients were provided with standard monitoring (ECG, pulse oximetry, non-invasive blood pressure). Patients received a 3-minute FiO_2: 80% preoxygenation. Anesthesia induction was achieved by intravenous (i.v.) administration of 0.05 mg/kg midazolam, 1-2 µg/kg fentanyl, propofol 2-3 mg/kg, and 0.6 mg/kg rocuronium. The muscle relaxant effect was planned to be controlled via train-of-four (TOF) neuromuscular blockade monitorization. After adequate muscle relaxation was achieved, all patients were intubated using high-volume, low-pressure cuffed endotracheal intubation tubes (ETT) (Bıçakçılar, İstanbul, Turkey). The endotracheal tube diameter was decided by evaluating the patient's age and body mass index (BMI). ETT cuff pressure was set as 25 cmH_2O so that there was no air leakage during inspiration. Anesthesia was maintained with sevoflurane (minimal alveolar concentration 0.8-1) and i.v. remifentanyl infusion (0,05-0,1 µg/kg/min). Rocuronium was administered when necessary according to the TOF evaluation. Depth of anesthesia was maintained in the range of 25-50 patient state index (SEDLine, Masimo, CA). All patients received 100 mg i.v. Tramadol and 1 g paracetamol before the end of surgery to achieve effective pain control. The patients were

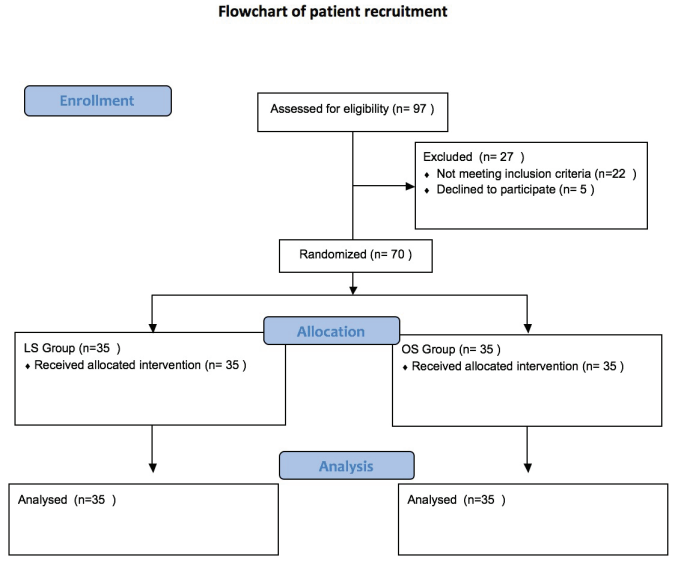

Figure 1. Consort flow chart of the study
OS: Open surgery, LS: Laparoscopic surgery

planned to be extubated after administering neostigmine 0.03 mg/kg and atropine 0.01 mg/kg. Patients who were connected to a mechanical ventilator during the operation were ventilated according to the protocol applied by our clinic. In volume control ventilation, tidal volume was adjusted to be 6-8 mL/kg (ideal body weight), I: E ratio of 1:2, positive end-expiratory pressure of 5 cmH_2O and respiratory rate, end-tidal carbon dioxide value of 35-45 mmHg.

The patients were placed in a supine position for the operation. The pneumoperitoneum and steep Trendelenburg position were used for the patients in the LS group. During the procedure, the intra-abdominal pressure was 11-13 mmHg. The ETT cuff pressure, peak inspiratory pressure (PIP), and plateau pressure values were measured at 5 minutes after intubation, at 15., 30., and 60. minutes after intra-abdominal CO_2 insufflation, and before extubation. Cuff pressure was not intervened unless a leak was detected during the measurements. The duration of anesthesia and surgery were recorded.

All patients were postoperatively evaluated for sore throat by an observer blinded to study groups using a 10-point Likert type visual analogue scale (VAS) (0: no pain, 10: the worst pain ever experienced) at 20 minutes in the recovery room and 1, 12, 24 hours in the patient room. In addition to sore throat, the presence of dysphagia, cough, and hoarseness was also questioned and recorded.

Statistical Analysis

Based on previous studies (3,5,6), a difference of at least seven mmHg in cuff pressure levels between the LS group and the OS group was considered significant. Therefore, it was determined that the study population should consist of at least 50 individuals, including at least 25 patients in each group, to achieve 95.5% power to reject the null hypothesis of equal means when the population means the difference is 2.5 with standard deviations of 4.0 for LS and 2.0 for OS, and with a significance level (alpha) of 0.050 using a two-sided two-sample unequal-variance t-test. A total of 70 patients were included in the study as a precaution against patient loss due to the patient or other factors. Additionally, the study did not bring any additional cost to the hospital.

The patients' demographic characteristics and the study variables were analyzed in IBM SPSS® (Statistical Package for the Social Sciences) version 23. The variables were presented as mean, maximum, and minimum values, and percentages were used to define qualitative variables. The continuous variables with homogenous distribution were compared via the Student's t-test. The Pearson's chi-square test or Fisher's Exact test analyzed qualitative variables. Non-parametric continuous variables were analyzed as median and compared using the Mann-Whitney U test. A repeated Two-Way ANOVA test reached the repeated cuff, peak, and plateau airway pressures at different time points. The Pearson correlation coefficient (r) was used to analyze correlations between study variables. A p-value <0.05 was considered statistically significant.

Results

Demographic data are presented in Table 1. The mean age of the study population was 47.1±13.4 years (range 19-70). There was no statistical difference between the groups regarding demographic data, surgery, and total anesthesia time. However, the patients who underwent hysterectomy + bilateral salpingo-oophorectomy (BSO) and hysterectomy-only were more common in the OS group compared to the LS group (55.6% vs. 44.4% and 52.9% vs. 47.1%, respectively; p<0.001).

Table 1. The comparison of demographic characteristics of the study groups

	Total	LS group (n=35)	OS group (n=35)	p
Age (year) mean ± SD	47.1±13.4	45.4±15.1	48.9±11.4	0.431
Height (cm) mean ± SD	163.7±5.1	163.4±5.5	164±4.7	0.438
Weight (kg) mean ± SD	78.3±12	76.7±13.3	79.9±10.6	0.374
Body mass index	29.3±4.8	28.8±5.2	29.8±4.5	0.601
Duration of surgery (min.) mean ± SD	154.8±45	154.7±48.9	155±41.4	0.782
Duration of anesthesia (min.) mean ± SD	139.1±47.7	137.7±51.6	140.5±44.2	0.773
Type of surgery n (%)				
BSO	17 (24.3%)	10 (58.8%)	7 (41.2%)	
Cystectomy	9 (12.9%)	5 (55.6%)	4 (44.4%)	0.793
Hysterectomy	17 (24.3%)	8 (47.1%)	9 (52.9%)	
Hysterectomy + BSO	27 (38.6%)	12 (44.4%)	15 (55.6%)	

BSO: Bilateral salpingooophorectomy, SD: Standard deviation, OS: Open surgery, LS: Laparoscopic surgery

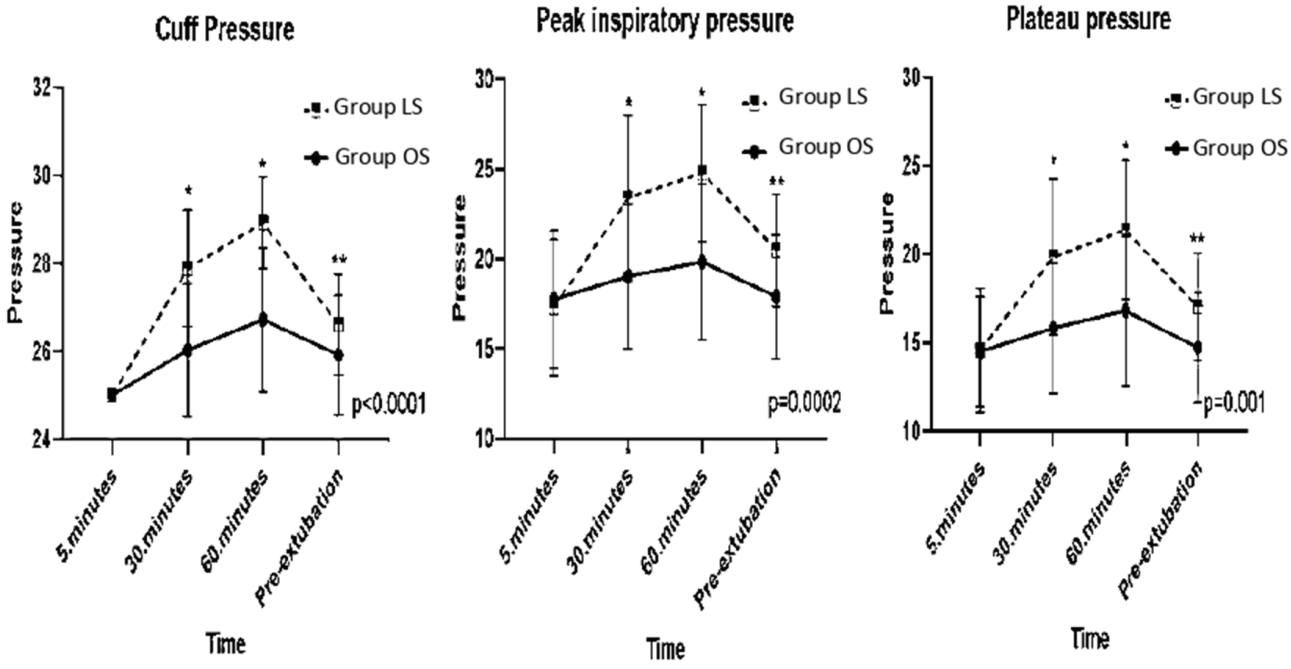

Figure 2. The comparison of ETT cuff, PIP and P plateau measurements in different time periods
PIP: Peak inspiratory pressure, ETT: Endotracheal intubation tubes

There was no difference between the study groups at 5 minutes after intubation about changes in cuff pressure, PIP, and plateau pressure values. However, the patients in the LS group had statistically significantly higher cuff, PIP, and P-plateau values compared to those in the OS group at all measurement time points after insufflation (p<0.05 for all comparisons) (Figure 2) (Table 2). In addition, the cuff pressure was significantly higher before extubation in the LS group compared to the OS group (26.6±1.2 vs. 25.9±1.4, p=0.022).

The association between cuff pressure levels at different time points and PIP and plateau pressure changes were evaluated, revealing no significant correlation between the OS and LS groups (Table 3). In the postoperative 12-hour follow-up, dysphagia was observed in four (10%) patients, and 11 (30%) patients had a cough in the LS group, which was significantly higher than that in the OS group (p<0.05). There was no significant difference between the two groups in terms of complications at the 1st and 24th hours postoperatively (Table 4). When postoperative sore throat VAS scores were evaluated, significantly higher rates were observed in the LS group at 1., 12., and 24. hours (p<0.05 for all comparisons).

The correlation analysis of cuff pressure, sore throat, BMI, and duration of surgery in different periods revealed that cuff pressure measurements at 15., 30., and 60. minutes after intra-abdominal insufflation were positively correlated with sore throat VAS scores at postoperative 1., 12., and 24. hours (p<0.05 for all correlations). Moreover, the duration of surgery also had a positive correlation with 1, 12, and 24-hour sore throat VAS scores (p<0.05 for all correlations) (Table 5).

Discussion

In our study, cuff pressure, PIP, and P-Plateau measurements were significantly higher in the LS group than in the OS group at 15., 30., and 60. minutes. Furthermore, a significant positive correlation was observed between postoperative sore throat VAS scores and cuff pressure levels at different time points.

Laparoscopic surgeries are associated with increased alveolar and endotracheal pressures (7). These increased pressures may be related to the increased intra-abdominal pressure due to pneumoperitoneum. Geng et al. (3) compared cuff pressure and airway pressure measurements in a study including 60 patients who underwent gynecological surgery. The authors evaluated 30 patients in the laparotomy group and 30 patients in the laparoscopic group and reported increases in airway pressure and

Table 2. Comparison of the study group regarding cuff pressure, PIP and plateau pressures in different time periods

	LS group (n=35)	OS group (n=35)	p
Cuff pressure			
5. min	25±0	25±0	1.000
15. min	30.3±1.7	26±1.5	**<0.001**
30. min	32±1.8	26.7±1.6	**<0.001**
60. min	29.4±1.4	25.9±1.1	**<0.001**
Before extubation	26.6±1.2	25.9±1.4	**0.022**
PIP			
5. min	17.3±3.8	18.1±4.1	0.439
15. min	23.4±4.6	19±3.9	**<0.001**
30. min	24.8±3.8	19.5±4	**<0.001**
60. min	21.6±3.8	17.7±3.5	**<0.001**
Before extubation	19.4±3.1	17.9±3.5	0.061
P plateau			
5. min	14.6±3.5	14.7±3.2	0.887
15. min	19.8±4.4	15.8±3.6	**<0.001**
30. min	21.4±3.9	16.6±4	**<0.001**
60. min	17.9±3.3	13.8±3.1	**<0.001**
Before extubation	16.3±3	14.7±3.1	0.061
Mean pressures*			
Mean cuff pressure	28.7±1.1	25.9±0.9	**<0.001**
Mean PIP	21.3±3.3	18.4±3.4	**<0.001**
Mean P plateau	18±3.1	15.1±3	**<0.001**

*The mean values comprised of 5. min, 15. min, 3.0 min and 6.0 min values, PIP: Peak inspiratory pressure, OS: Open surgery, LS: Laparoscopic surgery

Table 3. The correlation analysis of cuff pressure, PIP and plateau pressures in different time periods

	OS group		LS group	
	r	p	r	p
15. min cuff and PIP	0.073	0.680	0.179	0.304
15. min cuff and P plateau	0.172	0.330	0.138	0.428
30. min cuff and PIP	0.241	0.170	0.010	0.956
30. min cuff and P plateau	0.328	0.059	-0.002	0.993
60. min cuff and PIP	0.017	0.923	0.132	0.449
60. min cuff and P plateau	0.172	0.332	0.084	0.631
Before extubation cuff and PIP	0.003	0.988	0.085	0.626
Before extubation cuff and P plateau	0.139	0.434	0.092	0.599
Peroperative mean cuff and mean PIP	0.036	0.838	0.166	0.342
Peroperative mean cuff and mean P plateau	0.171	0.334	0.123	0.480

PIP: Peak inspiratory pressure, OS: Open surgery, LS: Laparoscopic surgery

Table 4. Comparison of postoperative laryngopharyngeal complications

	OS group (n=35)	LS group (n=35)	p
1. hour			
Cough, n (%)	4 (10.0%)	6 (20.0%)	0.498
Sore throat, n (%)	20 (60.0%)	25 (70.0%)	0.216
12. hour			
Cough, n (%)	3 (10.0%)	11 (30.0%)	**0.018**
Sore throat, n (%)	20 (60.0%)	25 (70.0%)	0.216
24. hour			
Cough, n (%)	4 (10.0%)	9 (30.0%)	0.127
Sore throat, n (%)	12 (30.0%)	19 (50.0%)	0.094
Sore throat VAS			
1. h, mean ± SD	2.37±2.17	3.6±2.5	**0.014**
12. h, mean ± SD	1.46±1.4	2.17±1.56	**0.032**
24. h, mean ± SD	0.51±0.78	1.09±1.04	**0.02**

SD: Standard deviation, VAS: Visual analogue scale

Table 5. The correlation analysis of cuff pressure, sore throat, BMI and duration of surgery in different time periods

	r	p
BMI		
15. min cuff	0.065	0.594
30. min cuff	0.079	0.517
60. min cuff	0.083	0.496
Before extubation cuff	0.107	0.380
1 h sore throat		
15. min cuff	0.421	**<0.001**
30. min cuff	0.356	**0.003**
60. min cuff	0.291	**0.015**
Before extubation cuff	0.259	**0.030**
12 h sore throat		
15. min cuff	0.415	**<0.001**
30. min cuff	0.36	**0.002**
60. min cuff	0.304	**0.010**
Before extubation cuff	0.233	0.053
24 h sore throat		
15. min cuff	0.437	**<0.001**
30. min cuff	0.395	**0.001**
60. min cuff	0.303	**0.011**
Before extubation cuff	0.243	**0.042**
Duration of surgery		
1 h sore throat	0.304	**0.011**
12 h sore throat	0.322	**0.007**
24 h sore throat	0.456	**<0.001**

BMI: Body mass index

cuff pressure in the laparotomy group. In addition, the patients in the laparoscopic group significantly suffered from sore throat, which was consistent with previous data (4,8). Rosero et al. (7) reported that ETT cuff pressures were associated with changes in mean airway and peak pressures in their study on obese patients. In addition, the authors concluded that the Trendelenburg position was significantly associated with increased endotracheal tube cuff pressures (7).

In contrast to other studies in the literature, we evaluated the airway pressures in different periods in addition to the cuff pressure (3-8). In line with the current knowledge, we also observed increased pressure levels in the LS group than in the OS group. The increase in the endotracheal cuff and airway pressures can be related to increased intra-abdominal pressure and trendelenburg position. In addition, the higher airway pressures result from reduced lung capacity due to diaphragm elevation and pneumoperitoneum. Overinflation of the tube cuff or intubation exceeding 180 minutes may increase the risk of tracheal ulceration (8). It was also reported that the steep Trendelenburg position might cause venous engorgement and reduced tracheal mucosal perfusion (7,8). Seet et al. (9) used a standard manometer to measure intra-cuff pressure to reduce pharyngolaryngeal complications in a study. They concluded that dysphagia and hoarseness rates were significantly decreased when the ETT cuff pressure was below 60 cmH_2O. In another study, Wong et al. (10) showed that postoperative laryngopharyngeal complications could be reduced when the cuff pressure was below 44 cm H_2O. On the other hand, Kang et al. (11) concluded that 25 cmH_2O intracuff pressure was sufficient for ventilation and was associated with fewer complications after laparoscopic surgery.

Regarding side effects, patients may have a sore throat, hoarseness, and cough after surgery. (12). The incidence of sore throat after endotracheal intubation ranges from 14.4% to 50% (13-15). Yildirim et al. (4) reported a higher rate of postoperative sore throat after laparoscopic surgery than after laparatomic surgery. We may speculate that sore throat could be related to gender, age, BMI, the diameter of the endotracheal tube, cuff pressure, and any movement or displacement of the tracheal tube during the operation.

In our study, significantly increased dysphagia and cough at 12 hours and higher sore throat VAS scores at different time points were observed in the LS group compared to the OS group. Besides, cuff pressures at 15., 30., and 60. minutes after insufflation were significantly correlated with sore throat VAS scores at 1., 12., and 24. hours. Moreover, the duration of surgery also showed a positive correlation with a sore throat at 1., 12., and 24. hours. The presence of sore throat may be associated with a longer duration of surgery, increased cuff pressure, and lung pressures, which may be a consequence of mucosal damage and irritation.

The strength of our study is its prospective design, which reduces the bias risk and the measurement of alveolar and tube pressures at different time points. The limitation of our study is the heterogeneity between the two groups in terms of patient position during surgeries. Although the increase in abdominal and airway pressure in the LS group was primarily due to CO_2 insufflation, the Trendelenburg position might have also contributed to increased airway pressure. However, we could not assess to what extent the position and the tube diameter contributed to the increase in airway pressures. Further studies could be designed considering our study limitations.

Conclusion

Endotracheal tube cuff pressures and alveolar pressures should be monitored, especially in laparoscopic surgeries, to protect the mucosal layer of the trachea. The clinical importance of continuous monitoring of cuff pressures is that it may prevent intubation-related complications such as sore throat in patients undergoing prolonged surgeries.

Ethics

Ethics Committee Approval: This prospective study was conducted after obtaining ethical approval from University of Health Sciences Turkey, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee of the institution where the study took place (approval number: 2020/92, date: 17.02.2020). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from the patients participating in the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: G.Ö.Y., Design: G.Ö.Y., G.S., Data Collection or Processing: G.Ö.Y., G.S., Drafting Manuscript: G.Ö.Y., G.S., Critical Revision of Manuscript: G.Ö.Y., G.S., Final Approval and Accountability: G.Ö.Y., G.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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