ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.61745/jsmsau.1517872

Evaluation of Volume Controlled Ventilation Mode and Volume Guaranteed Pressure Controlled Ventilation Modes in Lateral Decubitus Position; Randomized Controlled Study

Lateral Dekübit Pozisyonda Hacim Kontrollü Ventilasyon Modu ve Hacim Garantili Basınç Kontrollü Ventilasyon Modlarının Değerlendirilmesi; Randomize Kontrollü Çalışma

Ela Nur MEDETOĞLU KÖKSAL [1]
Erzurum City Hospital, Department of Anaesthesiology, Erzurum, Türkiye

Veysel KÖKSAL [2]
Atatürk University, Medical Faculty, Department of Anaesthesiology, Erzurum, Türkiye

Kenan GÜLBAHAR [2]
Atatürk University, Medical Faculty, Department of Anaesthesiology, Erzurum, Türkiye

Erkan Cem ÇELİK [2]
Atatürk University, Medical Faculty, Department of Anaesthesiology, Erzurum, Türkiye

ABSTRACT

Objectives: This study aims to examine the impact of two ventilation modes—volume-controlled ventilation (VCV) and volume-guaranteed pressure-controlled ventilation (PCV-VG)—on patient hemodynamic, lung mechanics, and alveolar gas exchange during laparoscopic surgery in the lateral decubitus position under general anaesthesia.
Methods: The study included 60 patients, aged 18-65, classified as ASA I-II, who were scheduled for laparoscopic nephrectomy. Patients were randomly assigned to either the VCV or PCV-VG group. Parameters such as peak pressure (Ppeak), mean pressure (Pmean), PaO2, PaCO2, SaO2, and haematocrit (htc) were recorded at four time points: in the supine position before lateral decubitus (T1), 5 minutes after lateral decubitus (T2), at the end of surgery in lateral decubitus (T3), and in the supine position before extubation (T4). Additional data collected included patient demographics, surgery details, operation time, and the side of the operation.
Results: When ventilation parameters and blood gas values at T1, T2, T3 and T4 were evaluated, significant differences were seen between the groups in Ppeak at T2 and Pmean at T3 ($P<.05$). There was no significant difference in PaO2, SaO2 and PaCO2 values between the groups ($P>.05$). There was a significant difference in Ppeak, Pmean, htc, systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse parameters between the groups at different time periods ($P<.05$). There was no significant difference in other parameters ($P<.05$).
Conclusions: Different ventilation modes have unique benefits for different clinical situations. While PCV-VG mode provided a significant decrease in pressure parameters, no difference was observed in blood gas parameters.

Keywords: General Anaesthesia, laparoscopic nephrectomy, lateral decubitus position, ventilation

ÖZ
Amaç: Bu çalışmanın amacı, Genel anestezi altında lateral dekübit pozisyonda iki ventilasyon modunun (hacim kontrollü ventilasyon (VCV) ve hacim garantili basınç kontrollü ventilasyon (PCV-VG)) laparoskopik sırasında hasta hemodinamikleri, akciğer mekaniği ve alveoler gaz değişimi üzerindeki etkisini incelemeyi amaçlamaktadır.
Yöntemler: Çalışmaya laparoskopik nefrektomi planlanan, ASA I-II olarak sınıflandırılan, 18-65 yaş arası 60 hasta dâhil edildi. Hastalar rastgele VCV veya PCV-VG grubuna ayrıldı. Hastaların demografik özellikleri, ameliyat ayrıntıları, ameliyat süresi ve ameliyatın tarafı ve tepe basıncı (Ppeak), ortalama basınç (Pmean), PaO_2, $PaCO_2$, SaO_2 ve hematokrit (htc) gibi yanal dekübitten önce sırtüstü pozisyonda (T1), yanal dekübitten 5 dakika sonra (T1) T2), ameliyat sonunda lateral dekübitte (T3) ve ekstübasyon öncesi sırtüstü pozisyonda (T4) olmak üzere parametreler dört zaman noktasında kaydedildi.
Bulgular: T1, T2, T3 ve T4'teki ventilasyon parametreleri ve kan gazı değerleri değerlendirildiğinde, gruplar arasında T2'de Ppeak ve T3'te ki Pmean'de anlamlı farklılıklar görüldü ($P<.05$). Gruplar arasında PaO_2, SaO_2 ve $PaCO_2$ değerlerinde anlamlı fark görülmedi ($P>,05$). Gruplar içerisinde farklı zaman dilimlerinde Ppeak, Pmean, htc, sistolik kan basıncı (SBP), diastolik kan basıncı (DBP) ve nabız parametrelerinde anlamlı fark mevcuttu ($P<.05$). Diğer parametrelerde anlamlı farklılık yoktu ($P<,05$).
Sonuç: Farklı ventilasyon modlarının farklı klinik durumlar için benzersiz faydaları vardır. PCV-VG modu basınç parametrelerinde anlamlı düşüş sağlarken kan gazı parametrelerinde farklılık gözlenmedi.

Anahtar Kelimeler: Genel anestezi, laparoskopik nefrektomi, lateral dekübit pozisyon, ventilasyon

Geliş Tarihi/Received	18.07.2024
Kabul Tarihi/Accepted	22.08.2024
Yayın Tarihi/Publication Date	25.08.2024

Sorumlu Yazar/Corresponding author: Ela Nur MEDETOĞLU KÖKSAL
E-mail: elamdtoglu@gmail.com

Cite this article: Köksal ENM, Köksal V, Gülbahar K, Çelik EC. Evaluation of Volume Controlled Ventilation Mode and Volume Guaranteed Pressure Controlled Ventilation Modes in Lateral Decubitus Position; Randomized Controlled Study. *Atatürk Univ Fac Med J Surg Med Sci.* 2024;3(2): 26-31

INTRODUCTION

The position of the patients and the ventilation management applied during the surgery may cause some changes in vital parameters. The goal of ideal ventilation is to protect the lungs and provide acceptable gas exchanges. Laparoscopic surgery is widely used in the treatment of various intra-abdominal and retroperitoneal pathologies using minimally invasive approaches. Laparoscopic nephrectomy is a minimally invasive approach frequently used in the surgical treatment of kidney cancer, obstructive uropathy and other kidney diseases. As with every surgical procedure, laparoscopic nephrectomy in the lateral decubitus position has some disadvantages and possible complications. Cardiovascular and respiratory complications may develop due to carbon dioxide insufflation. In addition, it provides benefits such as less postoperative pain, shorter hospital stay, significant reduction in blood loss, faster recovery, and nephron-sparing surgery. During laparoscopic surgery, pneumoperitoneum is created by injecting carbon dioxide (CO_2) into the abdominal cavity. Pneumoperitoneum pushes the diaphragm upward, causing compression at the bases of the lung. Elevation of the diaphragm and increased abdominal pressure leads to a decrease in FRC. Decreased lung volume and pressure on respiratory muscles increase respiratory workload. [1]

Laparoscopic nephrectomy in the lateral decubitus position is an effective and safe method in the treatment of kidney diseases. However, this position may have negative effects on lung dynamics. This can lead to V/Q imbalance. Ventilation-perfusion imbalance and decreased lung volumes can lead to decreased arterial oxygenation. [2] Compression of the underlying lung and reduced ventilation may increase the risk of atelectasis. The upper lung may expand further under the influence of gravity, leading to hyperinflation in the upper lobes.

Volume Controlled Ventilation (VCV) ensures that a certain tidal volume (TV) is delivered to the patient. In this mode, the ventilator delivers a preset volume to the patient during each respiratory cycle. Providing a reliable tidal volume facilitates ventilation control. However, if the patient has low lung compliance, there is a risk of high peak pressures. This may cause barotrauma in the lungs and cause changes in pulmonary gas distribution. [3]

Pressure Controlled Ventilation - Volume Guaranteed (PCV-VG) is a ventilation mode that combines the features of VCV and Pressure Controlled Ventilation (PCV) modes. In this mode, the ventilator guarantees a certain tidal volume while at the same time adjusting the inspiratory pressure, providing a pressure profile appropriate to the patient's lung compliance. Minimizes lung damage thanks to pressure control while providing a reliable tidal volume. [4] Additionally, it provides more physiological respiratory support as it dynamically adapts to the patient's lung compliance.

In this study, we aimed to determine the effect of volume-controlled ventilation mode and volume-guaranteed pressure-controlled ventilation modes on differences in patient hemodynamic, lung mechanics and alveolar gas exchange parameters in patients who underwent laparoscopic surgery in the lateral decubitus position under general anaesthesia.

METHODS

We obtained institutional review board permission from Atatürk University for this study (Date: 29/09/2022 Decision No: 2022/609). This randomized controlled study was conducted on patients who underwent laparoscopic nephrectomy surgery in the lateral decubitus position by the urology clinic at Atatürk University Anaesthesiology and Reanimation Department operating room. Written consent was obtained from all patients participating in the study.

After ethics committee approval was obtained, 60 patients in the ASA I-II group, between the ages of 18-65, without liver, kidney or advanced heart failure, without respiratory system disease, and non-smokers who agreed to participate in the study were included in the study. Patients with underlying serious cardiovascular disease, respiratory system disease, and patients who did not want to participate in the study were excluded from the study.

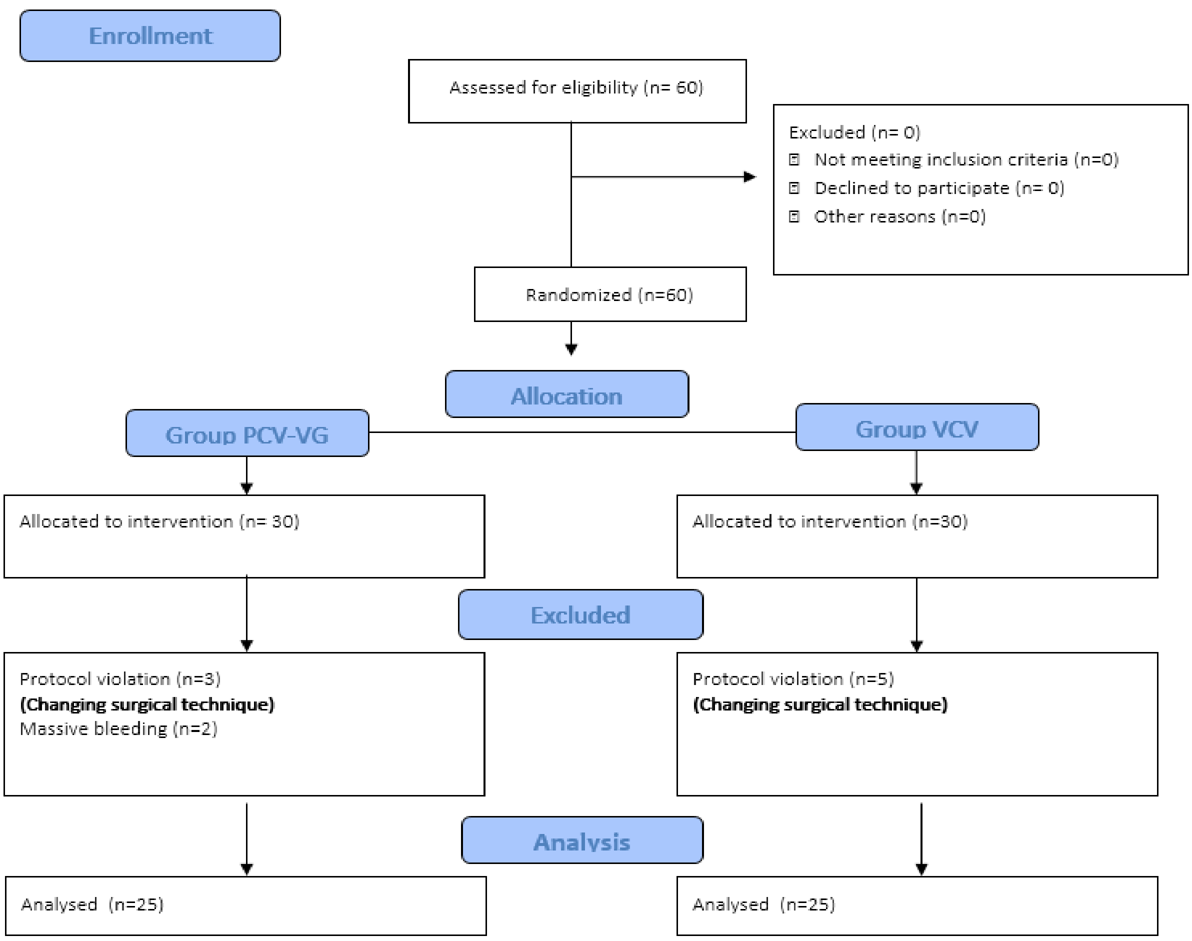
Anaesthesia induction was applied to the patients with 2-3 mg/kg propofol, 0.7 mg/kg rocuronium, 1 mg/kg fentanyl, and endotracheal intubation was performed when the TOF value was higher than 90%. After endotracheal intubation was performed, ventilation was started with VCV or PCV-VG ventilation mode in accordance with randomization. Arterial catheterization was performed. Ventilation settings were made so that the patients' tidal volume was 8 ml/kg, respiratory rate, end-tidal carbon dioxide levels were 35-40 mmHg, 2 litres of 50% oxygen mixture, I: E ratio was 1:2, and anaesthesia was maintained with desflurane. Ppeak, Pmean, PaO2, PaCO2, SaO2, pH in the supine position before the patient is placed in the lateral decubitus position (T1), in the 5th minute in the lateral decubitus position (T2), in the lateral decubitus position at the end of the surgery (T3), and in the supine position before extubation (T4), haematocrit, SBP, DBP, pulse values were noted. Demographic data of the patients, surgery, operation time, and the side where the operation was performed were noted. The enrolment and allocation of patients are summarised in a CONSORT flow diagram. (Figure 1)

Statistical analysis

In the post hoc power analysis analysed with the Ppeak parameter in the T2 time unit, the power of the study with a total of 50 patients, 25 patients in each group, was found to be 0.97 (Effect power; 1.04, Type 1 error; 0.05). With this result, it was seen that the sample size was sufficient.

Statistical analysis was performed using the statistical program SPSS (IBM SPSS Corp., Armonk, NY,). Chi-square test was used to evaluate categorical data. The distribution of the data was evaluated with the Kolmogorov-Smirnov test. Student-t test was used between independent groups for data showing normal distribution, and Repeated measures ANOVA test was used for evaluations between different time units. Data obtained at *P*<.05 were considered statistically significant.

Figure 1: Consort diagram



RESULTS

A total of 60 patients, 30 from each group, who underwent laparoscopic nephrectomy in the urology operating room were included in the study. As a result of the study, 5 patients in the VCV group who were converted to laparotomy surgery, 3 patients in the PCV-VG group due to conversion to laparotomy surgery, and 2 patients due to massive haemorrhage were excluded from the study. There was no statistically significant difference between the groups included in our study in terms of gender, average age, average height, average weight, operation and anaesthesia duration. (*P*>.05) As a result of the evaluation of the ventilation parameters and blood gas values of the patients in the supine position after endotracheal intubation (T1), at the 5th minute in the lateral decubitus position (T2), after the end of the surgery in the lateral decubitus position (T2), and in the supine position before extubation (T4), the Ppeak parameter was measured in the T2 time unit. There was a statistically significant difference between the groups in the T3 time unit and Pmean parameter. (*P*<.05). There was no significant difference in PaO2, PaCO2, SaO2, Htc, SBP, DBP, Pulse values between the groups. (*P*>.05)

Ppeak value was found to be higher in the VCV group than in the PCV-VG group at T2 time (*P*<.05). There was no significant difference at T1, T3, T4 times (*P*>.05).

Pmean value was found to be higher in the PCV-VG group than the VCV group at T3 time (*P*<.05). There was no significant difference at T1, T2, T4 times (*P*>.05).

When different times are evaluated in the same group, in the VCV group; Ppeak was found to be higher at T2 time than T1 (*P*<.05). T3 was found to be lower than T2 (*P*<.05). T4 was found to be lower than T3 and T2 (*P*<.05). Pmean was found to be higher in T2 than in T1 (*P*<.05). Htc T2 is lower than T1; T3 was found to be lower than T2 and T1, and T4 was found to be lower than T1 (*P*<.05). SBP lower than T2, T1, higher than T4, T2 and T3 (*P*<.05), DBP lower than T2, T1, higher than T4, T1 (*P*<.05), Pulse; T2 was lower than T1; T3 was lower than T1; T4 was higher than T3 (*P*<.05).

When different times were evaluated in the same group, Ppeak T2 was found to be higher than T1 in the PCV-VG group (*P*<.05). T3 was found to be higher than T1 (*P*<.05). T4 was found to be lower than T3 and T2 (*P*<.05). Pmean T2 was higher than T1, T3 was higher than T1, T4 was lower than T2 and T3 (*P*<.05). Htc T2 was found to be lower than T1, T3 was lower than T1, and T4 was lower than T1 and T2 (*P*<.05). SBP, T4 was higher than T2 and T3 (*P*<.05), in DBP, T2 was lower than T1, T3 was lower than T1, T4 was higher than T2 and T3 (*P*<.05), Pulse T2 was higher than T3 and T4 was lower than T1 (*P*<.05).

There was no statistically significant difference in PaO2, PaCO2, SaO2 parameters in the same group at different times. (*P*>.05)

DISCUSSION

Laparoscopic surgery in the lateral decubitus position has significant effects on lung dynamics. These effects may become more pronounced with pneumoperitoneum and may lead to complications such as ventilation-perfusion imbalance, atelectasis, and reduced oxygenation. Therefore, it is of great importance to take appropriate precautions and optimize ventilation strategies. The selection of VCV and PCV-VG modes varies depending on the patient's clinical condition and lung dynamics. Situations where the VCV mode is preferred include situations where a stable tidal volume requirement and ventilation control are at the forefront. PCV-VG mode is preferred especially in patients with variable lung compliance, in order to reduce the risk of barotrauma and provide more physiological ventilation.

In our study, we compared the effects of PCV-VG and VCV ventilation modes on lung parameters and hemodynamic in patients who underwent laparoscopic nephrectomy surgery in the lateral decubitus position. As far as can be determined, this is the first study comparing ventilation modes in laparoscopic cases in the lateral decubitus position. When the patients were moved from the supine position to the lateral decubitus position, the Ppeak value was observed to be lower in the PCV-VG mode. When their time periods were compared, it was seen that both groups reached the highest value in the lateral decubitus position. However, there was no significant difference in arterial oxygenation, which was similar to previous studies5. Many previous studies have found that the Ppeak value is lower in the PCV-VG mode than in the VCV mode. Dion et al. found that Ppeak pressures were lower in mechanical ventilation modes compared to pressure control modes in patients undergoing laparoscopic sleeve gastrectomy surgery. [5]

Pmean value related to alveolar ventilation and oxygenation was significantly higher in the PCV-VG group in the lateral decubitus position. Pmean is related to alveolar pressure, and an increased Pmean can stimulate the alveoli, improving alveolar ventilation and gas oxygenation. [6] However, in our study, although the Pmean value was significant at T3 time, no significant difference was found between the two groups in arterial oxygenation at any time. A meta-analysis by Aldenkortt et al evaluated 13 studies involving various ventilation strategies in obese adults. Similar to our study, they concluded that neither VCV nor PCV modes were superior for improving oxygenation or ventilation in patients. [7] In a study conducted on patients in the supine position who underwent VCV and PCV-VG, a significant decrease in Ppeak pressures was found, similar to our study. This decrease in Ppeak pressures was observed to be accompanied by a significant increase in compliance values. This result appears to be due to the generation of similar tidal volumes with lower airway pressures. Similar to our study, the authors concluded that PCV-VG may result in less airway damage in patients with high airway pressure values. [8]

Tablo 1: Comparison of Demographic Variables Between Groups

	VCV (n:25)	PCV-VG (n:25)	*P*
Age	49.3 ± 11	53.08 ± 12.4	.258
Weight	82.4 ± 13.5	80.36 ± 15.3	.619
Height	171.2 ± 6.9	169.92 ±10.2	.616
Gender (F/M)	9/16	10/15	N
Duration of the surgery	164.4 ± 46.2	172.7 ± 47.5	.538
Duraiton of the Anesthesia	194.4 ± 46.7	207.1 ± 50.7	.361
Comorbidities (Y/N)	8/17	12/13	.357
Side of the surgery (Right/Left)	12/13	13/12	N

Datas expressed with mean±SD and number

Table 2: Descriptive statistics for demographic qualitative variables

		T1	T2	T3	T4	*P*
Ppeak	VCV	17.68±2.49	21.08±2.51^{a}	19.64±3.37$^{a.b}$	17.60±3.73$^{b.c}$	<.001
	PCV-VG	15.64±2.95	18.08±3.17^{a}	17.88±3.34^{a}	16.36±2.81$^{b.c}$	<.001
	P	.11	.001	.070	.191	
Pmean	VCV	8.64±1.07	9.60±1.47^{a}	9.08±1.18	8.80±1.63	.024
	PCV-VG	8.92±1.35	10.00±1.32^{a}	9.92±1.46^{a}	8.84±1.90$^{b.c}$	.001
	P	.422	.317	.031	.937	
PaO_2	VCV	135.55±33.07	137.80±27.19	148.13±30.28	144.46±33.60	.262
	PCV-VG	145.24±25.62	143.74±28.05	143.15±27.26	137.61±26.24	.376
	P	.253	.451	.544	.426	
$PaCO_2$	VCV	36.72±4.72	34.94±4.73^{a}	36.74±4.59$^{a.b}$	36.89±4.26^{c}	.092
	PCV-VG	34.78±3.15	33.59±3.42^{a}	36.69±4.52^{b}	37.19±4.23^{c}	.092
	P	.095	.254	.968	.804	
SaO_2	VCV	97.90±1.91	98.12±1.89	98.39±1.38	98.12±1.50	.521
	PCV-VG	98.66±1.05	98.43±1.35	98.29±1.72	98.28±1.16	.476
	P	.902	.506	.822	.692	
Htc	VCV	43.33±7.33	42.09±6.93^{a}	40.54±6.26$^{a.b}$	40.47±6.94^{a}	.002
	PCV-VG	42.90±4.77	41.06±5.79^{a}	39.11±4.26^{a}	39.00±5.04$^{a.b}$	<.001
	P	.806	.571	.350	.397	
SBP	VCV	124.12±20.83	109.64±20.46^{a}	114.68±20.42	122.44±23.81$^{b.c}$	.019
	PCV-VG	119.32±21.19	112.24±21.63	110.64±19.09	125.96±22.64$^{b.c}$	.012
	P	.423	.664	.474	.595	
DBP	VCV	73.40±11.86	65.24±11.73^{a}	67.84±12.84	71.60±13.98^{b}	.020
	PCV-VG	73.08±13.84	65.52±10.82^{a}	64.72±12.26^{a}	72.96±14.59$^{b.c}$	.008
	P	.930	.930	.384	.738	
Nabız	VCV	80.48±14.55	76.00±19.18^{a}	70.80±12.54^{a}	79.32±15.20^{c}	.013
	PCV-VG	83.20±12.77	75.88±11.66^{a}	75.04±10.55^{a}	77.20±15.22^{a}	.008
	P	.486	.979	.202	.625	

Data expressed with mean±SD, PaO2; Partial oxygen pressure, PaCO2; Partial carbon dioxide pressure, SaO2; Oxygen saturation, Htc; hematocrit, SBP; systolic blood pressure, DBP; diastolic blood pressure.

[a] Significant difference between T1 and other time intervals.

[b] Significant difference between T2 and other time intervals

[c] Significant difference between T3 and other time intervals

The lack of significant difference in hemodynamic parameters such as SBP, DBP, and pulse was similar to previous studies. In a meta-analysis study by Han et al., which included randomized controlled studies, it was shown that there was no significant difference between groups in hemodynamic parameters, similar to our study. [8-9] The omission of the recruitment manoeuvres can be considered a limitation of the study.

CONCLUSION

VCV and PCV-VG are two important modes of mechanical ventilation, each offering advantages for specific clinical situations. While VCV is a simple mode that guarantees constant volume, PCV-VG is a more complex but potentially safer option with pressure limitation and the ability to adapt to dynamic fit. Clinical results vary depending on the individual patient's condition, respiratory mechanics and hemodynamic stability. Therefore, a patient-specific ventilation strategy should be developed, taking into account the advantages and disadvantages of both modes.

Ethics Committee Approval: Ethics committee approval was obtained from Atatürk University Local Ethics Committee (Date: 29.09.2022, Number: 2022/609))
Informed Consent: Patient consent form was achieved.
Peer-review: Externally peer-reviewed.
Author Contributions: Concept- ECÇ, ENMK; Design- ECÇ, ENMK,VK; Supervision- ECÇ, ENMK; Resources- VK,KG; Data Collection and/or Processing- ENMK,VK,KG; Analysis and/or Interpretation- ECÇ, ENMK; Literature Search- ENMK; Writing Manuscript- ENMK; Critical Review- ECÇ;
Conflict of Interest: The authors have no conflicts of interest to declare.
Financial Disclosure: The authors declared that this study has received no financial support.

Etik Komite Onayı: Etik kurul onayı Atatürk Üniversitesi Yerel Etik Kurul Başkanlığı'ndan (Tarih:29.09.2022, Sayı:2022/609) alınmıştır.
Hasta Onamı: Tüm hastalardan aydınlatılmış hasta onamı alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir- ECÇ, ENMK; Tasarım- ECÇ, ENMK,VK; Denetleme- ECÇ, ENMK; Kaynaklar- VK,KG; Veri Toplanması ve/veya İşlemesi- ENMK,VK,KG; Analiz ve/ veya Yorum- ECÇ, ENMK; Literatür Taraması- ENMK; Yazıyı Yazan- ENMK; Eleştirel İnceleme- ECÇ;
Çıkar Çatışması: Yazarlar, çıkar çatışması olmadığını beyan etmiştir.
Finansal Destek: Yazarlar, bu çalışma için finansal destek almadığını beyan etmiştir.

REFERENCES

1. Cohen E. Physiology of the lateral position and one-lung ventilation. *Chest Surg Clin N Am*. 1997;7(4):753-771.
2. Assad OM, El Sayed AA, Khalil MA. Comparison of volume-controlled ventilation and pressure-controlled ventilation volume guaranteed during laparoscopic surgery in Trendelenburg position. *J Clin Anesth*. 2016;34:55-61. doi:10.1016/j.jclinane.2016.03.053
3. Toker MK, Altıparmak B, Uysal Aİ, Demirbilek SG. [Comparison of pressure-controlled volume-guaranteed ventilation and volume-controlled ventilation in obese patients during gynecologic laparoscopic surgery in the Trendelenburg position]. *Brazilian J Anesthesiol*. 2019;69(6):553-560. doi:10.1016/j.bjan.2019.09.003
4. Song SY, Jung JY, Cho MS, Kim JH, Ryu TH, Kim B Il. Volume-controlled versus pressure-controlled ventilation-volume guaranteed mode during one-lung ventilation. *Korean J Anesthesiol*. 2014;67(4):258-263. doi:10.4097/kjae.2014.67.4.258
5. Dion JM, McKee C, Tobias JD, et al. Ventilation during laparoscopic-assisted bariatric surgery: volume-controlled, pressure-controlled or volume-guaranteed pressure-regulated modes. *Int J Clin Exp Med*. 2014;7(8):2242-2247.
6. Bao C, Cao H, Shen Z, et al. Comparison of volume-controlled ventilation, pressure-controlled ventilation and pressure-controlled ventilation-volume guaranteed in infants and young children in the prone position: A prospective randomized study. *J Clin Anesth*. 2024;95:111440. doi:10.1016/j.jclinane.2024.111440
7. Aldenkortt M, Lysakowski C, Elia N, Brochard L, Tramèr MR. Ventilation strategies in obese patients undergoing surgery: a quantitative systematic review and meta-analysis. *Br J Anaesth*. 2012;109(4):493-502. doi:10.1093/bja/aes338
8. Lee JM, Lee SK, Kim KM, Kim YJ, Park EY. Comparison of volume-controlled ventilation mode and pressure-controlled ventilation with volume-guaranteed mode in the prone position during lumbar spine surgery. *BMC Anesthesiol*. 2019;19(1):133. doi:10.1186/s12871-019-0806-7
9. Han J, Hu Y, Liu S, Hu Z, Liu W, Wang H. Volume-controlled ventilation versus pressure-controlled ventilation during spine surgery in the prone position: A meta-analysis. *Ann Med Surg*. 2022;78:103878. doi:10.1016/j.amsu.2022.103878