ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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Comparison of Pressure Controlled and Volume Controlled Ventilation in Morbidly Obese Patients Underwent Laparoscopic Sleeve Gastrectomy: A Randomized Controlled Trial

Laparoskopik Sleeve Gastrektomi Uygulanan Morbid Obez Hastalarda Basınç Kontrollü ve Hacim Kontrollü Ventilasyonun Karşılaştırılması: Randomize Kontrollü Bir Çalışma

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ABSTRACT Objective: To compare the influence of pressure controlled ventilation (PCV) and the volume controlled ventilation (VCV) on blood gas and respiratory mechanics during the operation in morbidly obese patients who underwent laparoscopic sleeve gastrectomy. **Material and Methods:** One hundred patients who had a body mass index above 35 were divided into PCV (Group A) and VCV groups (Group B). Heart rate, mean arterial pressure, SpO_2, end-tidal CO_2, tidal volume, frequency, Ppeak, Pplateau, compliance values were recorded at baseline, in every 15 minutes after the CO_2 insufflation and at 15th minute after the termination of the insufflation for each patient. Arterial blood gas samples were obtained at baseline, in the 15th and 60th minutes after the insufflation and at 15th minute after the termination of the insufflation. **Results:** The mean levels of Ppeak and Pplateau were significantly lower in Group A than Group B in all measurement points. The PCV also increased compliance at 15th min of insufflation and at the end of operation. There was no significant difference between the groups regarding the mean values of pH, PaO_2, PCO_2, HCO_3, BE, PAO_2-PaO_2. **Conclusion:** In laparoscopic sleeve gastrectomy, the PCV mode decreased Ppeak and Pplateau levels and increased compliance. The PVC found to have an advantage to VCV during the perioperative period.

Keywords: Obesity; laparoscopy; gastrectomy; ventilation strategy

ÖZET Amaç: Laparoskopik sleeve gastrektomi uygulanan morbid obez hastalarda, operasyon sırasında uygulanan basınç kontrollü ventilasyon (BKV) ve hacim kontrollü ventilasyonun (HKV) kan gazı ve solunum mekaniği üzerindeki etkisini karşılaştırmak. **Gereç ve Yöntemler:** Beden kitle indeksi 35'ten fazla olan 100 hasta BKV (Grup A) ve HKV (Grup B) gruplarına ayrıldı. Kalp atım hızı, ortalama arter basıncı, SpO_2, end-tidal CO_2, tidal hacim, frekans, Ppeak, Pplateau ve kompliyans değerleri başlangıçta, CO_2 insüflasyonu sonrası her 15 dk'da bir ve insüflasyonun sona ermesinden sonraki 15. dk'da kaydedildi. Arteriyel kan gazı örnekleri başlangıçta, insüflasyondan sonraki 15. ve 60. dk'larda ve insüflasyonun sona ermesinden sonraki 15. dk'da alındı. **Bulgular:** Ortalama Ppeak ve Pplateau seviyeleri, tüm ölçüm noktalarında Grup A'da Grup B'den anlamlı derecede düşüktü. BKV ayrıca insüflasyonun 15. dk'sında ve operasyon sonunda kompliyansı artırdı. PH, PaO_2, PCO_2, HCO_3, BE, PAO_2-PaO_2 ortalama değerleri açısından gruplar arasında istatistiksel olarak anlamlı fark yoktu. **Sonuç:** Laparoskopik sleeve gastrektomide BKV modunda düşük Ppeak ve Pplateau seviyeleri ve artmış kompliyans değerleri gözlendi. BKV modunun perioperatif dönemde HKV'ye göre avantaj sağladığı saptandı.

Anahtar Kelimeler: Obezite; laparoskopi; gastrektomi; ventilasyon stratejisi

In recent years, there is a serious increase in the incidence of obesity and bariatric surgery performed in the obese patients. For sleeve gastrectomy, laparoscopic surgical technique is preferred due to its low surgical and metabolic complications.[1]

The CO_2 insufflation and consequential increase of the intraabdominal pressure cause respiratory changes during the laparoscopic surgery. In addition, $PaCO_2$, inspiratory pressure, intrathoracic pressure increase and vital capacity, functional residual ca-

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pacity (FRC) and compliance decrease during the operation.[2-5] Considering the changes related to the laparoscopic surgery together with the respiratory changes related to the obesity, the perioperative ventilation strategies become important.[6] Pressure controlled ventilation (PCV) and volume controlled ventilation (VCV) modes are two possible modes that can be used. Each mode has its own advantages and disadvantages.[1] The VCV provides a pre-determined tidal volume (TV) and minute volume safety. However, high ventilator pressure carry a risk of lung damage. In contrast, PCV restricts the maximum respiratory tract pressure applied to the lung and allow clinician to titrate the pressure according to measured TV. However, with PCV, TV and minute volume may become unstable.[7] Besides, the most important difference between PCV and VCV is the flow pattern in which PCV uses decelerating flow. Some previous reports indicated that PCV might provide a lower respiratory work and a better comfort. Two meta-analyses resulted that ideal ventilations strategy in obesity surgery cannot be defined from existing literature.[7,8] Recent reports published in last years also highlighted ongoing need of well-designed studies to clarify the best strategy for subjects that underwent laparoscopic obesity surgery.[7]

In the present study, our objective was to compare the PVC and VCV mode on respiratory mechanics and blood gas composition during the operation in morbidly obese patients, who underwent a laparoscopic sleeve gastrectomy.

MATERIAL AND METHODS

This prospective, randomized study was conducted at Şişli Hamidiye Etfal Training and Research Hospital after the approval of the local ethics committee (Approval number: 431, Approval date: 17.03.2015). All participating patients signed an informed patient consent form. All procedures performed in the present study were made in accordance with the ethical standards of the Helsinki Declaration (2008).

SAMPLE SIZE CALCULATION

The sample size was calculated with G*Power v3.1.7 (Heinrich-Heine-Universität-HHU). Based on Toker et al.'s study, Pplateu levels, the effect size was calculated as 0.608.[9] For 0, 80 power with 0.05 error margin the number of patients for each group was calculated as 50 (100 total).

RANDOMIZATION

A consecutive randomization of the patients was performed.

INCLUSION AND EXCLUSION CRITERIA

Patients between the ages of 18 and 60 years, who had an American Society of Anesthesiologists (ASA) physical status I-III, a body mass index (BMI) above 35 and will undergo a laparoscopic sleeve gastrectomy, were included in the study. Patients, who did not give consent for the participation, who had severe restrictive or obstructive lung disease (presence of the values below 70% in the flow or volume pulmonary function tests), advanced stage heart failure, neuropsychiatric disorder, peripheral artery disorder and BMI under 35 were excluded from the study.

PREOPERATIVE EVALUATION

All patients underwent respiratory function tests and echocardiography before the surgery. Respiratory physiotherapy was initiated 5 days before the operation. Demographic characteristics such as age, BMI, gender were recorded. None of the patients received premedication.

STANDARD ANESTHETIC CARE IN OPERATING ROOM

In the operating room, the patients were monitored with electrocardiography (ECG-D2 derivation), noninvasive arterial pressure (AP) and oxygen saturation (SpO_2). A venous access was established with a 20 gauge cannula (Angiocut) and hydration was initiated. The preoxygenation of the patient was done with a facial mask for 3 minutes. A standard anesthesia protocol consisting of fentanyl (1 $\mu g.kg^{-1}$), propofol (2 $mg.kg^{-1}$) and rocuronium (0.6 $mg.kg^{-1}$) was administered. Doses were administered according to the ideal body weight calculation (IBW: For males: 50+0.91x (height cm-152.4) and for females: 45.5+0.91x (height cm-152.4). Sevoflurane (2%) and remifentanil (0.25 $\mu g.kg^{-1} min^{-1}$) were used for maintaining the anesthesia. Muscle relaxation was obtained with administration of rocuronium (0.15

mg.kg^{-1}) bolus doses. Response to rocuronium was checked from adductor policis muscle (at<2 twitches) by using a train-of-four sequence in every 5 minutes. The intubation was done in supine position. For the operation patient position was changed to 30° head-up position. All operations were done from same surgical team. Intra-abdominal pressure was kept in 15 mmHg pressure. End-tidal CO_2 monitorization was performed. For an invasive AP monitorization, radial artery cannulation was carried out after the Allen test. Arterial blood gas samples were obtained.

VENTILATION DYNAMICS-GROUP A

Ventilation was implemented with PCV mode following the intubation. An inspiratory pressure (Pins) was so adjusted that the TV was 8 mL/kg IBW. Frequency (f) was adjusted to 14 R/min. The positive end expiratory pressure (PEEP) level was 5 cmH_2O, FiO_2 was 0.5 and inspiratory to expiratory time was 1:2. The targeted end-tidal CO_2 level was 35-45 mmHg. If the end-tidal $CO_2$was elevated, the frequency was increased 2 R/min. If this was not sufficient, Pins increased about 2 cmH_2O.

VENTILATION DYNAMICS-GROUP B

Ventilation was implemented with VCV mode following the intubation. TV was adjusted to 8 mL/kg according to the IBW and the frequency (f) was adjusted to 14 R/min. The PEEP level was 5 cmH_2O, FiO_2 was 0.5 and inspiratory to expiratory time was 1:2. The targeted end-tidal CO_2 level was 35-45 mmHg. If the end-tidal CO_2 was elevated, the frequency was increased 2 R/min. If this was not sufficient, TV was increased to 10 mL/kg IBW.

Heart rate (HR), mean arterial pressure (MAP), SpO_2, end-tidal CO_2, TV, f, Ppeak, Pplateau values of both groups were recorded as the baseline values. Following the referral of the patients to surgery, HR, MAP, SpO_2, end-tidal CO_2, TV, Ppeak, Pplateau and compliance values were recorded in every 15 minutes between the 15th and 60th minutes after the CO_2 insufflation and at 15th minute after the termination of the insufflation at the end of the surgical procedure. The insufflation pressure levels were recorded simultaneously.

Arterial blood gas samples were obtained at 15th and 60th minutes after the insufflation and at 15th minute after the termination of the insufflation. pH, PaO_2, $PaCO_2$, HCO_3 and BE levels were recorded in each blood gas analysis. The alveolar-arterial oxygen gradient (PAO_2-PaO_2) was calculated and recorded.

After the operation had been completed, the antagonisation of the neuromuscular blockade was ensured with an appropriate dose of Sugammadex according to the IBW. The tube was removed in patients with spontaneous respiration and sufficient respiratory tract reflexes. Patients with an Aldrete Recovery Score equal to or greater than nine were considered as “recovered” and referred to the recovery room.

The duration of the anesthesia (the time between the induction and the recovery), duration of the operation (the time between the skin incision and final suturing) and the duration of the insufflation (time between the start and the termination of the CO_2 insufflation) were recorded.

All complications related to the anesthesia or surgery were recorded.

STATISTICAL ANALYSIS

Statistical analyses were performed with software package SPSS v15.0 for Windows. Descriptive statistics were analyzed for the numeric variables as mean, standard deviation, minimum and maximum values. Considering two independent groups, the comparison of numeric variables was done with Student’s t-test if a normal distribution was provided and with Mann-Whitney U test if a normal distribution was not provided. In the dependent group, as the differences of the numeric variables did not provide a normal distribution, the analysis was performed with Freedman method. All group analyses were carried out with Wilcoxon test method. Subgroup analyses were interpreted with Bonferroni correction method. In groups, the proportions were analyzed with Chi-square test. Statistical significance was accepted at $p<0.05$.

RESULTS

CONSORT diagram of the study was presented in Figure 1. One hundred patients were evaluated in the

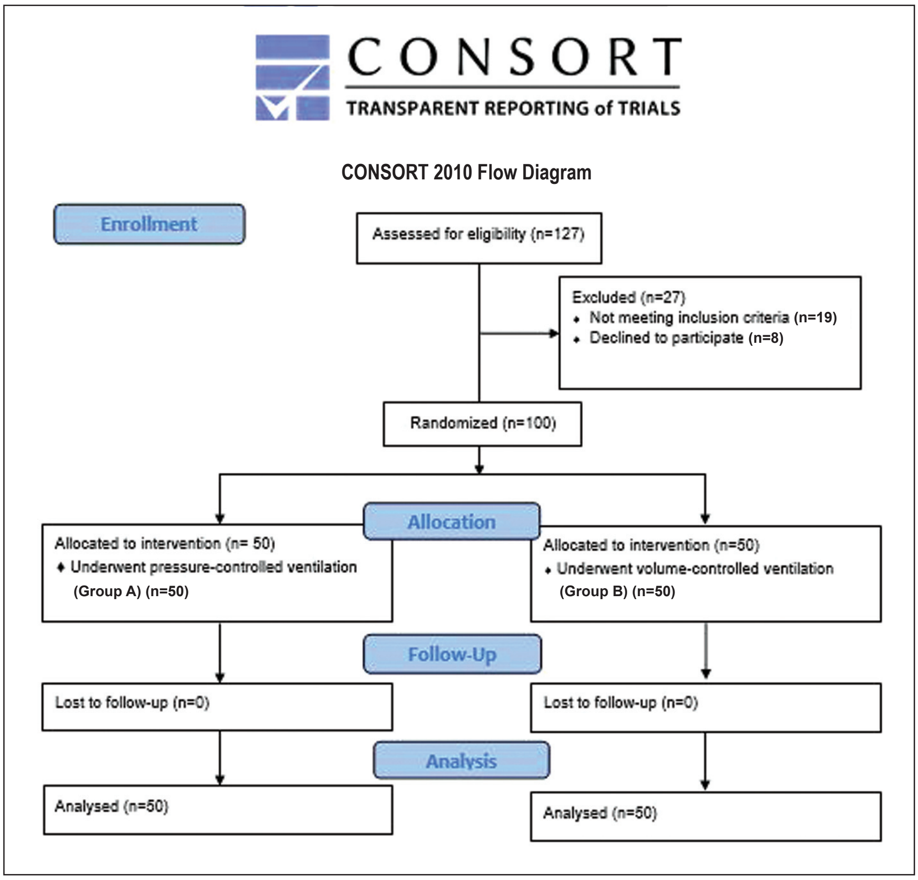

FIGURE 1: CONSORT diagram of the study.

study. There was no statistically significant difference between groups A and B regarding the gender, ASA distribution, BMI, mean duration of operation, anesthesia, and insufflation ($p>0.05$ for all comparisons) (Table 1). No complication was observed in the patients.

Among the comparisons, HR at 45th minute after insufflation was significantly high in Group A. (86.5 bpm for group A and 81.1 bpm for Group B, $p=0.039$). The MAP at the termination of the insufflation was significantly high in Group B (91.6 mm/Hg for Group A and 97.8 mm/Hg for Group B, $p=0.038$). The mean ventilation frequency values at 60th minute after the insufflation were significantly higher in Group A (14.1 b/m for Group A and 13.4 b/m for Group B, $p=0.007$). The mean compliance values were significantly higher in group A at 15th minute after the insufflation and at the termination of the insufflation compared to Group B (at 60th minute of insufflation 30.8 mL/cmH_2O for Group A and 29.3 mL/cmH_2O for Group B, $p=0.041$, at the end of insufflation 45.8 mL/cmH_2O for Group A and 39.5 mL/cmH_2O for Group B, $p=0.003$ respectively). Other comparisons for HR and MAP were not significant at relevant time points. The TV measurements and mean insufflation pressure levels did not show a significant difference between groups ($p>0.05$ for all comparisons) (Table 2).

The mean Ppeak values were significantly lower in Group A in all measurements ($p<0.001$). The mean Ppeak values were significantly higher between 15th minute and 60th minute after the insufflation compared to the baseline values in both groups ($p<0.001$). The Ppeak values decreased significantly between 60th minute after the insufflation and termination of the insufflation in both groups ($p<0.001$) (Table 3).

The mean Pplateau values were significantly lower in Group A in all measurements ($p<0.001$, $p=0.004$) (Table 2). The mean Pplateau values were

TABLE 1: Demographic data and time intervals of the study that compare pressure controlled and volume controlled anesthesia in morbidly obese patients underwent sleeve gastrectomy.

		Group A		Group B		
		n	%	n	%	p value
Sex	Male	23	46.0	24	48.0	1.000
	Female	27	54.0	26	52.0	
		Mean±SD	Minimum-Maximum	Mean±SD	Minimum-Maximum	
Age (year)		37.5±11.9	19-66	39.3±10.5	18-57	0.428
BMI		46.6±5.7	40-65	48.5±6.6	40-68.8	0.127
Anesthesia duration (min)		114.7±18.7	80-155	116.3±13.2	90-155	0.605
Operation duration (min)		89.3±17.8	55-135	85.4±14.7	55-120	0.328
Insufflation duration (min)		70.8±16.5	45-110	67.2±13.1	45-115	0.512

BMI: Body mass index; SD: Standard deviation.

significantly higher between 15^{th} minute and 60^{th} minute after the insufflation compared to the baseline values in both groups ($p<0.001$). The Pplateau levels decreased significantly between 60^{th} minute after the insufflation and termination of the insufflation in both groups ($p<0.001$). In Group A, the mean Ppleteau level decreased significantly at the termination compared to the baseline ($p=0.002$) (Table 3).

There was no statistically significant difference between the groups regarding the SpO_2, end-tidal CO_2, pH, PaO_2, HCO_3, BE, PAO_2-PaO_2 levels. For $PaCO_2$ values the mean $PaCO_2$ values at the termination of the insufflation were significantly higher in Group B (38.2 for Group A and 39.8 for Group B, $p=0.042$) (Table 4).

DISCUSSION

In a randomized comparative setting on 100 subjects, we compared the influence of the PCV and VCV on respiratory and blood gas parameters in morbidly obese patients who will undergo laparoscopic sleeve gastrectomy. Our results indicate that PCV can provide sufficient ventilation and oxygenation with lower pressure levels compared to VCV. The main finding of our study is that PCV resulted with low Ppeak and Pplateau measurements in all measurement points. The PCV also increased compliance at 15^{th} min of insufflation and at the end of the operation.

In our study, hemodynamic parameters (HR and MAP) were comparable in both ventilation modes. We did not detect any difference between two groups in respect of SPO_2 and end-tidal CO_2. The reason for that might be the implementation of the mechanic ventilation changes, which will provide sufficient ventilation and oxygenation. Regarding the respiratory mechanics, comparable TV was ensured in the PCV group with lower respiratory tract pressures. Moreover, the compliance was higher in PCV group at 15^{th} minute after the insufflation and after the termination of the insufflation compared to VCV group which will also be regarded as an advantage for PCV.

In our study, considering the arterial blood gas analysis, the levels of pH, PaO_2, $PaCO_2$ and PAO_2-PaO_2 were comparable in both groups but they were achieved with lower respiratory tract pressures in PVC group. The blood gas analysis performed after the termination of the insufflation showed that $PaCO_2$ level was higher in VCV group.

VCV and PCV have different control variables.[9] VCV provides a pre-determined TV and minute volume safety. However, optimal adjustment of inspiratory flow, flow waveform and inspiration time by the clinician is required. During VCV, as a response to the increased pressure in the respiratory tract, compliance decreases, resistance increases and the risk of lung damage caused by the ventilator may increase.

The PCV restricts the maximum respiratory tract pressure applied to the lung but the TV and minute volume become unstable. During PCV, the clinician will titrate the inspiration pressure according to the

TABLE 2: Comparison of hemodynamic and ventilation parameters between groups.

		Group A			Group B			
		n	Mean	SD	n	Mean	SD	p value
Heart rate (beats per minute-bpm)	Beginning	50	87.5	13.5	50	87.4	12.2	0.603
	Insf 15.min	50	84.0	14.6	50	80.9	12.6	0.259
	Insf 30.min	50	84.9	13.7	50	83.3	13.1	0.536
	Infl 45. min	50	86.5	13.4	50	81.1	12.0	**0.039**
	Insf 60. min	38	82.0	15.8	38	80.2	10.1	0.558
	Insf End	50	79.9	13.1	50	78.1	11.4	0.452
Mean arterial pressure (mmHg)	Beginning	50	83.8	12.7	50	85.6	18.2	0.937
	Insf 15.min	50	87.4	15.2	50	89.8	16.3	0.438
	Insf 30.min	50	88.2	14.0	50	90.2	15.3	0.511
	Infl 45. min	50	89.3	13.0	50	91.4	13.4	0.428
	Insf 60. min	38	88.4	12.9	38	89.5	14.9	0.731
	Insf End	50	91.6	15.4	50	97.8	14.3	**0.038**
Tidal volume (mL/min)	Beginning	50	653.3	91.2	50	644.0	66.3	0.559
	Insf 15.min	50	634.9	98.0	50	642.5	83.8	0.849
	Insf 30.min	50	625.2	100.9	50	643.4	106.2	0.209
	Infl 45.min	50	632.0	86.4	50	643.5	107.2	0.228
	Insf 60. min	38	636.0	68.7	38	655.8	70.8	0.218
	Insf End	50	652.3	83.6	50	657.5	69.1	0.736
Ventilation frequency (breaths/minute. b/m)	Beginning	50	12.1	1.2	50	11.9	0.7	0.408
	Insf 15.min	50	13.5	0.8	50	13.2	0.9	0.078
	Insf 30.min	50	13.8	1.0	50	13.3	1.0	0.058
	Infl 45.min	50	13.7	0.9	50	13.4	0.9	0.081
	Insf 60.min	38	14.1	1.2	38	13.4	0.8	**0.007**
	Insf End	50	11.9	1.0	50	11.9	0.7	0.934
Compliance (mL/cmH_2O)	Beginning	50	42.4	11.1	50	39.4	10.3	0.085
	Insf 15.min	50	30.8	6.0	50	29.3	7.2	**0.041**
	Insf 30.min	50	30.6	6.5	50	28.6	6.4	0.052
	Infl 45.min	50	31.4	6.4	50	29.3	7.5	0.127
	Insf 60. min	39	30.5	4.4	38	29.5	6.0	0.203
	Insf End	50	45.8	11.1	50	39.5	8.9	**0.003**
Insufflation pressure (mmHg)	Beginning	50	0.0	0.0	50	0.0	0.0	1.000
	Insf 15.min	50	14.6	1.9	50	14.7	2.2	0.675
	Insf 30.min	50	14.7	1.8	50	15.3	2.0	0.119
	Infl 45.min	50	14.5	1.8	50	14.9	2.0	0.202
	Insf 60. min	39	14.9	2.0	38	15.4	2.0	0.296
	Insf End	50	0.00	0.00	50	0.00	0.00	1.000

SD: Standard deviation.

measured TV, but the inspiratory flow and flow waveform tend to preserve a square inspiratory pressure profile. The most important difference between PCV and VCV is the flow pattern. PCV uses decelerating flow. Therefore, some investigators suggested that PCV might provide a lower respiratory work and a better comfort.[10] The superiority of the PCV on VCV was demonstrated for the supply of the sufficient oxygenation and normocapnia in obese patients, who were diagnosed with ARDS in intensive care units. In addition, it was emphasized that hemodynamics might proceed more stable in PCV as a result of the limitation of the pressure.[11,12]

TABLE 3: Changes in the Ppeak and Pplateau between groups.

		Group A			Group B			
		n	Mean	SD	n	Mean	SD	p value
Ppeak (cmH_2O)	Beginning	50	21.8	3.9	50	25.1	4.3	**<0.001**
	Insf 15.min	50	26.9	3.7	50	31.1	4.4	**<0.001**
	Insf 30.min	50	26.7	3.1	50	31.6	4.2	**<0.001**
	Infl 45. min	50	26.9	3.1	50	31.5	4.3	**<0.001**
	Insf 60. min	37	27.4	2.9	38	31.1	4.3	**<0.001**
	Insf End	50	21.0	3.0	50	25.2	3.4	**<0.001**
	p value		**<0.001**			**<0.001**		
Pplateau (cmH_2O)	Beginning	50	21.3	3.9	50	23.5	4.6	**0.004**
	Insf 15.min	50	25.7	3.4	50	28.8	4.5	**<0.001**
	Insf 30.min	50	25.6	3.0	50	29.5	4.4	**<0.001**
	Infl 45. min	50	25.7	3.1	50	29.4	4.2	**<0.001**
	Insf 60.min	38	26.3	2.7	38	29.4	4.6	**<0.001**
	Insf End	50	20.3	2.9	50	23.6	3.6	**<0.001**
	p value		**<0.001**			**<0.001**		

The dependent groups, subgroups analyses	Group A	Group B
	p value	p value
P peak insf 15.min-P peak Beg	**<0.001**	**<0.001**
P peak insf 30.min-P peak Beg	**<0.001**	**<0.001**
P peak insf 45.min-P peak Beg	**<0.001**	**<0.001**
P peak insf 60.min-P peak Beg	**<0.001**	**<0.001**
P peak insf end-P peak Beg	0.009	0.341
P peak insf 30.min-P peak insf 15.min	0.616	0.036
P peak insf 45.min-P peak insf 30.min	0.345	0.532
P peak insf 60.min-P peak insf 45min	0.933	0.422
P peak insf end-P peak insf 60.min	**<0.001**	**<0.001**
Pplateau insf 15.min-Pplateau beginning	**<0.001**	**<0.001**
Pplateau insf 30.min-Pplateau beginning	**<0.001**	**<0.001**
Pplateau insf 45.min-Pplateau beginning	**<0.001**	**<0.001**
Pplateau insf 60.min-Pplateau beginning	**<0.001**	**<0.001**
Pplateau insf end-Pplateau beginning	0.002	0.224
Pplateau insf 30.min-Pplateau insf 15.min	0.924	0.049
Pplateau insf 45.min-Pplateau insf 30.min	0.257	0.742
Pplateau insf 60.min-Pplateau insf 45.min	1.000	0.917
Pplateau insf end-Pplateau insf 60.min	**<0.001**	**<0.001**

SD: Standard deviation; Bonferroni correction method p<0.0055.

Recent studies reported superior outcomes with PCV. Toker et al. compared PCV and VCV on 104 patients.[9] Patients who underwent laparoscopic hysterectomy were evaluated. The PCV resulted with a significant decrease in Ppeak, Pmean, Pple-tau values. The PCV also increased dynamic compliance and resulted with better mean PaO_2 levels. Ozyurt et al. compared PCV and VCV on 62 subjects underwent sleeve gastrectomy.[13] The PCV resulted with a significant decrease in peak airway pressures however no significant difference was reported for other respiratory as well as blood gas parameters. Hans et al. conducted a comparative study between PCV and VCV on 40 subjects who under-

TABLE 4: Comparison of arterial blood gas analyses between groups.

		Group A			Group B			
		n	Mean	SD	n	Mean	SD	p value
SPO_2 (%)	Beginning	50	99.2	1.1	50	98.9	1.6	0.448
	Insf 15.min	50	99.1	1.2	50	98.8	1.8	0.440
	Insf 30.min	50	99.2	1.1	50	98.9	1.4	0.398
	Infl 45. min	50	99.3	0.9	50	98.9	1.3	0.277
	Insf 60. min	39	99.6	0.6	38	99.2	1.1	0.290
	Insf End	50	99.6	0.8	50	99.3	1.1	0.182
End-tidal CO_2 (mmHg)	Beginning	50	29.6	3.2	50	30.3	2.9	0.238
	Insf 15.min	50	31.6	3.7	50	31.5	3.1	0.986
	Insf 30.min	50	31.8	3.8	50	31.7	2.8	0.837
	Infl 45.min	50	31.9	3.4	50	31.9	3.0	0.895
	Insf 60. min	38	32.3	3.5	38	32.1	3.6	0.734
	Insf End	50	31.3	3.7	50	32.4	3.6	0.268
PH	Beginning	50	7.44	0.03	50	7.43	0.04	0.212
	Insf 15.min	50	7.41	0.03	50	7.40	0.03	0.353
	Insf 60. min	37	7.39	0.04	38	7.39	0.04	0.573
	Insf End	50	7.38	0.04	49	7.37	0.03	0.194
PaO_2	Beginning	50	172.8	49.6	50	167.1	37.5	0.523
	Insf 15.min	50	157.3	45.9	50	149.3	40.2	0.360
	Insf 60. min	37	163.7	40.2	38	162.9	38.6	0.954
	End	50	180.2	39.5	50	177.9	41.5	0.759
$PaCO_2$	Beginning	50	35.1	3.8	50	35.2	4.2	0.962
	Insf 15.min	50	37.0	3.1	50	37.1	3.0	0.844
	Insf 60. min	37	37.6	4.0	38	38.7	3.6	0.195
	End	50	38.2	4.2	50	39.8	3.2	0.042
HCO_3	Beginning	50	23.2	1.7	50	22.8	2.0	0.769
	Insf 15.min	50	22.7	1.5	50	22.8	1.1	0.836
	Insf 60. min	37	22.2	1.4	38	22.4	1.1	0.414
	End	50	22.3	1.4	50	22.6	1.1	0.255
BE	Beginning	50	-0.47	1.47	50	-1.04	2.02	0.442
	Insf 15.min	50	-1.46	1.49	49	-1.51	1.42	0.854
	Insf 60.min	37	-2.36	1.40	38	-2.15	1.45	0.522
	End	50	-2.36	1.49	50	-2.36	1.38	0.783
PAO_2-PaO_2	Beginning	48	98.4	4.9	50	99.2	3.0	0.610
	Insf 15.min	48	114.8	123.8	50	96.7	8.8	0.962
	Insf 60.min	35	99.2	2.9	38	99.7	1.8	0.553
	End	48	100.0	0.0	50	99.8	1.1	0.327

SD: Standard deviation.

went gastric bypass.[14] They found that Ppeak values were lower in PCV group, although the other ventilation parameters and $PaCO_2$ and PCO_2 values were comparable in both groups. De Baerdemaeker et al. compared PCV and VCV on 24 subjects who underwent laparoscopic gastric banding operation.[15] The respiratory tract pressures, cardiovascular effects and $PaCO_2$ levels were similar in both ventilation modes. Only PCO_2 levels were lower in VCV group. Dion et al. compared the PCV and VCV with pressure-controlled volume-guaranteed (PCV-VG) ventilation in obese patients, who will undergo laparoscopic surgery.[1] They concluded that PCV-VG and PCV were superior to VCV, because they enabled sufficient TV with lower peak pressures.

There are only a few randomized comparative studies focused on the ventilation strategies in obese patients, who underwent surgery.[7,8] Aldenkortt et al. conducted a meta-analysis covering 13 studies with 505 obese patients and investigated the ventilation strategies in these patients during the perioperative period.[7] They reported that the addition of PEEP to the recruitment maneuver enabled a better oxygenation than the PEEP application alone. However, they did not determine any significant difference between two ventilation modes. They concluded that the perioperative ventilation strategies in obese patients remained uncertain. Wang et al. conducted another meta-analysis on the ventilation of the obese patients and reported that VCV, high PEEP, and recruitment maneuver (for once) increased the compliance, prevented atelectasis and provided better oxygenation.[8]

The recruitment maneuver and PEEP application are one of the discussed subjects among the perioperative ventilation strategies in the obese patients. There were studies showing that they improved the pulmonary compliance. In a recent report, Sumer et al. compared the effect of recruitment maneuvers on 60 subjects. Adding recruitment maneuvers was found superior in improving respiratory mechanics which was reported according to PaO_2, $PaCO_2$ and compliance.[6] However contradictory studies exists that adding recruitment maneuvers might cause atelectasis as a counter-effect.[16] In addition, it is well known that the recruitment maneuver decreases the cardiac output and so causes a drop in the MAP.[17] In our study, we did not perform the recruitment maneuver, but we applied PEEP (5 cmH_2O) to the patients in both groups.

The limitations of our study were adding single type of surgery and excluding patients with obstructive or restrictive respiratory diseases.

CONCLUSION

The PCV was found to be advantageous over VCV, because it provided sufficient ventilation and oxygenation with a lower respiratory tract pressure in the morbidly obese patients during the perioperative period, who will undergo laparoscopic sleeve gastrectomy. Well-designed future studies are needed to clarify ideal ventilation strategy in morbidly obese patients who underwent laparoscopic sleeve gastrectomy.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

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