Original Article

Effect of the prone position on mechanical power in elective surgical patients under general anesthesia

A prospective observational study

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ABSTRACT

الأهداف: تقييم كيفية تأثير الانبطاح على MP أثناء العمليات الجراحية الاختيارية.

المنهجية: أُجريت هذه الدراسة المستقبلية في مستشفى كارادينيز إيريجلي الحكومي في تركيا خلال الفترة من يناير 2024م إلى فبراير 2024م، قمنا بتقييم 76 مريضًا تحت التخدير العام في نقاط زمنية متفاوتة أثناء العملية الجراحية. كما أجرينا تسجيل بيانات ديناميكا الدم والتهوية الميكانيكية وبيانات المختبر.

النتائج: زادت القوة الميكانيكية في الانبطاح في بداية الجراحة. أدى الانتقال إلى الانبطاح في نهاية الجراحة إلى انخفاض في MP. في نهاية الجراحة، وجد أن متوسط MP في أوضاع الاستلقاء والانبطاح أعلى مقارنة بتلك التي تم قياسها في الساعة الأولى من الجراحة. أظهرت القوة الميكانيكية ومؤشر كتلة الجسم (BMI) علاقة إيجابية كبيرة.

الخلاصة: تغييرات الوضعية تؤثر على MP. العودة إلى الانبطاح تزيد من MP. ترتبط الزيادة في مؤشر كتلة الجسم بزيادة في القوة الميكانيكية.

Objectives: To evaluate how the prone position influences mechanical power (MP) during elective surgical procedures.

Methods: In this prospective study carried out at Karadeniz Ereğli Government Hospital, Zonguldak, Turkey, from January 2024 to February 2024, 76 patients under general anesthesia were evaluated at different time points during the surgical procedure. Hemodynamic, laboratory, and mechanical ventilation data were also recorded.

Results: The MP increased in the prone position at the beginning of surgery. Transitioning to the supine position at the end of surgery led to a decrease in MP. At the end of surgery, the mean MP in supine and prone positions was found to be higher compared to those measured in the first hour of surgery. Mechanical power and body mass index (BMI) exhibited a significant positive correlation.

Conclusion: Position changes influence MP. Returning to the prone position increases MP. An increase in BMI is associated with an increase in MP.
ANZCTR Reg. No.: ACTRN12623001281684

Keywords: Mechanical Power, Obesity, Prone Position, Supine Position

Saudi Med J 2024; Vol. 45 (8): 814-820
doi: 10.15537/smj.2024.45.8.20240242

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Received 29th March 2024. Accepted 4th July 2024.

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Depending on the magnitude of mechanical power (MP) applied to the lungs, a broad spectrum of ventilation-associated lung injuries (VILI) may occur, ranging from mechanical breakdown to the development of inflammation in the lung parenchyma (involving macrophages, neutrophils, epithelial cells, or endothelial cell activation).[1,2] Ventilation-associated lung injuries refer to damage caused by positive or negative pressure applied by mechanical ventilation (MV) to the lungs. It refers to lung damage that has been proven to be caused by MV. Barotrauma, atelectotrauma, biotrauma, and oxygen toxicity all contribute to the development of VILI.

Mechanical power is the energy delivered to the respiratory system during MV and represents the amount of energy transferred from the ventilator to the patient per unit of time.[3] Mechanical power is determined by tidal volume (TV), driving pressure (DP), peak pressure, flow rate, respiratory rate (RR), and positive end-expiratory pressure (PEEP), which allows us to evaluate the effect of MV on pulmonary function using a single parameter.[4]

In damaged lungs, such as in acute respiratory distress syndrome (ARDS), the prone position facilitates recruitment to the vertebral regions of the lungs, facilitating a more uniform distribution of ventilation and reducing stress and mechanical ventilator-induced strain by reducing intracycle recruitment/derecruitment.[5] This reduces the risk of developing VILI. When combined with controlled PEEP titration, the prone position helps limit the impact of MP on the lungs.[6]

In the prone position, pressure on the intraabdominal organs, particularly during surgeries close to the thorax, can affect the lung mechanics and hemodynamics due to surgical compression. Turning the patient from the supine to the prone position can lead to an increase in intrathoracic and abdominal pressures, significantly elevating peak airway pressure (Ppeak) and airway resistance, while reducing compliance. Consequently, the prone position may adversely affect MV parameters.[7-9]

When a patient under general anesthesia is placed in the prone position, the absence of free abdominal and chest wall movements results in decreased dynamic lung compliance and an increase in the Ppeak. With reduced lung compliance, a higher airway pressure is required to ensure adequate ventilation.

The prone position has been demonstrated to improve oxygenation in several cases of acute lung injury or ARDS in previous studies.[10] Opening the collapsed dorsal lung areas, achieving more homogeneous ventilation, improving ventilation/perfusion ratios, reducing alveolar shunt volume, increasing functional residual capacity (FRC), and facilitating secretion clearance contribute to enhanced oxygenation. The prone position improves gaseous exchange by correcting the ventral-dorsal transpulmonary pressure gradient, reducing dorsal lung compression, and enhancing lung perfusion. An increase in FRC was observed in the prone position.[11] Although we are familiar with the effects of the prone position on damaged lungs, data on the effect of the prone position and MP on healthy lungs under general anesthesia with MV are limited.

Herein, we aimed to investigate the changes in respiratory mechanics and MP induced by the prone position in patients undergoing elective surgery under general anesthesia.

Methods. This was a prospective observational study, carried out at Karadeniz Ereğli Government Hospital, Zonguldak, Turkey. Patients aged ≥18 years, classified as the American Society of Anesthesiologists (ASA) I, II, and III, scheduled for elective neurosurgery in the prone position, were included in the study from January 2024 to February 2024. Patients with significant organ dysfunction or failure, a history of lung surgery (lobectomy), morbid obesity (body mass index [BMI] of >40), those who refused to participate in the study, and those classified into the ASA of >III risk group were excluded from the study.

Ethical approval was granted by the non-interventional ethics committee of Bülent Ecevit University, Zonguldak, Turkey (2023\12). The research was carried out in compliance with the principles outlined in the Declaration of Helsinki.

Demographic data, weight, height, BMI, ASA score, comorbidities, smoking history, and surgery duration were recorded. Standard ASA monitoring (blood pressure, electrocardiogram, end-tidal carbon dioxide, SpO2, and peripheral body temperature) and invasive arterial pressure measurements were carried out for each participant. After intubation with standard doses of propofol (2 mg/kg Propofol-PF 1%, Polifarma, Turkey), fentanyl (2 mcg/kg Fentanyl Citrate, Abbott Lab., North Chicago, USA), and rocuronium (0.7 mg/kg Muscuron, Kocak Pharma, Turkey), patients were ventilated with volume-controlled ventilation using a TV of 6-8 mL/kg, PEEP of 2-5 cmH2O, I:E ratio of 1:2, RR of 12/min, flow rate of 3 L/min, and FiO2 of 40-50%. Tidal volume was calculated according to the predicted body weight (PBW). In females, PBW was determined using the equation: 45.5+0.91×(height (cm)-152.4), while in males, it was calculated using the equation 50+0.91×(height (cm)-152.4). Endotracheal tube (ETT, Bıçakcılar, Turkey) sizes in our study are 7.5 mm inner diameter for females and 8 mm for males. The initial settings of the ventilator were set by the responsible anesthetist and remained constant throughout the case. Patients were monitored under neuromuscular blockade (maintenance dose with rocuronium at 0.1 mg/kg [Kocak Pharma, Turkey]) without allowing spontaneous respiration. Anesthesia was provided with 2-4% sevoflurane (Forane, Abbott Lab., England) and remifentanil (0.6-1 mcg/kg/h Ultiva, Eczacıbaşı, Turkey) infusions. The ventilatory data were recorded using a MINDRAY WATO EX-65 mechanical ventilator (Pharma Machines, UK).

After endotracheal intubation, hemodynamic, laboratory, and mechanical ventilator data were recorded at 15 minutes (min) in the supine position (T1), 15 min after turning to the prone position (T2), at the first hour in the prone position (T3), hourly until

Disclosure. Authors have no conflict of interests, and the work was not supported or funded by any drug company.

the end of the surgery, at the end of the surgery in the last prone position (T4), and 15 min after returning to the supine position (T5).

According to BMI, the subjects were categorized into 2 groups: one with a BMI of <30 and the other with a BMI of ≥30 (indicating obesity). Mechanical power were compared at specified time points according to BMI groups.

There are several methods for calculating MP. In pressure- or volume-controlled ventilation modes, MP per breath is typically calculated by measuring the area between the curve on the pressure-volume graph and the volume axis (y-axis) using the geometric method, which is considered the gold standard. However, this method can be challenging in practice, leading to the development of calculated formulas incorporating TV, Ppeak, RR, DP, and PEEP for measuring MP.

Studies carried out by Gattinoni et al[12] demonstrate a correlation between MP calculated using the formula developed for volume-controlled ventilation mode and MP measured using the geometric method. After collecting the data, Gattinoni's formula for calculating MP in volume-controlled ventilation was applied: MP = TIDAL VOLUME × RESPIRATORY RATE × 0.098 × [P_PEAK - 1/2 (P_PLATEAU - PEEP)].[12]

Statistical analysis. The data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 23.0 (IBM Corp., Armonk, NY, USA), and SPSS Amos, version 24.0. The normal distribution suitability of the data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. An independent samples t-test was employed for comparing data with a normal distribution between paired groups. The Mann-Whitney U test was utilized for comparing data without a normal distribution between paired groups. Spearman's rho correlation coefficient was applied to investigate the relationship between non-normally distributed continuous parameters, while the Pearson correlation coefficient was used for exploring the relationship between normally distributed continuous parameters. Robust ANOVA test with Bonferroni correction was carried out to compare non-normally distributed data based on position and time. The Wilcoxon test was used to compare non-normally distributed data at 2 different time points, whereas the Friedman test was employed for comparisons involving non-normally distributed data at 3 or more time points. Path analysis was utilized to examine the impact of independent variables on MP in the prone position. Results were presented as mean ± standard deviation (SD) and median (minimum-maximum). Statistical significance was accepted as $p<0.05$.

The study's power analysis was carried out utilizing the G-Power version 3.1.9.7 software package program with an effect size of 0.15 and a statistical power of 0.80 accepting the level of significance of 0.05 for the Friedman test for the estimation of sample size. The estimated sample size was 60 to determine the mean MP. However, we carried out the present study with 76 participants to mitigate potential dropouts and missing data.

Results. A total of 76 patients participated in the study (Table 1). The MP were as follows: 6.6 in the initial position, 7.2 after prone positioning, 7.8 at the first hour of the operation, 7.7 in the prone position at the end of the operation, and 7.1 after supine positioning indicating a significant change in MP with positional alterations ($p<0.01$; Table 2).

Returning to the prone position resulted in an increase in MP, while repositioning from the prone to the supine position after surgery led to a decrease in

Table 1 - Patients' demographics (N=76).

Patients' characteristics	n (%)
Age median, year (IQR)	54 (18-81)
Female gender	38 (50.0)
BMI (kg/m^2), median (IQR)	30.4 (20-39.9)
Predicted body mass, mean±SD	62±9
BMI <30	38 (50.0)
BMI ≥30	38 (50.0)
Operation duration (hour), median (IQR)	4 (1-6)
Current smoker	25 (32.9)
Hypertension	38 (50.0)
Coronary artery disease	11 (14.5)
Diabetes mellitus	21 (27.6)

Values are presented as numbers and percentages (%), median and interquartile range (IQR), or mean ± standard deviation (SD). BMI: body mass index

Table 2 - Differences in mechanical power calculations among different conditions.

Parameters	Difference (95% CI)	Standard deviation	*P*-values
T1-T3	-1.2 (-1.5 - -0.91)†	1.246	<0.001*
T1-T2	-0.65 (-0.9 - -0.54)‡		<0.001**
T5-T4	-0.58 (-0.86 - -0.3)‡		<0.001**

*Dependent samples t test, **Wilcoxon test: †mean difference (95% confidence interval [CI]), ‡median difference (95% CI). T1: 15th minute in the supine position, T2: 15th minute into the first prone position, T3: at the first hour in the prone position, T4: at the conclusion of the surgery in the final prone position, T5: in the final supine position, 15 minutes after return

MP. The mean MP obtained in the supine and prone positions at the beginning of surgery was found to be 6.9, whereas at the end of surgery, the mean MP in the prone and supine positions was determined to be 7.3 (p=0.03). This highlights the relationship between time spent on MV and the increase in MP. However, no statistically significant differences were observed in MP during the time spent in the prone position (p=0.136).

The measured and calculated respiratory mechanics (Pplateau, Ppeak, DP, compliance, and MP) showed significant differences in all 5 conditions (T1, T2, T3, T4, and T5; **Table 3**). When transitioning from the supine to the prone position, MP, Ppeak, Pplateau, and DP significantly increased, while compliance significantly decreased. Moreover, the impact of independent variables on T2 MP was observed through pathway analysis. The T2 DP showed a statistically significant positive effect (p<0.001), indicating that a one-unit change in T2 DP increased T2 MP by 0.0282 units.

When examining the relationship between BMI and MP, a positive correlation was found under all conditions and at all data collection intervals (p<0.05).

In the 2 groups classified according to BMI, a significant difference in MP was found across all positions and data collection points. Mean MP was higher in the obese group compared to the non-obese group (p<0.05; **Table 4**). However, when examining the effect of obesity on the change in MP with position, no differences were observed under any condition (**Table 5**).

In the non-obese group, median values of T2 MP-T1 MP and T4 MP-T5 MP were similar (p=0.604). Similarly, in the obese group, no difference was observed between the median values of T2 MP-T1 MP and T4 MP-T5 MP (p=0.279).

A statistically significant negative correlation was observed between the PaO2/FiO2 ratio, PaO2, and mean arterial pressure (MAP) levels throughout the study (T1-5). Turning to the prone position increased MAP levels under general anesthesia. However, it led to a decrease in the PaO2/FiO2 ratio and PaO2 levels. This can be explained by the use of anesthetic agents and surgical conditions in healthy lungs. Additionally, a statistically significant negative correlation was found between T2 MP and temperature (r= -0.24, p=0.047), PaO2/FiO2 (r= -0.39, p=0.001), SpO2 (r= -0.32, p=0.006), and PaO2 (r= -0.04, p=0.001). Although evaluating the effect of the prone position using a single oxygenation index and determining a cut-off value is limited, we determined a cut-off at T2 MP to be 6.66 when PaO2/FiO2 was of <300 (AUC: 0.681, p=0.014).

Discussion. A limited number of studies have assessed changes in MP based on patient position. These studies generally focused on compromised lungs, particularly in conditions such as ARDS.[13] Mechanical power has the potential to become one of the parameters of protective ventilation not only in critically ill patients monitored in the intensive care unit or those with ARDS, but also in healthy lungs. We examined the effect of the prone position on MP in elective cases under general anesthesia. Additionally, the effect of obesity on MP was examined in a subgroup analysis.

In a study carried out under general anesthesia during laparoscopic surgery, patients were grouped based on BMI, and MP was examined during the intubation, pneumoperitoneum, Trendelenburg, and releasing pneumoperitoneum positions.[14] This study investigated different components of MP (total respiratory system and lung power) during MV. Dissipated power, particularly in obese individuals, increased with BMI and was influenced by specific surgical conditions, such as Trendelenburg. These findings emphasize the necessity to consider both patient characteristics and surgical factors when assessing the energetics of MV at various stages of surgery. Moreover, when compared with total MP, dissipated power density was more strongly associated with the risk of postoperative pulmonary complications (PPC).[14] In the same study, an increase in the MP paralleled an increase in the BMI, especially in the supine position. The use of pneumoperitoneum and the steep Trendelenburg position increased the MP. However, some of these energetic forces were decreased by partitioning into the lungs to balance the forces of the surgical conditions. After repositioning the patient to the supine position and releasing the pneumoperitoneum, the patients showed an increase in MP compared with their initial values.[14] In our study, MP also varied with position, notably increasing in the prone position. Additionally, MP was found to be higher at all evaluated time points in the obese group. These findings underscore the impact of position and body habitus on the MP applied to the lungs under surgical conditions. However, the patients were not monitored for PPC, and the different bioenergetics of MP were not evaluated. Nevertheless, because of the positive effects of the prone position on respiratory mechanics, we did not observe any intraoperative respiratory distress. The measured MP at the beginning of the surgery showed an increase compared to the final MP, indicating an increase over time.

In patients with ARDS, maintaining the MP below 12 J/min is recommended, whereas in non-ARDS patients, the suggested limit is <17 J/min.[15] The normal

Table 3 - Comparison of quantitative parameters according to conditions.

Parameters	T1	T2	T3	T4	T5	*P*-values*
MP (J/min)	6.57±1.3 6.57 (3.81-11.39)	7.17±1.25 7.1 (4.38-11.05)	7.77±1.36 7.52 (4.56-11.11)	7.64±1.51 7.49 (4.58-15.52)	7.1±1.48 6.91 (3.69-13.03)	<0.001
P peak (cmH_2O)	17.06±3.81 17 (11-30)	19.25±3.83 19 (12-31)	20.94±4.12 20 (12-31)	20.25±3.47 20 (12-29)	18.04±3.9 18 (9-27)	<0.001
P plateau (cmH_2O)	16.66±3.78 17 (10-30)	18.79±3.8 18 (12-30)	20.38±3.96 20 (11-30)	19.69±3.35 20 (11-28)	17.63±4.36 17 (8-32)	<0.001
DP (cmH_2O)	11.77±3.81 12 (5-27)	13.94±3.86 13 (8-27)	15.52±3.93 15 (6-25)	14.76±3.32 15 (6-23)	12.56±4.05 12 (3-24)	<0.001
C (ml/cmH_2O)	67.31±18.24 65 (22-113)	53.08±15.19 51 (23-94)	46.97±15.79 45 (22-136)	48.1±13.72 45 (28-96)	62.65±24.16 58 (25-150)	<0.001
TV (ml)	499±18.08 497 (451-587)	497±23.06 496 (375-572)	501±24.55 499 (431-571)	502±49.8 498 (441-683)	509±44.9 500 (407-682)	0.66

Values are presented as mean ± standard deviation and median (minimum-maximum). *Friedman test. P: pressure, MP: mechanical power, TV: tidal volume, DP: driving pressure, C: compliance, T1: 15th minute in the supine position, T2: 15th minute into the first prone position, T3: at the first hour in the prone position, T4: at the conclusion of the surgery in the final prone position, T5: in the final supine position, 15 minutes after return

Table 4 - Comparison of mechanical power according to body mass index groups.

Parameters	BMI groups <30		≥30		*P*-values
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	
T1 MP (J/min)	6.26±1.48	5.97 (3.81-11.39)	6.86±1.06	6.87 (4.99-8.9)	0.011**
T2 MP (J/min)	6.77±1.4	6.67 (4.38-10.47)	7.64±1.13	7.36 (5.53-11.05)	0.001**
T3 MP (J/min)	7.14±1.29	7.01 (4.56-11.11)	8.32±1.19	8.08 (6.38-10.76)	<0.001*
MP 2H (J/min)	7.03±1.19	7.17 (4.69-9.42)	8.15±1.15	7.82 (6.68-10.47)	0.002**
MP 3H (J/min)	7.22±1.4	7.14 (4.88-9.97)	8.29±1.74	8.05 (5.19-14.86)	0.023**
MP 4H (J/min)	6.92±0.95	7.08 (4.89-8.52)	7.92±0.79	7.79 (6.9-9.2)	0.012*
T4 MP (J/min)	7.05±1.13	7.08 (4.58-10.24)	8.14±1.6	7.69 (5.78-15.52)	<0.001**
T5 MP (J/min)	6.71±1.57	6.31 (3.69-10.42)	7.45±1.26	7.34 (5.57-13.03)	0.008**

Values are presented as mean ± standard deviation (SD) and median (minimum-maximum). *Independent samples t-test. **Mann Whitney U test. BMI: body mass index, H: hour, MP: mechanical power, T1: 15th minute in the supine position, T2: 15th minute into the first prone position, T3: at the first hour in the prone position, T4: at the conclusion of the surgery in the final prone position, T5: in the final supine position, 15 minutes after return

range is 4-7 J/min in general. Mechanical power in the operating room is notably different from that in the intensive care unit. However, the behavior of MP under surgical conditions is not well defined. In our study, the average MP ranged between 6.81-7.91 J/min (with a minimum of 3.81 J/min and a maximum of 14.86 J/min).

In the supine position, ventilation decreases due to the increase in intraabdominal pressure in dependent areas, whereas perfusion is better in this region. This creates a mismatch in ventilation/perfusion (V/Q). In the prone position, improved ventilation was observed due to the relatively decreased intraabdominal pressure affecting the dorsal region, which enhanced V/Q matching and provided better oxygenation. Particularly in patients with ARDS, a beneficial impact of the prone position on oxygenation was noted, leading to an increase in the PaO2/FiO2 ratio. This is explained by less overdistension in non-dependent lung regions and reduced cyclic opening and closing in dependent lung regions, resulting in more homogeneous ventilation and reduced lung stress and strain, thereby distributing the total energy to the lungs.[16]

In a retrospective study investigating PPC on >200,000 patients, an association was identified between MP exceeding 7.67 J/min and the need for reintubation. This study focused on elective non-cardiac surgeries, indicating an average MP of 6.62 J/min and an increased likelihood of reintubation by 30% with each 5-J increment in MP.[17] Records from up to 1200 elective abdominal surgeries, where data collection was limited to 5 hours, showed an MP of 7.6 J/min,

Table 5 - Comparison of the effect of position on mechanical power change according to body mass index group.

Parameters	BMI groups				*P*-values*
	<30		≥30		
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	
T2 MP-T1 MP	0.51±0.9	0.59 (-2.33-2.58)	0.77±0.89	0.84 (-1.48-2.41)	0.197
T4 MP-T5 MP	0.34±1.15	0.58 (-2.65-2.41)	0.7±1.48	0.6 (-2.17-8.07)	0.564
P-values**	0.604		0.279		

Values are presented as mean ± standard deviation (SD) and median (minimum-maximum). *Mann Whitney U test, **Wilcoxon test. MP: mechanical power, BMI: body mass index, T1: 15th minute in the supine position, T2: 15th minute into the first prone position, T4: at the conclusion of the surgery in the final prone position, T5: in the final supine position, 15 minutes after return

demonstrating that the duration of surgery was an effective factor in MP increase.[18] In the current study, we obtained an average MP of 7.3 J/min, which is consistent with the literature.

When examining the effect of prone positioning on MP in ARDS, a longitudinal increase in MP was observed, particularly in the initial and final prone positions. When examining the increase in MP between non-survivors and survivors, it was more pronounced in non-survivors. This finding suggests that the effect of MP levels may not only influence outcomes, but also implies that the duration of parenchymal exposure may contribute to additional lung damage.[19] Similarly, in our study, we observed an increase in MP over time, suggesting that the majority of the patients undergoing elective surgery have healthy lungs, and therefore, the high MP may not lead to significant complications. However, considering the effect of the duration of surgery on MP, it can be speculated that prolonged surgical procedures may increase MP, leading to lung damage. Future studies examining the relationship between MP and time in more detail can shed light on this issue.

Obesity, characterized by a high BMI, can lead to an increase in MP due to a decrease in lung elastance compared to total elastance.[20] Pelosi et al[21] demonstrated an increase in lung volume, compliance, and oxygenation in anesthetized and paralyzed obese patients placed in the prone position with freely hanging abdomens. The prone position, where the abdomen can move freely in obese individuals with paralyzed, appears to have a positive effect on lung function by reducing the cephalad shift of the diaphragm or reopening the atelectatic segments. Therefore, it increases lung volume, compliance, and oxygenation, suggesting that the prone position does not negatively affect lung function in obese patients.[21]

In our study, an increase in MP was observed with increasing BMI and MP was consistently higher in obese patients across all time intervals. However, the change in MP did not show a difference with changes in position in obese individuals. Perhaps the positive effects of the prone position in obese patients limited further increases in MP, suggesting that the benefits of the prone position may have a greater effect on lung function in the present study population. We believe that this study will guide future research on the effect of positional changes on MP in obese patients.

The size of the ETT is a significant factor in MP calculations. However, it is important to note that the resistance generated by the ETT becomes more critical for ventilation modes involving spontaneous breathing, as it increases the respiratory workload for the patient. In our study, patients were under neuromuscular blockade, and spontaneous breathing was not allowed. A clinical study has suggested that a minor reduction in the inner diameter of the ETT (from 8-7.5 mm) may still be acceptable for clinical purposes as long as the inspiratory flow does not exceed 48 L/min.[22]

In a certain study, different PEEP levels were investigated for their effects on respiratory mechanics in varying positions. Different PEEP levels were applied in supine and prone positions, with no change observed in compliance. It was noted that a moderate increase in PEEP when transitioning to the prone position positively affected respiratory mechanics.[23] In our study, a decrease in compliance and an increase in MP were observed in the prone position, possibly attributed to the applied constant PEEP. New studies investigating the impact of varied PEEP levels on MP in the prone position could provide more information.

Study limitations. The limitations of the study include the timing of the measurements, which were carried out over time. Surgical factors such as changes in abdominal pressure were not considered. Postoperative pulmonary complications were not recorded for the patients. Furthermore, the single-center nature inherent in this study imposes constraints on the extent to which the results can be generalized. The MP components, such as elastic static, elastic dynamic, resistive, or dissipated factors, were not individually measured. To enhance methodological simplicity, the MP affecting the entire respiratory system was calculated, and the presence of confounding factors such as the respiratory circuit and ETT resistance was disregarded in the analysis. Further research is required to explore the different components of the MP during intraoperative ventilation and to understand the contribution of the MP to PPC.

In conclusion, position changes affect MP, and turning to the prone position increases MP. An increase in BMI is associated with an increase in MP.

Acknowledgment. *The authors gratefully acknowledge Editage (www.editage.com) for their English language editing.*

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