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Original article

Optimization of positive end-expiratory pressure in reverse Trendelenburg position during laparoscopic surgery in adult patients

Gulfairus Yessenbayeva [1], Sanzhar Shalekenov [2], Dmitriy Klyuyev [3], Vilen Molotov-Luchanskiy [4], Irina Mukatova [5], Dinara Zharlyganova [6], Altynai Kassenova [7], Andrey Yaroshetskiy [8]

[1] Chief specialist of the science department, National Research Oncology Center, Astana, Kazakhstan. E-mail: yessenbayeva.gulfairus@gmail.com
[2] Chairman of the board, National Research Oncology Center, Astana, Kazakhstan. E-mail: s.shalekenov@gmail.com
[3] Director of the Institute of Life Sciences, Karaganda Medical University, Karaganda, Kazakhstan. E-mail: klyuev@qmu.kz
[4] Professor of internal medicine Department, Karaganda Medical University, Karaganda, Kazakhstan. E-mail: Molotov-luchanskiy@qmu.kz
[5] Professor of Pulmonology Department, Astana Medical University, Astana, Kazakhstan. E-mail: kozlovapulm@gmail.com
[6] Head of Department of Science, National Research Oncology Center, Astana, Kazakhstan. E-mail: dinarazh@mail.ru
[7] Anesthesiologist, Multidisciplinary Hospital 1, Karaganda, Kazakhstan. E-mail: Zhamaukan@mail.ru
[8] Professor of Pulmonology Department, Sechenov First Moscow State Medical University (Sechenov University), Moscow, Russia. E-mail: dr.intensivist@gmail.com

Abstract

The optimal level of PEEP during laparoscopic surgery without lung injury remains unclear and controversial. We hypothesized that personalized adjustment of positive end-expiratory pressure (PEEP) by best compliance could improve perioperative gas exchange and respiratory biomechanics in adult patients undergoing laparoscopic surgery in the reverse Trendelenburg (RT) position.

Objective: The primary objective of the study was to determine the difference in oxygenation between the groups. Secondary objectives were differences in intraoperative dynamics of compliance and driving pressure.

Methods. A randomized trial was conducted with patients undergoing laparoscopic cholecystectomy, divided into two groups. In the PEEP titration group (iPEEP), PEEP was adjusted according to best compliance. PEEP titration was performed in 1 cmH2O increments. In control group (PEEP5) we set PEEP of 5 cmH2O.

Results. Sixty patients were included in the study. PEEP during pneumoperitoneum (PNP) did not differ between the two groups at 5 minutes and 1 hour after PNP (t2, 5.3±4.58 vs 5.0±0.0 cmH2O, t3 5.93±5.09 vs 5.0±0.0 cmH2O, respectively, both P>0.05) and corresponded with esophageal pressure monitoring. Oxygen saturation (SpO2) levels were comparable throughout surgery. Higher driving pressure (DP) was observed in the iPEEPgroup at 5 minutes post-PNP, but DP values remained within protective limits. Compliance decreased in both groups 5 minutes post-PNP but was lower in the iPEEPgroup. These differences in DP and compliance disappeared one hour after PNP and by the end of surgery. The P/F ratio was significantly higher in the iPEEPgroup compared to the PEEP5 group 1 hour and 24 hours post-surgery (p<0.05), although the iPEEPgroup had higher preoperative P/F values.

Conclusions. During laparoscopic cholecystectomy in RT position PEEP 5 is sufficient, but some patients need personalized adjustment. Intraoperative titrated PEEP improved perioperative oxygenation and did not affect on respiratory mechanics.

Keywords: PEEP, compliance, oxygenation, laparoscopy, lung protective ventilation.

Corresponding author: Gulfairus A. Yessenbayeva, Chief specialist of the science department, National Research Oncology Center, Astana, Kazakhstan.
Postal code:Z05K4F3
Address: Kazakhstan, Astana Kerey-Zhanibek Khandar str. 3
Phone: +7 778 843-45-63
E-mail: yessenbayeva.gulfairus@gmail.com

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Introduction

Annually, approximately 230 million patients worldwide require surgery with general anesthesia and mechanical ventilation (MV) [1]. Laparoscopic procedures are increasingly becoming the primary method of surgical intervention each year. This technique involves making a minimal surgical incision to allow camera access, insufflating the abdomen with carbon dioxide (CO^2), and placing additional ports under direct visual control through the camera to facilitate the insertion of laparoscopic instruments [2].

Pneumoperitoneum (PNP) and the patient position required for laparoscopic surgery lead to pathophysiological changes that complicate anesthesia [3]. PNP is characterized by increased intra-abdominal pressure (IAP) and cranial displacement of the diaphragm, which can lead to intraoperative atelectasis and decreased end-expiratory lung volume (EELV) [4,5]. Moreover, PNP can reduce respiratory system compliance by 30-50% in healthy patients [6,7]. During elective abdominal surgeries under general anesthesia, atelectasis forms in almost 90% of patients [8] and may become a focus of postoperative pneumonia. One method of preventing the effects of PNP on lung tissue is the use of positive end-expiratory pressure (PEEP) [9]. PEEP is recognized as a component of lung protective ventilation (LPV) along with a low tidal volume (TV) of 6-8 ml/kg [10,11]. On the other hand, excessive PEEP can lead to lung overdistension, causing volutrauma [12] and hemodynamic instability. It is crucial to use appropriate PEEP levels to minimize atelectasis, improve respiratory mechanics, and maintain oxygenation.

A recent systematic review and meta-analysis of intensive care unit (ICU) patients without acute respiratory distress syndrome (ARDS) found no reduction in in-hospital mortality or duration of ventilation in patients with higher PEEP. However, hypoxemia and ARDS occurred less frequently with higher PEEP (assessed by arterial partial pressure of oxygen (PaO2) or the PaO2/FiO2 ratio) [13]. In a large observational study of general surgery patients without obesity, a PEEP of 5 cm H2O was identified as a protective factor associated with fewer postoperative pulmonary complications (PPC) [14]. Additionally, zero PEEP was associated with worse outcomes, including increased hypoxemia, ventilator-associated pneumonia, and in-hospital mortality [15]. One systematic review and network meta-analysis suggested that individually tailored PEEP combined with a recruitment maneuver (RM) may be the optimal ventilation strategy in combination with low VT in abdominal surgery, but it involved mixed groups of patients undergoing laparoscopic and open surgery [16]. A recent systematic review and meta-analysis found that high and individualized PEEP during laparoscopic surgery in non-obese patients can improve oxygenation and respiratory mechanics without causing clinically significant effects on hemodynamics. While a moderate PEEP may be insufficient to improve airway compliance and oxygenation, low PEEP may result in decreased airway compliance and impaired oxygenation [17]. In obese patients, higher PEEP may be used, as some studies indicate worsening respiratory mechanics in this group [18,19]. Although low VT is recognized as a protective component during surgery, randomized controlled trials (RCTs) comparing PEEP levels during laparoscopic surgery have been small and have shown conflicting results regarding the effects of PEEP on oxygenation, respiratory mechanics, and hemodynamic stability [20–25]. Thus, the optimal level of PEEP during laparoscopic surgery without lung injury remains unclear and controversial.

Due to the ambiguity of available data, many authors are actively developing the idea of personalized intraoperative PEEP titration [26–28], and further studies are needed to determine an effective and safe intraoperative PEEP level during laparoscopic surgery.

Objective: The primary objective of the study was to determine the difference in oxygenation between the groups. Secondary objectives were differences in intraoperative dynamics of compliance and driving pressure.

Materials and methods

Subjects. We conducted a prospective, blinded, randomized controlled trial (RCT) at Professor Makazhanov H.J. Multidisciplinary Hospital from April 2021 to June 2022 in Kazakhstan. The study protocol was approved by Local Bioethics Committee of Karaganda Medical University (assigned number 66, protocol №18, dated 12.04.2021). Written informed consent was obtained from all patients before inclusion in the study. This manuscript adheres to the CONSORT guidelines.

Sixty consenting patients with ASA physical status I-II (see Figure 1 for CONSORT study profile) were included in the study. All patients underwent laparoscopic cholecystectomy between April 2021 and June 2022. Exclusion criteria were age <18 and >65 years, BMI >30 kg/m2, pregnancy, ASA III-IV patients, life-threatening cardiac rhythm disturbances and/or systolic blood pressure < 80 mm Hg despite norepinephrine at a dose >2 μg/kg/min, primary lung diseases (e.g., interstitial lung disease, interstitial lung disease, pulmonary emphysema) or tumor metastases to the lungs, chronic decompensated disease with extrapulmonary organ dysfunction (tumor progression, cirrhosis, congestive heart failure), Glasgow Coma Scale score <14 points, upper airway obstruction. Patients were withdrawn from the study and replaced in case of protocol violation and when conversion to open laparotomy cholecystectomy occurred.

Baseline electrocardiogram (ECG), heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), hemoglobin oxygen saturation (SpO2), and end-tidal carbon dioxide (ETCO2) were recorded in the operating room using a multi-frame monitor. Baseline arterial blood gases (ABG) were measured. After induction of anesthesia with standard doses of fentanyl, propofol, and rocuronium, general anesthesia was maintained in TIVA mode by continuous infusion of propofol and fentanyl. Intravenous crystalloids and norepinephrine were administered as needed at the discretion of the attending anesthesiologist. After induction and intubation, an arterial catheter was placed in the radial artery for repeated arterial blood gas sampling.

Mechanical ventilation was performed in volume control mode with inspiratory square flow. Tidal volume was 6 mL/kg ideal body weight, FIO2 was set to maintain SpO2 >92%, and respiratory rate was adjusted to achieve and maintain end-expiratory carbon dioxide concentration at 30-45 mm Hg. The inspiratory time was 33% of the total respiratory cycle time, and the inspiratory pause was equal to 20% of the inspiratory time. Initially, PEEP was not added. According to the anesthesia maintenance plan, propofol was administered intravenously at a rate of 2-10 mg/kg/h, fentanyl 0.05-0.15 mg/kg/min, and emergency rocuronium.

Study protocol. All patients were randomized into one of two groups (main or control) using a computerized randomization sequence (www.sealedenvelope.com); assignment was communicated to the attending physician before the patient entered the operating room. The main group were patients with calculous cholecystitis who underwent ventilation with PEEP adjustment titrated by best static compliance; the control group were patients with calculous cholecystitis who underwent standard ventilation with PEEP of 5 cmH2O throughout surgery.

In the PEEP titration group (iPEEP), PEEP was adjusted according to best compliance. PEEP titration was performed in 1 cmH2O increments. In the control group (PEEP5), a PEEP of 5 cmH2O was set. Esophageal pressure monitoring was used in both groups. Group allocation was concealed in a sealed envelope before induction of anesthesia.

In both groups, FiO2 was chosen by the anesthesia staff to maintain an SpO2 > 92% and a plateau respiratory system pressure (Pplat) < 30 cmH2O according to our institutional protocol. When SpO2 decreased to 92%, FIO2 was increased first, followed by PEEP, after excluding common possible causes such as endotracheal tube misplacement or airway secretions. If SpO2 persistently remained below 92%, a recruitment maneuver was performed with continuous hemodynamic monitoring. In the iPEEP group, PEEP was adjusted to achieve the best static compliance.

Tidal volume was based on ideal body weight (6 ml/kg), the inspiratory/expiratory ratio was set to 1:2, and the breathing frequency was adjusted to maintain an end-tidal carbon dioxide value < 55 mm Hg in both groups. Furthermore, recruitment maneuvers could be performed based on clinical judgment if SpO2 was < 92%. During recovery from anesthesia, patients were transferred to the postanesthesia care unit while spontaneously breathing room air or, when required, oxygen via a Venturi face mask.

Study steps were defined as follows: baseline, before starting surgery (t0); after intubation in the absence of external PEEP (t1); randomization and 5 minutes after PEEP application (t2); after 5 minutes of pneumoperitoneum application (t3); after 5 minutes the reverse Trendelenburg and changing position (t4); and 24 hours after surgery (t24).

Measurements. Demographic characteristics such as sex, age, ASA physical status, body mass index, and ideal body weight were recorded for each subject. Arterial pH, the ratio of arterial partial pressure of oxygen to the fraction of inspired oxygen (PaO2/FIO2), and arterial carbon dioxide partial pressure were assessed at randomization, as well as at one hour and 24 hours after the end of surgery. Hemodynamic status was continuously monitored throughout the study, with mean arterial blood pressure and heart rate recorded from t1 to t4. At each step from t1 to t4, occlusion maneuvers at both end-expiration and end-inspiration were performed to measure static pressures in the airways (Pplat) and in the chest. These values were used to compute static compliance. Volumetric capnography was also recorded, and the driving pressure of the respiratory system was calculated.

Statistics. The statistical analysis was carried out using the Statistical Package for the Social Sciences program, version 26 (SPSS Inc., Chicago, Illinois, USA). Intergroup comparisons for variables with a normal distribution were conducted through Student's t-test, while variables lacking normal distribution were assessed using the Mann–Whitney U test. The χ^2 test was employed for intergroup comparisons of categorical data, and paired samples t-test was used for intragroup comparisons. Results are presented as mean (M) ± SD when quantitative data were normally distributed. In non-normal distribution, quantitative data were described based on the median (Me) and upper and lower quartiles (Q25, Q75). A significance level of P < 0.05 was considered statistically significant.

Sample size calculations were performed using the PASS 15.0 program. The sample size determination was based on observations obtained in a study conducted by Sen and Erdogan Doventas (29). In this study, the group with PEEP 10 demonstrated a mean PaO2 of 176.1 (37.9) mmHg after 30 minutes of pneumoperitoneum, while the group with PEEP 5 had a mean PaO2 of 135.2 (36.9) mmHg. To detect a similar difference in PaO2 at 80% power and α 0.05 error, the sample size was 14 persons per group. Considering possible dropout from the study, total 60 adults were included.

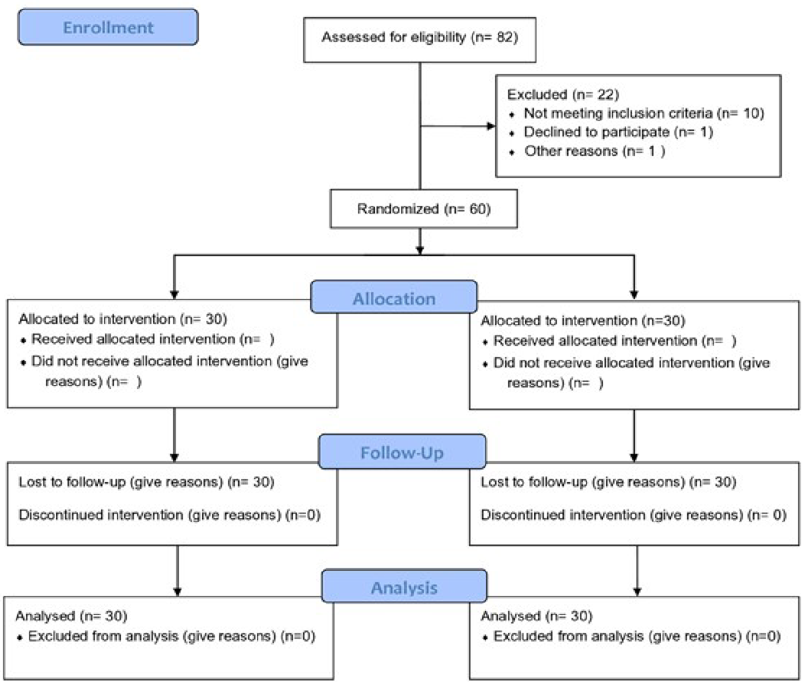

Figure 1 - CONSORT Flow Diagram

Results

From April 2021 to April 2022, 82 patients were eligible for inclusion in the study, but 22 were not included. Of these, 10 did not meet the inclusion criteria, one refused to participate, and one was excluded for other reasons, resulting in 60 patients being included in the study. No patients dropped out or had incomplete follow-up (Figure 1).

The baseline characteristics of the study groups are summarized in Table 1. Both groups were well-matched in terms of gender, age, body mass index (BMI), weight, height, and smoking status. The iPEEP group consisted of 6 males and 24 females, while the PEEP5 group had 8 males and 22 females, with no significant difference in gender distribution (p = 0.54). The mean age was 42.46 ± 12.29 years in the iPEEP group and 47.37 ± 14.02 years in the PEEP5 group, without a statistically significant difference (p = 0.14). Similarly, there were no significant differences in BMI (25.91 ± 3.05 kg/m^2 vs. 25.26 ± 3.585 kg/m^2, p = 0.49), weight (71.70 ± 11.91 kg vs. 67.53 ± 11.39 kg, p = 0.29), and height (166.03 ± 8.48 cm vs. 163.33 ± 6.90 cm, p = 0.41) between the groups. Smoking status was also comparable, with 5 smokers in the iPEEP group and 6 in the PEEP5 group (p=0.74). These findings confirm that the study groups were comparable, allowing for a fair assessment of the effects of different mechanical ventilation strategies.

Table 1 - Basic characteristics of the study group

Characteristics	IPEEP	PEEP5	p
Sex (M/F)	6/24	8/22	0,54
Age, years	42,46/12,29	47,37/ 14,02	0,14
BMI, kg/m^2	25,91/ 3,05	25,26/ 3,58	0,49
Weight, kg	71,70/ 11,91	67,53/ 11,39	0,29
Height, sm	166,03/ 8,48	163,33/ 6,90	0,41
Smoker, yes/no	5/25	6/24	0,74

Data presented as mean ± SD. BMI - body mass index. A value of P < 0.05 was considered statistically significant
F - female, M – male

In terms of oxygenation parameters, SpO2 levels were similar between the groups throughout the study. The P/F ratio, a key indicator of oxygenation, was consistently higher in the iPEEP group at all time points (Figure 2). At t0, the median P/F ratio was 452.85 (Q25-Q75: 406.19-547.61) in the iPEEP group, compared to 391.19 (Q25-Q75: 367.14-470.95) in the PEEP5 group (p = 0.028). This trend persisted at t1, with medians of 438.57 (Q25-Q75: 393.33-614.28) vs. 402.85 (Q25-Q75: 353.09-455.83) (p = 0.020), and at t24, with medians of 480.95 (Q25-Q75: 385.23-619.04) vs. 378.80 (Q25-Q75: 333.80-463.09) (p = 0.010). Similarly, the partial pressure of arterial oxygen (PaO2) was significantly higher in the iPEEP group one hour and 24 hours after surgery, indicating improved oxygenation under the iPEEP strategy.

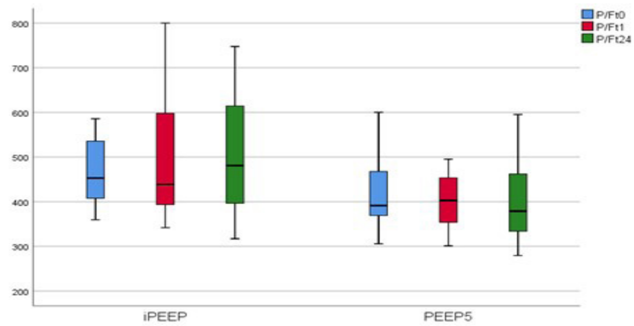

Figure 2 oxygenation parameters

P/F - the ratio of partial pressure of oxygen in arterial blood (PaO2) to the fraction of inspiratory oxygen concentration (FiO2) is an indicator of pulmonary shunt fraction
t0 - before starting surgery
t1 - 1 hours after surgery
t24 - 24 hours after surgery

Conversely, the partial pressure of arterial carbon dioxide (PaCO2) did not differ significantly between the groups at any time point. At t0, the median PaCO2 was 33.30 (Q25-Q75: 32.20-35.60) in the iPEEP group, compared to 35.95 (Q25-Q75: 32.97-38.95) in the PEEP5 group (p = 0.067). Similar non-significant differences were observed at t1 and t24 (p = 0.164 and p = 0.554, respectively).

When examining driving pressure (DP) and static compliance (Cstat), the iPEEP group showed significantly higher DP at early time points (Figure 3 and 4, respectively). At DP1, the median DP in the iPEEP group was 12.00 (Q25-Q75: 11.000-14.250), compared to 10.00 (Q25-Q75: 9.075-12.000) in the PEEP5 group (p = 0.042). At DP2, the difference was even more pronounced, with medians of 11.00 (Q25-Q75: 10.000-12.000) vs. 9.5 (Q25-Q75: 8.00-11.00) (p = 0.008). However, no significant differences in DP were observed at later time points (DP3 and DP4), and static compliance (Cstat) did not differ significantly between the groups at any time point.

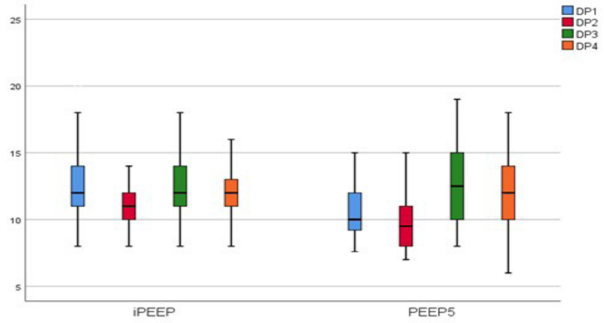

Figure 3 DP parameters
DP – driving pressure
1 - after intubation in the absence of external PEEP (t1)
2 - randomization and 5 minutes after PEEP application (t2)
3 - after 5 minutes of pneumoperitoneum application (t3)
4 - after 5 minutes the reverse Trendelenburg and changing position (t4)

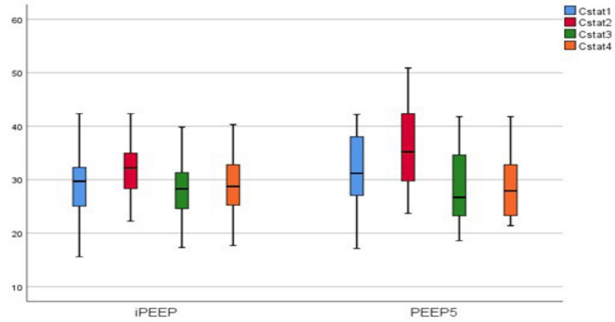

Figure 4 Cstat parameters
Cstat – static compliance
1 - after intubation in the absence of external PEEP (t1)
2 - randomization and 5 minutes after PEEP application (t2)
3 - after 5 minutes of pneumoperitoneum application (t3)
4 - after 5 minutes the reverse Trendelenburg and changing position (t4)

Finally, gas exchanges parameters during ventilation, including VCO2 (volumetric capnography), PetCO2 (partial pressure of end-tidal carbon dioxide), and EELV (end expiratory lung volume), did not show statistically significant differences between the iPEEP and PEEP5 groups (table 2). For example, VCO2 and PetCO2 medians were comparable between the groups at all time points, with p-values exceeding 0.64 and 0.08, respectively. Similarly, EELV measurements showed no significant differences, with p-values greater than 0.09 at all measured intervals.

Table 2 - Gas exchanges parameters during ventilation

	IPEEP	PEEP5	p
N	30	30	
VCO2_1	95,50, (82,50-114,00)	96,00, (78,00-109,50)	0,90
VCO2_2	93,00, (78,00-103,50)	99,00, (76,50-108,00)	0,69
VCO2_3	96,00, (82,50-102,50)	93,00, (78,00-126,00)	0,64
VCO2_4	102,00, (84,00-109,50)	99,00, (90,00-120,00)	0,91
PetCO2_1	28,82, (25,919-31,507)	32,18, (27,757-35,771)	0,49
PetCO2_2	37,00, (32,75-38,25)	36,00, (34,00-40,25)	0,08
PetCO2_3	36,00, (33,75-38,00)	36,00, (34,00-39,00)	0,73
PetCO2_4	38,00, (35,75-41,25)	40,00, (37,00-43,00)	0,08
EELV_1	-	-	
EELV_2	167,71, 81,78-250,35	210,94, 162,94-265,13	0,09
EELV_3	169,56, 57,70-289,84	147,77, 117,04-205,09	0,83
EELV_4	146,40, 45,85-296,83	152,28, 122,06-192,73	0,50

Data presented as median and 25th, 75th percentiles. A value of P < 0.05 was considered statistically significant
VCO2 – volumetric capnometry, PetCO2- - arterial partial pressure of carbon dioxide
1 - after intubation in the absence of external PEEP (t1)
2 - randomization and 5 minutes after PEEP application (t2)
3 - after 5 minutes of pneumoperitoneum application (t3)
4 - after 5 minutes the reverse Trendelenburg and changing position (t4)

In conclusion, the iPEEP strategy resulted in significantly better oxygenation (higher P/F ratio and PaO2) compared to the PEEP5 strategy, without significantly affecting carbon dioxide elimination, driving pressure at later time points, static compliance, or overall ventilation parameters. These findings suggest that iPEEP may offer advantages in maintaining superior oxygenation during mechanical ventilation without compromising other aspects of respiratory mechanics.

Discussion

Our study demonstrated that the PEEP titration strategy resulted in significantly better oxygenation compared to the fixed PEEP of 5 cmH_2O. This was evident from the consistently higher P/F ratios and PaO_2 levels in the iPEEP group at all measured time points, indicating that the iPEEP strategy is more effective in maintaining oxygenation during mechanical ventilation.

These findings align with previous research, which also highlighted the potential benefits of individualized PEEP settings. For instance, the study by Meininger et al. (30) found that higher PEEP levels during robot-assisted laparoscopic surgery improved oxygenation, particularly during prolonged procedures. Although the beneficial effects of PEEP on oxygenation were more pronounced with longer pneumoperitoneum durations, our study indicates that even in shorter surgeries, a tailored PEEP approach can yield significant oxygenation benefits.

Interestingly, despite the improvement in oxygenation, there was no significant difference in $PaCO_2$ levels between the two groups in our study. This suggests that while PEEP titration can enhance oxygenation, it does not adversely affect carbon dioxide elimination, maintaining respiratory function stability. However, in a previous study, during pneumoperitoneum, PaCO2 was found to be significantly increased from baseline in both groups (31). This could be a consequence of intra-abdominal carbon dioxide insufflation combined with Trendelenburg position. However, it did not cause significant disturbances in acid-base status.

In terms of respiratory mechanics, our findings revealed that driving pressure (DP) was significantly higher in the iPEEP group at early time points, but this difference diminished over time. This aligns with the hypothesis that PEEP titration may initially increase DP as lung recruitment improves, but as the lungs adapt, DP stabilizes without significantly affecting static compliance (Cstat). This result is in line with other research suggesting that individualized PEEP settings can optimize lung mechanics without increasing the risk of ventilator-induced lung injury (32,33).

Moreover, ventilation and respiratory volume parameters such as VCO_2, $PetCO_2$, and EELV did not show statistically significant differences between the groups, indicating that the PEEP titration strategy did not compromise other aspects of respiratory mechanics. This further supports the safety and efficacy of the iPEEP strategy in clinical practice.

Conclusion

In the context of laparoscopic cholecystectomy performed in the reverse Trendelenburg (RT) position, a fixed PEEP of 5 cmH_2O generally suffices. However, some patients may benefit from personalized PEEP adjustments. Our study demonstrated that titrating PEEP based on individualized measurements significantly enhances perioperative oxygenation without adversely affecting respiratory mechanics. Thus, PEEP titration is a feasible and potentially superior alternative to fixed PEEP settings. Future research should investigate the long-term effects of this strategy, especially in broader patient populations and various surgical settings.

Competing interests. No

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Ересек науқастарда лапароскопиялық хирургия кезінде кері Тренделенбург жағдайында оң экспираторлық қысымды оңтайландыру

Есенбаева Г.А. [1], Шалекенов С.Б. [2], Клюев Д.А. [3], Молотов-Лучанский В.Б. [4], Мукатова И.Ю. [5], Жарлыганова Д.С. [6], Касенова А.К. [7], Ярошецкий А.И. [8]

[1] Ғылым бөлімінің бас маманы, Ұлттық ғылыми онкологиялық орталық, Астана, Қазақстан.
E-mail: yessenbayeva.gulfairus@gmail.com
[2] Басқарма төрағасы, Ұлттық ғылыми онкологиялық орталық, Астана, Қазақстан. E-mail: s.shalekenov@gmail.com
[3] Өмір туралы ғылымдар институтының директоры, Қарағанды медициналық университеті, Қарағанды, Қазақстан.
E-mail: klyuev@qmu.kz
[4] Ішкі аурулар кафедрасының профессоры, Қарағанды медициналық университеті, Қарағанды, Қазақстан.
E-mail: Molotov-luchanskiy@qmu.kz
[5] Пульмонология кафедрасының профессоры, Астана Медициналық Университеті, Астана, Қазақстан.
E-mail: kozlovapulm@gmail.com
[6] Ғылым бөлімінің бастығы, Ұлттық ғылыми онкологиялық орталық, Астана, Қазақстан. E-mail: dinarazh@mail.ru
[7] Анестезиолог, №1 Көпсалалы аурухана, Қарағанды, Қазақстан. E-mail: Zhamaukan@mail.ru
[8] Пульмонология кафедрасының профессоры, И.М. Сеченов атындағы Бірінші Мәскеу мемлекеттік медицина университеті (Сеченов университеті), Мәскеу, Ресей. E-mail: dr.intensivist@gmail.com

Түйіндеме

Өкпеге зақым келтірмейтін лапароскопиялық операциялар кезінде дем шығарудың соңында оң қысымның (ДСШҚ) оңтайлы деңгейі әлі де белгісіз және даулы болып қалып отыр. Біз оңтайлы комплаенс арқылы ДСШҚ жеке түзету ересек пациенттерде лапароскопиялық хирургия кезінде, кері Тренделенбург (КТ) позициясында, периоперациялық газ алмасуды және тыныс алу биомеханикасын жақсарта алады деп болжадық.

Зерттеудің мақсаты: Зерттеудің негізгі мақсаты - топтар арасындағы оттегімен қанығу айырмашылығын анықтау. Екіншілік мақсаттар - комплаенс пен қозғаушы қысымының операциялық динамикасындағы айырмашылықтарда анықтау.

Әдістері. Лапароскопиялық холецистэктомиядан өткен пациенттер арасында рандомизацияланған сынақ өткізілді, олар екі топқа бөлінді. ДСШҚ реттеу тобында (iPEEP) ДСШҚ оңтайлы сәйкестікке сәйкес реттелді. ДСШҚ реттеу 1 смН2О қадамымен жүргізілді. Бақылау тобында ДСШҚ 5 смН2О (PEEP5) деңгейінде орнатылды.

Нәтижесі. Зерттеуге 60 пациент қатысты. Пневмоперитонеум (ПНП) кезінде ДСШҚ 5 минуттан және ПНП-ден 1 сағат өткен соң екі топта да айырмашылық болмады (t2, 5,3±4,58 қарсы 5,0±0,0 смН2О, t3 5,93±5,09 қарсы 5,0±0,0 смН2О, тиісінше, екеуі де P>0,05) және өңеш қысымын бақылауға сәйкес келді. Операция барысында оттегімен қанығу деңгейі (SpO2) ұқсас болды. ПНП-ден кейін 5 минут өткен соң iPEEPтобында қозғаушы қысым (ҚҚ) жоғары болды, бірақ ҚҚ мәндері қорғаныс шектерінде қалды. Сәйкестік екі топта да ПНП-ден кейін 5 минуттан соң төмендеді, бірақ iPEEP тобында төмен болды. Бұл ҚҚ және сәйкестік айырмашылықтары ПНП-ден 1 сағат өткен соң және операция соңына дейін жоғалып кетті. P/F арақатынасы iPEEP тобында PEEP5 тобымен салыстырғанда операциядан кейін 1 сағат және 24 сағаттан кейін едәуір жоғары болды (p<0,05), бірақ iPEEP тобында операция алдындағы P/F мәндері жоғары болды.

Қорытынды. Лапароскопиялық холецистэктомия кезінде КТ позициясында ПДКВ 5 жеткілікті, бірақ кейбір пациенттерге жеке түзету қажет. Ішкі операциялық реттелген ДСШҚ периоперациялық оттегімен қанығуды жақсартты және тыныс алу механикасына әсер етпеді.

Түйін сөздер: дем шығарудың соңында оң қысым, комплаенс, оттегімен қанығу, лапароскопия, өкпені қорғайтын желдету.

Оптимизация положительного давления в конце выдоха в обратном положении Тренделенбурга во время лапароскопической операции у взрослых пациентов

Есенбаева Г.А. [1], Шалекенов С.Б. [2], Клюев Д.А. [3], Молотов-Лучанский В.Б. [4], Мукатова И.Ю. [5], Жарлыганова Д.С. [6], Касенова А.К. [7], Ярошецкий А.И. [8]

[1] Главный специалист отдела науки, Национальный научный онкологический центр, Астана, Казахстан.
E-mail: yessenbayeva.gulfairus@gmail.com
[2] Председатель правления, Национальный научный онкологический центр, Астана, Казахстан.
E-mail: s.shalekenov@gmail.com
[3] Директор Института наук о жизни, Медицинский университет Караганды, Караганда, Казахстан.
E-mail: klyuev@qmu.kz
[4] Профессор кафедры внутренних болезней, Медицинский университет Караганды, Караганда, Казахстан.
E-mail: Molotov-luchanskiy@qmu.kz
[5] Профессор кафедры пульмонологии, Медицинский университет Астаны, Астана, Казахстан.
E-mail: kozlovapulm@gmail.com
[6] Начальник отдела науки, Национальный научный онкологический центр, Астана, Казахстан.
E-mail: dinarazh@mail.ru
[7] Анестезиолог, Многопрофильная больница №1, Караганда, Казахстан. E-mail: Zhamaukan@mail.ru
[8] Профессор кафедры пульмонологии, Первый Московский государственный медицинский университет имени И. М. Сеченова (Сеченовский университет), Москва, Россия. E-mail: dr.intensivist@gmail.com

Резюме

Оптимальный уровень ПДКВ (положительного давления в конце выдоха) во время лапароскопических операций без повреждения легких остается неясным и вызывает споры. Мы предположили, что индивидуальная настройка ПДКВ на основе наилучшей податливости (compliance) может улучшить периоперационный газообмен и биомеханику дыхания у взрослых пациентов, перенесших лапароскопическую операцию в положении обратного Тренделенбурга (ОТ).

Цель исследования: Основной целью исследования было определить разницу в оксигенации между группами. Второстепенные цели включали различия в интраоперационной динамике податливости и давления вождения (ДВ).

Методы. Проведено рандомизированное исследование среди пациентов, перенесших лапароскопическую холецистэктомию, *разделенных на две группы. В группе титрации ПДКВ (iPEEP) ПДКВ настраивалось в соответствии с наилучшей податливостью. Титрация ПДКВ проводилась с шагом 1 см Н2О. В контрольной группе ПДКВ было установлено на уровне 5 см Н2О.*

Результаты. В исследование было включено 60 пациентов. ПДКВ во время пневмоперитонеума (ПНП) не различалось между двумя группами через 5 минут и 1 час после ПНП (t2, 5,3±4,58 против 5,0±0,0 см Н2О, t3 5,93±5,09 против 5,0±0,0 см Н2О, соответственно, оба P>0,05) и соответствовало данным мониторинга давления в пищеводе. Уровни сатурации кислорода (SpO2) были сопоставимы на протяжении всей операции. В группе iPEEP наблюдалось более высокое давление на вдохе через 5 минут после ПНП, но значения ДВ оставались в пределах защитных границ. Податливость снизилась в обеих группах через 5 минут после ПНП, но была ниже в группе iPEEP. Эти различия в ДВ и податливости исчезли через час после ПНП и к концу операции. Соотношение P/F было значительно выше в группе iPEEP по сравнению с группой PEEP5 через 1 час и 24 часа после операции (p<0,05), хотя в группе iPEEP были выше предоперационные значения P/F.

Выводы. Во время лапароскопической холецистэктомии в положении ОТ ПДКВ 5 см Н2О является достаточным, но некоторым пациентам требуется индивидуальная настройка. Интраоперационное титрование ПДКВ улучшило периоперационную оксигенацию и не повлияло на механику дыхания.

Ключевые слова: ПДКВ, податливость, оксигенация, лапароскопия, протективная вентиляция легких.