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THE IMPACT OF PROTECTIVE VENTILATION STRATEGY, APPLIED IN PATIENTS DURING PROLONGED GYNECOLOGICAL SURGERY, ON POSTOPERATIVE OXYGENATION

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Abstract

Atelectasis occurs in nearly 90% of patients operated under general anesthesia and persists for about 24 hours after laparoscopic surgery and 3 days after open surgery. According to some randomized studies, intraoperative application of mechanical protective ventilation with a low tidal volume (VT), positive end-expiratory pressure (PEEP) and recruitment maneuvers (RMs) decreases left to right shunting and improves postoperative oxygenation. During these trials statistically significantly higher values of oxygen partial pressure (PaO_2) in arterial blood gas analysis and PaO_2/FiO_2 ratio (FiO_2 – fraction of inspired oxygen; $FiO_2 = 0.21$) were observed in patients ventilated with PEEP and RMs.

Our purpose is to prove that the application of PEEP in patients during prolonged gynecological surgery can improve postoperative oxygenation and decrease the incidence of postoperative atelectasis.

In this observational cohort study we included women, who underwent conventional gynecological surgery with a duration of more than 2 hours. Patients were divided into 2 groups – control group A (35 patients) and exposed group B (35 patients). The ones in the control group were ventilated with a tidal volume (VT) of 8–10 ml/kg, without PEEP and RMs, whereas those in group B were ventilated with VT = 6−8 ml/kg (based on ideal body weight),

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PEEP = 6 cm H_2O and RMs performed after intubation, at every disconnection from the ventilator and at extubation.

We proved that the patients in group B had statistically significantly higher values of PaO_2 and PaO_2/FiO_2 on the first postoperative day, therefore intraoperative protective mechanical ventilation improves postoperative oxygenation. We also observed a significantly reduced incidence of newly developed postoperative atelectasis in this patient group. Patients in group A had a significantly longer stay in intensive care unit (ICU) than those in group B.

The use of protective ventilation strategy (low VT, PEEP and RMs) in patients during prolonged gynecological surgery can decrease the incidence of postoperative atelectasis and improves oxygenation on the first postoperative day.

Key words: PEEP, RM, low VT, protective ventilation, postoperative oxygenation, atelectasis

Introduction. Every year about 240 million patients worldwide undergo surgery which requires general anesthesia and mechanical ventilation. Postoperative pulmonary complications are the second most common type of complications, following general anesthesia [1]. General anesthesia with muscle relaxation and surgery in the supine position can lead to alveolar collapse in the lung bases – atelectasis [1,2]. The resulting ventilation/perfusion mismatch in these zones increases right to left shunting, which, in turn, leads to hypoxia [3]. Atelectasis occurs in nearly 90% of patients operated under general anesthesia [4]. It persists for about 24 h after laparoscopic surgery and 3 days after open surgery and it may predispose the lung to infection – pneumonia [5]. Atelectasis formation depends on many factors – age, FiO_2, type of surgery, duration of intraoperative mechanical ventilation, patient positioning, postoperative analgesia, early mobilization, etc. [1]. According to randomized clinical trials, the intraoperative application of PEEP reduces the incidence of postoperative atelectasis, which decreases right to left shunting and improves oxygenation [6–15]. The PaO_2/FiO_2 ratio on the first postoperative day is statistically significantly higher in patients ventilated with low tidal volumes and PEEP (protective group) and the ratio increases with PEEP level. Respiratory compliance is also higher [6,8,9,12,13], and pulmonary infiltrates on X-ray are statistically significantly lower [6,7,9,13]. Some of these trials also prove that this strategy of intraoperative mechanical ventilation can decrease ICU and hospital length of stay [6,7].

PEEP application during general anesthesia prevents alveolar collapse at the end of expiration and the use of RMs can open up already collapsed alveoli. What level of PEEP should be used is controversial because of possible hemodynamic impairment.

The purpose of this study is to investigate the effect of positive end-expiratory pressure (PEEP), together with recruitment maneuvers (RMs) and low tidal volumes (based on ideal body weight) on patients during prolonged non-laparoscopic

gynecologic operations, on postoperative oxygenation and on intensive care unit length of stay.

Materials and methods. In this prospective cohort study we observed 70 patients from November 1, 2016 to May 19, 2017, who had fulfilled the inclusion criteria.

Inclusion criteria: age > 18; non pregnant women; non laparoscopic open gynecological surgery, lasting for more than 2 hours.

In all selected patients the following exclusion criteria were absent:

- mechanical ventilation within the last preoperative month;
- previous pulmonary surgery;
- severe chronic obstructive pulmonary disease (COPD), requiring non-invasive ventilation with CPAP (continuous positive airway pressure), oxygen therapy or systemic corticosteroid therapy;
- morbid obesity – Body Mass Index > 40;
- hemodynamically unstable patients – ones with acute coronary syndrome, persistent ventricular tachycardia, heart failure – NYHA 4;
- emergency surgery.

We used data from preoperative consultations with an anesthesiologist and an internal medicine specialist, preoperative laboratory tests, imaging studies and other specialized consultations to determine the ASA and ARISCAT scores. The latter can be used to predict postoperative pulmonary complications. Most patients included in this study were classified as ASA 3 – 52.9%, with an ARISCAT score of 34 p. – 51.4%, the most common duration of surgery being 2 h 30 min.

The selected patients were divided into 2 groups:

- Control group A – conservative strategy of mechanical ventilation – Vt = 8−10 ml/kg, without PEEP and RMs;
- Exposed group B – protective strategy of mechanical ventilation – Vt = 6−8 ml/kg (based on ideal body weight), PEEP=6 cm H_2O, with RM.

We used the following formula to calculate the ideal weight for women:

$$45.5 + 0.91 \times (\text{height} - 152.4).$$

RMs were performed by applying CPAP = 30 cm H_2O on the patients for 30 s. This was done after intubation, at each disconnection of the patients from the ventilator, and at extubation. The purpose of this maneuver is to expand any collapsed alveoli, whereas the application of PEEP aims to prevent the open alveoli from collapsing. RM was not performed in hemodynamically unstable patients, as it decreases cardiac output. In both groups we used a respiratory rate of 10–14/min and an inspiration:expiration ratio (I:E) of 1:2. We used side stream spirometry to determine peak inspiratory pressure (Ppeak), plateau pressure (Pplat), and respiratory compliance, pulse oximetry to monitor arterial blood saturation, non-invasive measurement of systolic blood pressure (SBP),

mean blood pressure (MBP) and diastolic blood pressure (DBP), ECG monitoring. We noted the total dose of vasopressor used, as well as the amount of infused crystalline and colloid solutions, fresh frozen plasma and erythrocite concentrate during the operations. We also measured intraoperative blood loss. Arterial blood gas analysis was performed on the first postoperative day.

Results. On the first postoperative day we did an arterial blood gas test on patients in both groups and compared the results. Mean PaO_2 values were 70.95 ± 2.6 mmHg for the control group, compared to 81.27 ± 2.03 mmHg for the protective group.

After performing a parametric independent t-test, we proved that there is a statistically significant difference between the mean PaO_2 values of the two groups ($P = 0.003 < 0.05$). We concluded that intraoperative protective ventilation strategy improves postoperative oxygenation.

We compared the mean values of the PaO_2/FiO_2 ratio, where FiO_2=0.21: control group – 337 ± 12.6, protective group – 386 ± 9.92. After performing an independent t-test, we found a statistically significant difference $P = 0.004 < 0.05$, therefore the patients of group B had better oxygenation on the first postoperative day.

We analyzed the mean values of intraoperative respiratory compliance: 44.8 ± 3.94 ml/H_2O for group A vs. 50.8 ± 4.15 ml/H_2O for group B. We used the Mann–Whitney U test, where $P = 0.00 < 0.05$, therefore there is a statistically significant difference between the values of intraoperative respiratory compliance. The protective group had a higher compliance than the control group, which leads to the conclusion that intraoperative mechanical ventilation with PEEP and RMs can improve lung compliance.

We observed the incidence of postoperative atelectasis, the diagnosis of which was based on X-ray findings. 21.2% of the patients in group A had developed atelectasis versus 0.0% in group B. By performing a nonparametric chi-square test, we determined that the incidence of postoperative atelectasis was statistically significantly higher in the control group compared to the protective group ($P = 0.017 < 0.05$).

We investigated the impact of intraoperative protective ventilation strategy on the duration of intensive care unit (ICU) stay. The mean values for the two groups were: control group – 51.9 ± 2.56 h vs. protective group – 45.3 ± 1.71 h. With the use of a parametric independent t-test, we found a statistically significant difference ($P = 0.041 < 0.05$), with a shorter ICU length of stay for patients from the protective group.

We had no cases of barotrauma.

In our trial we performed a chi-square test to compare the incidence of intraoperative hypotension and the need for vasopressors in the control and protective group.

Intraoperative hypotension:

– control group – 27%
– protective group – 33.3%.
Intraoperative use of vasopressors:
– control group – 29.7%
– protective group – 24.2%.
We found no statistically significant difference between the results:
– intraoperative hypotension – $\alpha < 0.05$, $P = 0.56 > 0.05$
– vasopressor use – $\alpha < 0.05$, $P = 0.6 > 0.05$.

Discussion. In this trial we investigated the impact of intraoperative mechanical ventilation with low Vt, PEEP=6 cm H_2O (the value of PEEP was constant) and RMs on postoperative oxygenation, atelectasis development and ICU length of stay. We only included women, who underwent conventional gynecological surgery with a duration of more than 2 hours. We proved that protective intraoperative mechanical ventilation can improve postoperative oxygenation – PaO_2 and PaO_2/FiO_2 values on the first postoperative day were statistically significantly higher in the protective group compared to the control group. Some randomized studies have also proved better postoperative oxygenation in patients, ventilated with low VT, PEEP and RMs [6–14]. Higher levels of PEEP are associated with higher PaO_2 and PaO_2/FiO_2 values [7–9]. In our study, the respiratory compliance of patients ventilated intraoperatively with PEEP and RMs was significantly higher. There are clinical trials that have proved the same. Moreover, the highest respiratory compliance has been measured in patient groups ventilated with the highest PEEP levels, with the use of RMs. We also observed a statistically significantly lower incidence of postoperative atelectasis in the protective group. Some randomized clinical trials have also found a statistically significant reduction of both postoperative atelectasis and pulmonary infiltrates on X-ray [6,8,10,14,16]. However, they did not successfully prove a lower incidence of postoperative pneumonia and respiratory failure [9,12]. Some of them observe a statistically significantly shorter ICU and hospital stay of the patients in the protective group [6–8], which correlates with the results of our study. One multicentre randomized double-blinded trial proves that protective intraoperative ventilation with PEEP and RMs decreases the risk of postoperative pulmonary complications, reduces mortality and ICU and hospital length of stay [16]. Another multicentre randomized double-blinded study concludes that higher levels of intraoperative PEEP are associated with a higher incidence of intraoperative complications like intraoperative hypotension, without significantly decreasing postoperative complications [17]. We investigated the effect of PEEP on intraoperative hemodynamic stability and found no statistically significant difference between the incidence of intraoperative hypotension and the intraoperative use of vasopressors in the investigated patient groups.

Conclusion. This study proves that the application of PEEP – 6 cm H_2O, together with RMs, and low VT (based on ideal body weight) during prolonged

conventional gynecological surgery improves postoperative oxygenation, reduces the risk of postoperative atelectasis and leads to a shorter ICU stay. Pulmonary complications are the second most common cause for postoperative mortality. Therefore, it is necessary to look for ways to reduce them. We can conclude that the use of protective ventilation strategy is inexpensive, simple and safe for patients.

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