Section: Anaesthesiology

Original Research Article

# COMPARING THE CHANGES IN ARTERIAL BLOOD GASES INDUCED BY APPLYING LOW TIDAL VOLUME WITH PEEP VENTILATION VS CONVENTIONAL VENTILATION STRATEGY IN PATIENTS UNDERGOING LAPAROSCOPIC SURGERY

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## Abstract

**Background:** Although laparotomy has given way to laparoscopy as the mainstay of intraabdominal surgery, anaesthetic management during laparoscopic surgery is complex for doctors because pneumoperitoneum can exacerbate respiratory mechanics and arterial oxygenation. This study assesses the changes in arterial blood gases when applying low volume with high peep ventilation for patients undergoing laparoscopic appendectomy. **Materials and Methods:** A prospective, randomised, comparative study was conducted at Tirunelveli medical college hospital on 40 patients undergoing laparoscopic abdominal surgeries. By sequential randomisation, patients were allocated into two groups, Group C and Group L. The procedure was explained to the patients. **Result:** In ASA-I and II, both conventional and low tidal with a peep value is 10, which is statistically significant $p < 0.05$. In the duration of surgery, both before and after insufflation, Conventional is 50.25 ± 4.99, Low tidal with peep is 48.75 ± 4.66, which is statistically significant $p < 0.05$. PaCO2, in conventional ventilation, there is a significant rise in the partial pressure of arterial carbon dioxide (PaCO2); in peak, inspiratory pressure is significantly elevated. In PH, there was a significant fall in PH values, and In PaO2, there was a significant decrease in the partial pressure of arterial oxygen (PaO2). **Conclusion:** In patients undergoing laparoscopic appendectomy and cholecystectomy under general anaesthetic, a low tidal volume with PEEP and a high respiratory rate may be employed to improve arterial blood gas readings.

## INTRODUCTION

Every year, more than 230 million patients worldwide require general anaesthesia and mechanical breathing for major surgery. Because postoperative pulmonary problems have a negative impact on clinical outcomes and healthcare usage, preventing them has become a metric of hospital patient care. Several extensive cohort studies show that about 20 to 30% of general anaesthesia patients are at a greater threat of postoperative pulmonary problems.[1] According to extensive prospective studies, about 30% of surgical patients with general anaesthesia and mechanical breathing are at moderate to severe risk for postoperative pulmonary complications (PPC). Both alveolars overstretching and atelectasis cause inflammatory mediators to be released, failing the lungs and other organs.[2] Lung-protective ventilation, which includes low tidal volumes and positive end-expiratory pressure (PEEP), is intended to avoid atelectasis and enhance gas exchange. Additionally, PEEP has been shown to lower outcomes in patients with acute respiratory distress syndrome (ARDS) and those severely sick.[3]

Laparoscopic techniques frequently result in several postoperative advantages, including faster healing and a more extended remain in the hospital. These benefits describe the growing popularity of laparoscopic surgery recommended for various surgical treatments. Moreover, pneumoperitoneum (PNP) and laparoscopic patient postures cause pathophysiological alterations that complicate anaesthetic administration.[4,5]

Pneumoperitoneum is a complicated but also well physiopathological state case of an increase in intra-abdominal pressure but instead, partial pressure of carbon dioxide (CO2); which has a significant impact on respiratory mechanics including intraoperative atelectasis, plateau pressure (Pplat), elevated peak inspiratory pressure (Ppeak) and tended to decrease respiratory system dynamic compliance.[4] $CO_2$ absorption following pneumoperitoneum may result in hypercarbia and respiratory acidosis. Excessive intraabdominal pressure can cause the diaphragm to migrate cephalad, resulting in decreased lung expansion, diaphragmatic excursion, reduced respiratory compliance and increased airway pressure. These harmful consequences of pneumoperitoneum were clinically controllable with suitable ventilatory adjustments.[6,7]

Lung preventive ventilation has grown over the last few years, focusing on patients suffering from acute respiratory distress syndrome (ARDS), including acute lung injury (ALD). In animal and human studies, mechanical ventilation induces and aggravates lung damage; therefore, the current standard of care is to employ a lung preventive ventilation technique in patients with ARDS and also ALD.[8] Most researchers were done in large randomised studies that recommend that lower tidal volumes are related to better results and a reduced incidence of ventilatory-induced lung damage.[9] Besides lowering the tidal volume, boosting (PEEP) is increasingly regarded as an essential component of protective ventilation.[10]

This study aimed to evaluate the effects of decreasing tidal volume with PEEP and traditional breathing techniques during laparoscopic appendectomy and cholecystectomy at the Trendelenburg and reverse Trendelenburg positions.

**AIM**

This study assesses the changes in arterial blood gases when applying low volume with high peep ventilation for patients undergoing laparoscopic appendectomy in Trendelenburg and laparoscopic cholecystectomy in reverse Trendelenburg position and compares it with conventional ventilation strategy.

## MATERIALS AND METHODS

A prospective, randomised, comparative study was done on 40 patients undergoing laparoscopic abdominal surgeries from Jan 2022 to June 2022. By sequential randomisation, patients were allocated into two groups, Group C and Group L. The procedure was explained to the patients, and the ethical committee's approval and informed consent were obtained. The study includes patients with ASA physical status 1 and 2, patients undergoing elective laparoscopic cholecystectomy or laparoscopic appendectomy, BMI 30 kg/m2, and patients who provided valid informed approval. In addition, patients who did not meet the inclusion criteria had a history of haemorrhagic diathesis and clotting condition or had a respiratory illness such as chronic bronchitis, congestive heart failure, respiratory failure, emphysema, bronchial asthma, as well as renal failure were excluded from the study.

We conducted a power analysis to find the required sample size and calculated that at least 20 patients per group should see a significant difference with 80% power. The formula used was $n=(Z\alpha/2+Z\beta)2 \times 2\times\sigma2 /d2$, where $Z\alpha/2$ is the critical value of the Normal distribution at $\alpha/2$ (e.g. for a confidence level of 95%, $\alpha$ is 0.05, and the critical value is 1.96), $Z\beta$ is the critical value of the Normal distribution at $\beta$ (e.g. for a power of 80%, $\beta$ is 0.2, and the critical value is 0.84), $\sigma2$ is the population variance, and d is the difference you would like to detect. Based on this, 20 patients were in each group. By sequential randomisation, patients were allocated into two groups, Group C and Group L.

Patients were instructed to fast for 8 hours overnight. All patients received T.Ranitidine 150 mg and T.Perinorm 10 mg the morning before the operation. In addition, all patients were given an injection of Glycopyrrolate 10 Mcg/kg (IM) 45 minutes before surgery. After being transferred to the operating room, the right cephalic vein was cannulated with an 18 G iv cannula and ringer lactate. Basal parameters were obtained after connecting the monitors for electrocardiogram, oxygen saturation probe, and non-invasive blood pressure.

Patients received Inj fentanyl 2 Mcg/kg for analgesia, Inj propofol 2 mg/kg for sedation, and Inj succinylcholine 1.5mg/kg for paralysis. After adequate relaxation, the patient was intubated with a suitable endotracheal tube and connected to a Dragor ventilator.

Ventilator settings were set according to the group allocated:

GROUP C: Tidal volume is 10 ml/kg, the respiratory rate was regulated between 12 and 14 /min, PEEP was zero, and Fio2- 50 percent was used (oxygen and nitrous oxide).

GROUP L: The tidal volume is 7ml/kg and respiratory rate 20/min, with PEEP=6 cmH2O, maintained with Fio2 - 50% (oxygen and nitrous oxide).

The magnitudes of Ppeak and Pplat were directly accessed from the ventilator and monitored 10 minutes before and 30 minutes after Pneumoperitoneum (T1) (T2). T1 and T2 arterial blood gas analyses were performed. In addition, all hemodynamic parameters were measured, including peripheral oxygen saturation (SpO2), mean arterial pressure (MAP), heart rate (HR), and ETCO2.

The intra-abdominal pressure was kept between 10 and 12 mmHg throughout the procedure. After the procedure was completed and appropriate breathing efforts were made, the patient was reversed with injections of neostigmine 50 mcg/kg and glycopyrrolate ten mcg/kg. Then, the patient was extubated after appropriate oral suctioning and restoring enough muscular strength and reflexes. SPSS and Microsoft Excel were used to analyse the data. The paired and unpaired t-tests were used to compare groups. The mean and standard deviation were used to produce descriptive findings.

## RESULTS

Each group had a total of 20 patients. Patient features were comparable among groups ($p > 0.05$). In each group, there were no statistically significant variations in hemodynamic measures (systolic BP, diastolic BP, MAP, HR) assessed before and after Pneumoperitoneum ($p > 0.05$). [Table 1]

In age, Conventional is 28.15 ± 5.97, and Low tidal with peep value is 30.45 ± 3.74. In ASA-I and II, both conventional and low tidal with a peep value is 10, which is statistically significant $p > 0.05$. [Table 2]

In the duration of surgery, both before and after insufflation, Conventional is 50.25 ± 4.99, Low tidal with peep is 48.75 ± 4.66, which is statistically significant $p < 0.05$. In pulse rate, before insufflation Conventional is 76.90 ± 10.15, After insufflation Conventional is 80.80 ± 10.14, Before insufflation Low tidal with peep, is 74.75 ± 9.43, After insufflation Low tidal with peep, is 80.80 ± 10.14. After insufflation, the p-value is 0.54, and the p-value is 0.492, which is insignificant.

In SBP, before insufflation, Conventional is 119.70 ± 7.00; after insufflation, Conventional is 126.30 ± 5.48; before insufflation, Low tidal with peep is 116.75 ± 9.18; after insufflation, Low tidal with peep is 122.75 ± 9.18 therefore, before insufflation p-value is 0.261 and the p-value after insufflation is 0.146, which is not statistically significant.

In DBP, before insufflation, Conventional is 70.60 ± 5.37; after insufflation, Conventional is 76.90 ± 5.45; before insufflation, Low tidal with peep is 71.20 ± 6.19; after insufflation, Low tidal with peep is 76.75 ± 6.31. Before insufflation, the p-value is 0.745, and the p-value after insufflation is 0.936, which is also not significant.

In MAP, before insufflation, Conventional is 86.96 ± 4.27; after insufflation, Conventional is 93.36 ± 4.11; before insufflation, Low tidal with peep is 86.38 ± 5.82; after insufflation, Low tidal with peep is 92.08 ± 5.99. Before insufflation, the p-value is 0.72, and the p-value after insufflation is 0.435, which is also not significant.

$PaCO_2$, in conventional ventilation, there is a significant rise in the partial pressure of arterial carbon dioxide ($PaCO_2$) values 30mins after pneumoperitoneum in the reverse Trendelenburg (41.55±1.22mmHg P=0.000) and Trendelenburg positions (41.10±1.51 mmHg, P=0.036). On the contrary, in low tidal volume with PEEP ventilation, there is no significant rise in the partial pressure of arterial carbon dioxide ($PaCO_2$) values 30mins after pneumoperitoneum in the reverse Trendelenburg (41.55±1.22mmHg P=0.122) and Trendelenburg positions (41.10±1.51 mmHg, P=0.812).

In PIP, Peak inspiratory pressure is significantly elevated 30mins after pneumoperitoneum at both Trendelenburg (18.80±2.25, P=0.000) and reverse Trendelenburg (18.3±1.76, P=0.000) positions in the conventional ventilation group. But in low tidal volume with the PEEP ventilation group, significant peak inspiratory pressure rise was seen only at the Trendelenburg position (18.3±1.15, P=0.000) and no significance at the reverse Trendelenburg position.

In Pplateau pressure, there was no significant change in the Pplateau pressure after pneumoperitoneum in both the groups at all positions. Likewise, in $HCO_3$, there is no significant change in the bicarbonate value before and after Pneumoperitoneum in both groups at all positions.

In PH, there was a significant fall in PH values noted 30mins after pneumoperitoneum in conventional ventilation groups at all positions and no significant fall in PH in the low tidal volume group at all positions.

In $PaO_2$, there is a significant decrease in the partial pressure of arterial oxygen ($PaO_2$) values 30mins after pneumoperitoneum in both the groups at all positions.

**Table 1: Patient characteristics distribution.**

| Characteristics | Conventional | Low tidal with peep | P value |
|---|---|---|---|
| Age (in years) | 28.15 ± 5.97 | 30.45 ± 3.74 | 0.152 |
| Sex (M/F) | 11/9 | 11/9 | 1.000 |
| ASA (I/II) | 10/10 | 10/10 | 1.000 |

**Table 2: Distribution of Pulse rate, Duration of surgery, SBP, DBP and MAP.**

| | | Before insufflation | After insufflation |
|---|---|---|---|
| Duration of surgery | Conventional | 50.25 ± 4.99 | |
| | Low tidal with peep | 48.75 ± 4.66 | |
| | P value | 0.105 | |
| Pulse rate | Conventional | 76.90± 10.15 | 80.80± 10.14 |
| | Low tidal with peep | 74.75± 9.43 | 78.80± 10.31 |
| | P value | 0.492 | 0.54 |
| SBP | Conventional | 119.70± 7.00 | 126.30± 5.48 |
| | Low tidal with peep | 116.75± 9.18 | 122.75± 9.18 |
| | P value | 0.261 | 0.146 |
| DBP | Conventional | 70.60± 5.37 | 76.90± 5.45 |
| | Low tidal with peep | 71.20± 6.19 | 76.75± 6.31 |
| | P value | 0.745 | 0.936 |
| MAP | Conventional | 86.96± 4.27 | 93.36± 4.11 |
| | Low tidal with peep | 86.38± 5.82 | 92.08± 5.99 |
| | P value | 0.72 | 0.435 |


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Table 3: Distribution of PACO2, PIP, P PLATEAU, HCO3, PH, and PAO2.

| Parameters | | Conventional | | Low tidal with peep | |
|---|---|---|---|---|---|
| | | Reverse Trendelenburg | Trendelenburg | Reverse Trendelenburg | Trendelenburg |
| PACO2 (mmHG) | Before insufflation | 36.05±1.78 | 32.73±10.28 | 37.81±1.78 | 37.98±1.58 |
| | After insufflation | 41.55±1.22 | 41.10±1.51 | 37.63±1.67 | 37.95±1.73 |
| | P value | 0.000 | 0.036 | 0.122 | 0.812 |
| PIP (Cm H2O) | Before insufflation | 15.70±1.41 | 15.6±0.96 | 15.7±0.67 | 15.6±1.64 |
| | After insufflation | 18.3±1.76 | 18.80±2.25 | 16.1±0.87 | 18.3±1.15 |
| | P value | 0.000 | 0.000 | 0.153 | 0.000 |
| P PLATEAU (cm H2O) | Before insufflation | 13±1.15 | 13.6±1.24 | 13.5±0.70 | 14.20±1.39 |
| | After insufflation | 14.2±1.31 | 14.1±0.99 | 13.8±0.78 | 15.00±1.05 |
| | P value | 0.091 | 0.124 | 0.613 | 0.112 |
| HCO3 | Before insufflation | 25.47±0.17 | 25.63±0.20 | 24.86±0.22 | 24.98±0.23 |
| | After insufflation | 25.77±0.31 | 25.88±0.30 | 24.83±0.19 | 24.81±0.14 |
| | P value | 0.121 | 0.154 | 0.616 | 0.501 |
| PH | Before insufflation | 7.39±0.01 | 7.38±0.01 | 7.40±0.03 | 7.40±0.02 |
| | After insufflation | 7.36±0.01 | 7.37±0.01 | 7.40±0.01 | 7.39±0.02 |
| | P value | 0.000 | 0.000 | 0.086 | 0.065 |
| PAO2 (mmHg) | Before insufflation | 186.20±6.62 | 181±11.04 | 182.20±10.60 | 181.80±9.63 |
| | After insufflation | 166.60±6.73 | 163±10.33 | 165.60±13.09 | 167.20±11.32 |
| | P value | 0.000 | 0.000 | 0.000 | 0.000 |

## DISCUSSION

The primary finding of our study was that using a low tidal volume with PEEP significantly affected the PaCO2 and PH of patients having laparoscopic surgery.

Pelosi et al. found that PEEP 10 cm H2O had no effect on pulmonary function in anaesthetised surgical patients with tidal volumes ranging from 8 to 12 mL/kg.[11] So, in our low tidal volume with the PEEP group, we set PEEP 6 cmH2O just above the minimal PEEP suggested by the present guidelines (≥5cmH2O).

Determann et al. evaluated mechanical ventilation with tidal volumes of 10 versus 6 mL/kg in severely sick patients without ALD at the time of mechanical ventilation. Mechanical administration of 10 mL/kg is linked to persistent plasma cytokine production. These results indicate that mechanical ventilation using conventional tidal volumes causes the progression of respiratory problems in people that did not even have ALD when at time mechanical ventilation was initiated.[12]

Cinnella et al. examined how the recruiting manoeuvre and PEEP affected respiratory efficiency and transpulmonary pressures following gynaecological laparoscopy. The authors observed that performing a recruiting manoeuvre following PEEP resulted in considerable alveolar recruitment, improved chest wall, and lung elastance in all individuals.[13] In our study, we employed a tidal volume of 10 mL vs 7 mL and 6 cm H2O PEEP, but we saw beneficial effects in PaCO2 and pH values of arterial blood gases. Moreover, PaO2 levels fell in both groups after Pneumoperitoneum; to avoid this, the recruiting manoeuvre may be performed after Pneumoperitoneum.

Hirvonen Eila A et al. demonstrated that by increasing ventilation and keeping ETC02 values normal or slightly lower during laparoscopy, In healthy people, PaCO2 levels may be maintained normal and acidosis at bearable levels.[14]

According to Wurst H et al., minute volume must be raised by roughly 40% to maintain PaCO2 constant during pneumoperitoneum.[15] To minimise respiratory acidosis, we employed a respiratory function of 20 breaths per minute with a modest tidal volume at the start of the operation in our study. We also kept ETCO2 levels in the traditional group from reaching 50 mmHg by increasing the respiratory muscles rate. Although there was a considerable rise in PaCO2 following pneumoperitoneum in the comparison group at the reverse Trendelenburg and Trendelenburg positions, there was no change in the low tidal group with the PEEP group at either position. Therefore, it could not determine if the cause was low tidal volume or PEEP.

Russo et al. used transthoracic echocardiography to assess the impact of PEEP on respiratory and cardiac function. They discovered that PaO2 levels improved in the PEEP groupings, but PaCO2 and ETCO2 rose following gas insufflation in the comparison group. Even though both were reduced by 10 cm H2O of PEEP, using 5 cm H2O of PEEP only raised the ETCO2 values.[16]

## CONCLUSION

Low tidal volume with PEEP administration improved PaCO2 in PH patients undergoing laparoscopic surgery. As a result, using a low tidal volume with PEEP and a high respiratory rate during laparoscopic procedures may be explored to enhance arterial blood gas readings.

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