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Original Research Article

# EFFECT OF PRE-EMPTIVE ALVEOLAR RECRUITMENT STRATEGY BEFORE PNEUMORERITONEUM ON ARTERIAL OXYGENATION DURING LAPAROSCOPIC SURGERIES

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ABSTRACT

**Background:** The objective was to find whether pre-emptive Alveolar recruitment strategy before pneumoperitoneum improves arterial oxygenation during laparoscopic surgeries.

**Material and Methods:** In a randomised, controlled, single-blind trial, we examined the effect of a pre- emptive alveolar recruitment strategy on arterial oxygenation during subsequent pneumoperitoneum. After intubation, 60 patients were randomly allocated to receive either tidal volume 10 ml/kg with no positive end-expiratory pressure (group C) or alveolar recruitment strategy of 10 breaths with peak inspiratory pressure of 40 cmH2O plus positive end-expiratory pressure of 15 cmH2O before gas insufflation (group P).

**Results:** During pneumoperitoneum, group P was ventilated with the same setting as group C (FiO2=0.35, tidal volume 10 ml/kg). PaO2 measured during peumoperitoneum was higher in group P than in group C (210.4mmHg vs 144.84mmHg at 15 minutes, P<0.001 170.6 mmHg vs 135.44mmHg at 30 minutes, P<0.001).

**Conclusion:** We conclude that the alveolar recruitment strategy we applied before insufflation of the peritoneal cavity may improve oxygenation during laparoscopic surgeries.

**Keywords:** Alveolar recruitment, Laparoscopic surgeries, Peumoperitoneum.

## INTRODUCTION

The physiological changes during laparoscopic surgeries occurs due to increased abdominal pressure, diffusion of CO2, position of the patient, decreases compliance of lung and arterial oxygenation. This atelectasis produced by pneumoperitoneum can be overcome by Alveolar recruitment strategy (ARS) and PEEP (positive end expiratory pressure). ARS and PEEP will produce increased airway pressure. To avoid additional increase in airway pressure during pneumoperitoneum, ARS and PEEP were applied before pneumoperitoneum.[1]

Laparoscopic surgeries involves changes in patients position from trendelenberg to reverse trendelenburg position and intraperitoneal CO2 insufflation. Laparoscopic surgeries has the advantage of short hospital stay, more returns to normal activity, less pain associated with small incision and less postoperative ileus compared with open laparotomy procedures.[2]

Patient position head-down tilt of 10-20 degrees with decrease central blood volume, vital capacity, and diaphragmatic excursion and inadvertent right mainstem bronchial intubation. Increase in systemic vascular resistance, and mean arterial pressure due to increase in sympathetic output due to CO2 absorption and neuroendocrine response to pneumoperitoneum. Pulmonary changes as elevated diaphragm, decreased lung volumes (functional residual capacity), increased ventilation-perfusion mismatch, increased alveolar-arterial oxygen gradient, decreased lung compliance and increased resistance,

cephalad displacement of carina leading to endobronchial intubation.[3]

Atelectasis and ventilation-perfusion mismatch is the major reason for gas exchange impairment during surgery. Role of mechanical ventilation: the changes in pulmonary function during laparoscopy require intraoperative modification in mechanical ventilation. Use of positive end expiratory pressure (PEEP) and recruitment maneuvers are beneficial before laparoscopic surgeries.

## MATERIAL AND METHODS

It is single blind trial randomised controlled study in Department of Anesthesia in cases posted for laparoscopic surgeries. The institutional ethical committee approval for the study was obtained. the informed written consent was obtained from the patient participating in the study was obtained.

**Inclusion Criteria:** 20-60 years in both genders with ASA 1 and 2posted for Elective laparoscopic surgeries

**Exclusion Criteria:** Patients with pre-existing lung and cardiac illness, who are obese history of bleeding disorders or on anticoagulant therapy, with known allergy to anaesthetic drugs, Psychiatric illness, with heart disease

Patient including both groups are premedicated with injection glycopyrolate 0.2mg and injection fentanyl 2mic/kg and induced with propofol 2mg/kg and paralysed with injection atracurium(0.5mg/kg). After adequate relaxation patient was intubated with adequate sized cuffed endotracheal tube and maintained with titrated dose of injection atracurium (0. lmg/kg). After intubation, 60 patients were randomly allocated to receive either tidal volume 10 ml/kg with no positive end-expiratory pressure (group C) or alveolar recruitment strategy of 10 manual breaths with peak inspiratory pressure of 40 cmH2O plus positive end-expiratory pressure of 15 cmH2O before gas insufflation (group P). During pneumoperitoneum, group P was ventilated with the same setting as group C (FiO2=0.35, tidal volume 10 ml/kg)

Repeated measures of analysis of variance can be performed to evaluate the time-by-ARS treatment interaction effect (baseline, 15 and 30 minutes after pneumoperitoneum). If there was significant difference between groups, the Mann-Whitney rank sum test can be performed for the difference between groups at each time point. P <0.05 was considered statistically significant. Mean, standard deviation, percentages, student's t-test and the Fisher's exact test are used for statistical comparisons. P < 0.05 was considered significant.

## RESULTS

The mean duration of pneumoperitoneum is comparable in both groups and found to be statistically insignificant. The comparison of PH of the patients in both the groups are compared and found to be statistically insignificant. [Table 2]

The comparison of PH and PACO2 of the patients in both the groups are compared and found to be statistically insignificant. The comparison of PAO2 of the patients in both the groups are compared and found to be statistically insignificant. The comparison of PaO2 in both the groups before pneumoperitoneum, 15 minutes after pneumoperitoneum, 30 minutes after pneumoperitoneum were statistically significant. [Table 3]

The comparison of MAP in both the groups after intubation, during ARS, 15 minutes after pneumoperitoneum, 30 minutes after pneumoperitoneum shows a difference and were statistically significant. [Table 4]

The comparison of PIP in both the groups before pneumoperitoneum is statistically insignificant, 15 minutes after pneumoperitoneum, 30 minutes after pneumoperitoneum shows a difference and were statistically significant. [Table 5]

The comparison of static compliance in both the groups before pneumoperitoneum shows statistical insignificance, 15 minutes after pneumoperitoneum, 30 minutes after pneumoperitoneum shows a difference and were statistically significant. [Table 6]

The comparison of PaO2/FiO2 in both the groups before pneumoperitoneum, 15 minutes after pneumoperitoneum, 30 minutes after pneumoperitoneum shows a difference and were statistically significant. [Table 7]

**Table 1: Patient details Distribution**

| Age Group | Group C | Group P |
|---|---|---|
| <=30 | 2 | 3 |
| 31-40 | 6 | 9 |
| >40 | 22 | 18 |
| Mean | 42.87 | 40.93 |
| SD | 7.40 | 8.20 |
| P - Value | 0.299 Not Significant | |
| **Weight** | | |
| <=45 | 2 | 2 |
| 46-55 | 17 | 16 |
| >55 | 11 | 12 |
| Mean | 52.17 | 52.47 |
| SD | 5.00 | 5.25 |
| P - Value | 0.705 Not Significant | |

**Table 2: Tidal Volume and duration of Pneumoperitoneum**

| Tidal Volume | Group C | Group P | P - Value |
|---|---|---|---|
| Mean | 515.33 | 526 | 0.499 |
| Standard deviation | 47.18 | 53.79 | |
| **Duration of Pneumoperitoneum** | | | |
| Mean | 39.23 | 39.4 | 0.828 |
| Standard deviation | 5.12 | 4.12 | |

**Table 3: PH, PACO2 and PAO2 levels in both groups**

| PH | Group C | | Group P | | P - value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| BEFORE PP | 7.48 | 0.07 | 7.49 | 0.08 | 0.394 |
| 15 MINS AFTER PP | 7.44 | 0.09 | 7.45 | 0.12 | 0.279 |
| 30 MINS AFTER PP | 7.41 | 0.07 | 7.44 | 0.09 | 0.403 |
| **PACO2** | | | | | |
| BEFORE PP | 35.5 | 2.81 | 35.57 | 3.19 | 0.982 |
| 15 MINS AFTER PP | 36.8 | 3.14 | 36.77 | 2.75 | 0.982 |
| 30 MINS AFTER PP | 38.4 | 1.99 | 38.3 | 1.93 | 0.815 |
| **PAO2** | | | | | |
| BEFORE PP | 144.2 | 9.0 2 | 240. 6 | 14.9 1 | < 0.001 |
| 15 MINS AFTER PP | 148.2 | 7.4 8 | 210. 4 | 48.6 8 | < 0.001 |
| 30 MINS AFTER PP | 135.4 3 | 8.2 4 | 170. 6 | 27.0 2 | < 0.001 |

**Table 4: Comparison of Mean Arterial Pressure (MAP)**

| MAP | Group C | | Group P | | P - value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| AFTER INTUBATION | 98.3 | 0.99 | 99.36 | 0.925 | 0.95 |
| DURING ARS | 98.9 | 1.06 | 99.56 | 1.506 | 0.395 |
| 15 MINS AFTER PP | 101.93 | 1.31 | 103.04 | 1.012 | 0.006 |
| 30 MINS AFTER PP | 95.03 | 1.88 | 96.24 | 1.865 | 0.012 |

**Table 5: Comparison of Peak Inspiratory Pressure (PIP)**

| PIP | Group C | | Group P | | P - value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| BEFORE PP | 14.63 | 1.45 | 13.96 | 1.74 | 0.49 |
| 15 MINS AFTER PP | 24.8 | 1.3 | 22.56 | 2.25 | < 0.001 |
| 30 MINS AFTER PP | 25.5 | 3.71 | 22.88 | 3.47 | 0.006 |

**Table 6: Comparison of Static Compliance**

| Static Compliance | Group C | | Group P | | P - value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| BEFORE PP | 57.23 | 5.91 | 61.2 | 4.89 | 0.106 |
| 15 MINS AFTER PP | 29.6 | 2.14 | 32.44 | 3.65 | 0.002 |
| 30 MINS AFTER PP | 28.53 | 3.1 | 31.16 | 4.94 | 0.042 |

**Table 7: Comparison of PaO2/FiO2 (PF ratio)**

| PaO2/FiO2 | Group C | | Group P | | P - value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| BEFORE PP | 411.33 | 25.64 | 687.429 | 86.04 | < 0.001 |
| 15 MINS AFTER PP | 412.38 | 25.95 | 601.143 | 101.08 | < 0.001 |
| 30 MINS AFTER PP | 385.99 | 23.58 | 487.429 | 99.5 | < 0.001 |

## DISCUSSION

In this study the effect of an ARS before gas insufflation during laparoscopic surgery improved oxygenation, without an increase of airway pressure, patients undergoing laparoscopy surgeries are predisposed to decrease in arterial oxygenation because of basal atelectasis, reduced functional residual capacity induced by general anaesthesia, mechanical ventilation and surgical positioning. Takahata et al,[4] observed the decrease in Pa02 during pneumoperitoneum, even in young patients. It has been reported that a longer duration of intraperitoneal gas insufflation decreases Pa02. Healthy subjects in our study had a similar result and Pa02 decreased mildly after 30 minutes with pneumoperitoneum. It has been known that alveolar recruitment with PEEP during general anaesthesia is effective in improving arterial oxygenation. Alveolar recruitment therapy produces re-expansion of atelectasis occurring due to general anaesthesia and PEEP prevents the redevelopment of atelectasis. Pang et al,[5] reported that an ARS applied during laparoscopic cholecystectomy improved arterial oxygenation compared with conventional ventilation. Whalen et al,[6] applied an alveolar recruitment manoeuvre using 12 cmH2O PEEP in morbidly obese patients and found that this ARS was very effective in improving intraoperative oxygenation. However, due to the ARS, the peak airway pressure rose to 42

cm H2O during laparoscopy, even in the supine position. Higher peak and mean airway pressures presumably caused the hypotension requiring treatment noted in that study, with patients receiving the ARS needing more vasopressor. High airway pressure and PEEP are also reported as risk factors for lung barotrauma, especially among patients with lung disease.[7] In our study, the ARS was conducted only before CO2 insufflation and no PEEP was applied during pneumoperitoneum, even though PEEP during surgery is an effective method of improving oxygenation. The main advantage of ARS before CO2 insufflation over intraoperative ARS appears to be avoidance of further increase in airway pressure, which could increase the risk of ventilator induced lung injury and hemodynamic compromise. We postulated that anaesthesia-induced alveolar collapse could be fully reversed before CO2 insufflation, such that the beneficial effect would be long-lasting despite the detrimental effects of pneumoperitoneum. We found that ARS before CO2 insufflation kept arterial oxygenation higher during pneumoperitoneum without additional airway pressure increases or Hemodynamic compromise.

Broadly there are two ways of performing an ARM: sustained inflation of the lungs up to 40 seconds to a defined peak inspiratory pressure or by a stepwise increment in PEEP.[7] The hemodynamic outcomes of ARM in anesthetised patients have not been much studied. Two studies in hemodynamically stable cardiac patients, using ARM with sustained lung inflation, showed a significant reduction in cardiac output and left ventricular end-diastolic area.[8,9] In obese patients under general anesthesia, a strategy of higher PEEP with ARMs versus lower PEEP did not show any difference in PPCs. However, intraoperative hypotension was more frequent in the high PEEP group, suggesting that some amount of permissive atelectasis should be accepted.[11,12] Biais et al. showed that the magnitude of SV decrease (20% versus 43%) during an ARM could predict preload responsiveness in mechanically ventilated patients in the operating room.[13]

This study had some limitations. First, the between-group Pa02 after 45 minutes of pneumoperitoneum could not be compared, because only 4 patients remained at this time. The risk of hypoxemia becomes greater when the duration of pneumoperitoneum is longer.[6,7] Even though the mean value of Pa02 at 45 minutes in group P was higher than that of group C (149 mmHg vs 127 mmHg), this was not significant and statistical power was low. In a computer model of absorption atelectasis, the time to collapse in a lung unit filled with 30% oxygen was estimated to be three hours. Rothen et al,[14] used computed tomography to assess the extent of atelatasis, which recurred after recruitment manoeuvres. They observed that a recruitment manoeuvre with 40% oxygen in nitrogen virtually eliminated atelectasis for at least 40 minutes, so the preventive effect of ARS before pneumoperitoneum may persist in surgery of longer duration, such as laparoscopic colectomy. Second, the effect of ARS during pneumoperitoneum may be more important and more pronounced in the elderly, obese and those with impaired respiratory function.

## CONCLUSION

In conclusion, pre-emptive ARS before gas insufflation may be useful in improving arterial oxygenation without additional increase in airway pressure in laparoscopic surgeries.

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