

Research Paper: Effects of Low Pressure of Laparoscopic Cholecystectomy on Arterial Pressure of Carbon Dioxide and Mean Blood Pressure



Behzad Nematihonar¹, Nasser Malekpour¹, Morteza Hashemian², Amirhosein Jalaeifar¹, Alireza Mirkheshti^{3*}, Shahram Sayadi³

1. Department of General Surgery, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

2. Department of Anesthesiology, Faculty of Medicine, Kerman University of Medical Sciences, Kerman, Iran.

3. Department of Anesthesiology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran.



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ABSTRACT

Background: The effect of low pressure pneumoperitoneum in laparoscopic cholecystectomy on partial pressure of carbon dioxide in the arterial blood (PaCO₂) is an important subject which has not been completely defined.

Methods: In a double-blind clinical trial, we randomly studied 202 ASA (The ASA physical status classification system) class 1, 2 patients aged between 20 and 85 years who were candidates for elective laparoscopic cholecystectomy. They were randomly divided into two groups of low pressure pneumoperitoneum (6-8 mm Hg) and standard pressure pneumoperitoneum (12-14 mm Hg). By the same general anesthesia protocol in the two groups, PaCO₂ was assessed before CO₂ insufflation and desufflation. Mean Arterial blood Pressure (MAP) was measured in the two groups.

Results: PaCO₂ was not significantly different between the 2 groups before CO₂ insufflation. But, PaCO₂ was statistically lower in low pressure pneumoperitoneum group before CO₂ desufflation (P= 0.001). Mean Arterial Pressure (MAP) in standard pressure pneumoperitoneum group was lower than the low pressure pneumoperitoneum group at 5 and 10 minutes after CO₂ insufflation and before the time of CO₂ desufflation (P=0.001, P=0.006 and P=0.001, respectively). While, MAP was not statistically different between the two groups before CO₂ insufflation (P=0.55).

Conclusion: Low pressure pneumoperitoneum during laparoscopic cholecystectomy can be an effective protocol to prevent the rise of PaCO₂ by preserving the hemodynamic status in such cases.

* Corresponding Author:

Alireza Mirkheshti, MD

Address: Department of Anesthesiology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Tel: +98 (21) 77567840

E-mail: drmirkheshti@gmail.com

1. Introduction

Laparoscopic surgery is one of the most important procedures for diagnosis and treatment of abdominal and pelvic lesions. The most common gas used during laparoscopy is Carbon Dioxide (CO₂). Insufflated CO₂ is absorbed and may increase pCO₂ which is further exacerbated by V/Q mismatch [1]. There are noticeable reports about the side effects of CO₂ insufflation during laparoscopy such as CO₂ pneumothorax, pulmonary emphysema, pneumomediastinum, pneumopericardium, and CO₂ embolism, etc. [2-7].

Standard pressure pneumoperitoneum in laparoscopic surgery is defined when the pneumoperitoneum is maintained between 12 to 16 mm Hg and low pressure pneumoperitoneum is generally defined as an intra-abdominal pressure of 6–10 mm Hg [8-11]. Several studies compared the differences between standard pressure pneumoperitoneum and low pressure pneumoperitoneum in different conditions, such as postoperative nausea and vomiting, shoulder pain, pulmonary and liver function [12-15]. Further studies are required to use low pressure pneumoperitoneum during laparoscopy [16].

As there are limited research about comparison of the partial pressure of carbon dioxide in the arterial blood between standard and low peritoneal pressure during laparoscopic cholecystectomy, which is one of the most prevalent laparoscopic surgeries, we aimed to compare the effect of different pressures of pneumoperitoneum on PaCO₂ to detect whether decreasing CO₂ pressure could affect blood gas analysis during such operations.

2. Materials and Methods

A double-blind clinical trial was conducted on, 202 (The ASA physical status classification system) American Society of Anesthesiologists (ASA) classification I, II participants aged between 20 and 85 years who were candidates for elective laparoscopic cholecystectomy. Study participants were randomly divided into two groups of low pressure pneumoperitoneum (6-8 mm Hg) and standard pressure pneumoperitoneum (12-14 mm Hg). Exclusion criteria consisted of cases of pregnancy, cholangitis, carcinomas, history of previous laparotomy, addiction or mental illnesses, laparoscopic procedures converted to open cholecystectomy or occurrence of intraoperative bleeding of more than 500 mL, and the operation time of more than two hours.

All patients were monitored by ECG, blood pressure and cerebral state index, SpO₂ and end-tidal CO₂ (ETCO₂) monitoring. Two samples of arterial blood gas were taken at the beginning of operation before CO₂ insufflation and at the end of operation before CO₂ desufflation to assess partial pressure of carbon dioxide (PaCO₂) in the arterial blood. Midazolam 0.02 mg/kg and fentanyl 2 µg/kg IV were injected as premedication. Induction of anesthesia was performed by propofol 1-2 mg/kg and atracurium 0.5 mg/kg IV. Anesthesia was maintained by propofol 100-150 µg/kg/h and remifentanyl 0.1 µg/kg/h, in order to keep the BIS score between 40 and 60. Ventilator set up was the same in both groups. All patients received Ringer's solution infusion as hydrating agent compatible to intraoperative fluid therapy management. Duration of laparoscopy was defined as the time between CO₂ insufflation and CO₂ desufflation.

Statistical analysis

In order to detect the mean difference of 1.2 ETCO₂, a sample size of 101 patients was calculated for each group, with an α value of 0.05, and within group standard deviation of 3.1 and a power of 80%. The results were expressed as Mean±SD for continuous variables and frequency (percentage) to express categorical variables. Continuous variables were compared with t test. Categorical variable was gender. Variables were compared using the Chi-square test. All the statistical analysis were done in SPSS V. 16. P<0.05 were considered as statistically significant.

3. Results

Mean±SD values for age, the Body Mass Index (BMI) and duration of laparoscopy (min), in low and standard pressure pneumoperitoneum groups of patients and number of male and female participants are presented in Table 1. Kolmogorov–Smirnov test shows that the assumption of normality is met. Results of the t test indicate no significant differences between the two groups in respect with the demographic characteristics. Also, Chi-square test indicates no significant difference between genders.

ETCO₂ was assessed between the two groups at different times. The t test indicates no significant difference in terms of ETCO₂ between low pressure pneumoperitoneum and standard pressure pneumoperitoneum groups before CO₂ insufflation. But ETCO₂ was statistically lower in low pressure pneumoperitoneum group than the standard pressure group, before desufflation of CO₂ (P=0.001) (Table 2).

Table 1. Demographic characteristic of two groups of patients

Variables	Mean±SD (n=101)		P
	Low Pressure Pneumoperitoneum	Standard Pressure Pneumoperitoneum	
Age, y	44.5±7.8	45.3±8.4	0.24
Sex (Male/Female)	35/ 66	34/ 67	0.68
BMI, kg/m ²	26.7±3.6	26.9±4.1	0.33
Duration of laparoscopy, Min	32.5±8.2	31.6±7.47	0.25

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Table 2. ETCO₂ of patients at different times

ETCO ₂	Mean±SD (n=101)		P
	Low Pressure Pneumoperitoneum	Standard Pressure Pneumoperitoneum	
Before CO ₂ insufflation	29.5±3.2	30.4±3.2	0.55
5 min after insufflation	37.3±2.5	37.8±2.6	0.38
10 min after insufflation	36.8±2.7	37.1±2.5	0.48
Before CO ₂ desufflation	31.5±3.1	34.6±3.4	0.001

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According to t test, PaCO₂ was the only significant different parameter between the two groups, during the two times of arterial blood sampling (before CO₂ insufflation-desufflation). PaCO₂ had no significant difference between the two groups before CO₂ insufflation. However, PaCO₂ was statistically lower in the low pressure pneumoperitoneum group before CO₂ desufflation (P=0.001) (Table 3).

As Table 4 presents, Man Arterial Pressure (MAP) was lower in the standard pressure pneumoperitoneum group than the low pressure pneumoperitoneum group at 5 and 10 minutes after CO₂ insufflation and before the time of CO₂ desufflation (P=0.001, P=0.006 and P=0.001, respectively), while MAP was not statistically different between the two groups before CO₂ insufflation (P=0.55).

4. Discussion

This study assessed the effect of low pressure pneumoperitoneum in PaCO₂ during laparoscopic cholecys-

tectomy. Our study showed that after a period of CO₂ insufflation, PaCO₂ was significantly higher among the patients who had laparoscopic cholecystectomy under standard pressure of CO₂, compared to those with low pressure pneumoperitoneum. Moreover, ETCO₂ trending was compatible with PaCO₂, because the value of ETCO₂ was less than standard pressure pneumoperitoneum at the time of CO₂ desufflation, in the group of low pressure pneumoperitoneum. Our assessment about mean arterial pressure in both groups showed that MAP in the low pressure pneumoperitoneum group was better preserved than the standard pressure pneumoperitoneum group, during the laparoscopic operation.

There are few studies available, about the effects of low pressure pneumoperitoneum on PaCO₂. Sefr R et al. assessed two different standard pressures of 10 and 15 mm Hg insufflation pressures in laparoscopic cholecystectomy on arterial blood gas changes and reported no statistical differences in acid-base balance (pH, pCO₂,

Table 3. PaCO₂ of patients before CO₂ insufflation and desufflation

PaCO ₂	(n=101), Mean±SD		P
	Low Pressure Pneumoperitoneum	Standard Pressure Pneumoperitoneum	
Before CO ₂ insufflation	27.8±3.7	28.2±3.5	0.21
Before CO ₂ desufflation	31.4±3.5	34.8±3.6	0.001

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Table 4. Mean arterial pressure of patients at different times

MAP	(n=101), Mean±SD		P
	Low Pressure Pneumoperitoneum	Standard Pressure Pneumoperitoneum	
Before CO ₂ insufflation	95.3±8.5	95.8±8.3	0.55
5 minutes after CO ₂ insufflation	76.2±4.4	70.5±4.7	0.001
10 minutes after CO ₂ insufflation	77.4±5.7	72.7±5.4	0.006
Before CO ₂ desufflation	79.4±5.4	72.5±4.1	0.001

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pO₂, Base Excess [BE] and HCO₃) [17]. Another study assessed PH, PaCO₂, PaO₂, HCO₃, alkalinity (BE) and MAP between two groups of patients who underwent laparoscopic cholecystectomy by intraperitoneal pressure of 12 mm Hg and 20 mm Hg and showed statistical differences in MAP and other parameters between the two groups, but the differences were transient and within normal limit, with no clinical impact on patients [18].

The above-mentioned studies that assessed acid-base parameters in different intraperitoneal pressure within the standard pressure pneumoperitoneum limit, are in contrast with our study in which we assessed the PaCO₂ between low pressure pneumoperitoneum and standard pressure pneumoperitoneum. The results of our survey were in favor with these two studies about the absence of any clinical impact of different pressures on patients and the changes were ranged in the normal and safe limits.

Hemodynamic effects of gas insufflation in laparoscopic surgeries have been assessed well. Hemodynamic insults secondary to increased intra-abdominal pressure such as increased afterload and preload and decreased cardiac output accompanied by ventilatory consequences, including increased airway pressures, decreased pulmonary compliance and hypercarbia, have been investigated. Hemodynamic effects aggravate in patients with previous cardiovascular diseases like congestive heart failure, ischemic heart disease, valvular disease, pulmonary hypertension, or congenital heart disease [19]. Low pressure pneumoperitoneum has fewer effects on blood pressure- both systolic and diastolic- in comparison with standard pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy [20]. Moreover, the effects of low pressure pneumoperitoneum on stress responses during laparoscopic operations have been investigated [21] which may influence hemodynamic parameters. Our study about the effect of low pressure pneumoperitoneum on MAP was in line with other stud-

ies which showed the lower hemodynamic alteration in comparison with standard pressure pneumoperitoneum.

Laparoscopic cholecystectomy can be completed successfully by applying low pressure pneumoperitoneum in approximately 90% of cases. However, no evidence is still available to assert using of low pressure pneumoperitoneum in low-risk patients undergoing elective laparoscopic cholecystectomy. Thus, further investigations are specially required in people with cardiopulmonary disorders who undergo laparoscopic cholecystectomy [22].

Our study showed the protective effects of low pressure pneumoperitoneum on preventing the rise of PaCO₂ during laparoscopic cholecystectomy. The effects of such outcome should be assessed by further studies in patients with pulmonary diseases in which increased PaCO₂ may result in noticeable post-operative complications among them. We did not use intra-arterial catheter to prevent the probable hazards of the catheter and only had two samples of arterial blood gas. Therefore, we recommend future studies to have more blood gas samples from patients who have intra-arterial catheter during laparoscopic cholecystectomy to assess the effects of low CO₂ pressure at different times of laparoscopy.

5. Conclusion

Low pressure of pneumoperitoneum in laparoscopic cholecystectomy can be a preventive measure against the partial pressure increase of carbon dioxide in arterial blood and an appropriate way to preserve mean arterial blood pressure during such operations.

Ethical Considerations

Compliance with ethical guidelines

We obtained approval from the Ethics Committee of Shahid Beheshti University of Medical Sciences and written consent from all patients.

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Conflict of interest

The authors certify that they have no affiliation with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

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