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

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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 ($PaCO_2$) 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, $PaCO_2$ was assessed before CO_2 insufflation and desufflation. Mean Arterial blood Pressure (MAP) was measured in the two groups.

Results: $PaCO_2$ was not significantly different between the 2 groups before CO_2 insufflation. But, $PaCO_2$ was statistically lower in low pressure pneumoperitoneum group before CO_2 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 CO_2 insufflation and before the time of CO_2 desufflation (P=0.001, P=0.006 and P=0.001, respectively). While, MAP was not statistically different between the two groups before CO_2 insufflation (P=0.55).

Conclusion: Low pressure pneumoperitoneum during laparoscopic cholecystectomy can be an effective protocol to prevent the rise of $PaCO_2$ by preserving the hemodynamic status in such cases.

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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 (CO_2). Insufflated CO_2 is absorbed and may increase pCO_2 which is further exacerbated by V/Q mismatch [1]. There are noticeable reports about the side effects of CO_2 insufflation during laparoscopy such as CO_2 pneumothorax, pulmonary emphysema, pneumomediastinum, pneumopericardium, and CO_2 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 $PaCO_2$ to detect weather decreasing CO_2 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, SpO_2 and end-tidal CO_2 ($ETCO_2$) monitoring. Two samples of arterial blood gas were taken at the beginning of operation before CO_2 insufflation and at the end of operation before CO_2 desufflation to assess partial pressure of carbon dioxide ($PaCO_2$) 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 remifentanil 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 CO_2 insufflation and CO_2 desufflation.

Statistical analysis

In order to detect the mean difference of 1.2 $ETCO_2$, 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.

$ETCO_2$ was assessed between the two groups at different times. The t test indicates no significant difference in terms of $ETCO_2$ between low pressure pneumoperitoneum and standard pressure pneumoperitoneum groups before CO_2 insufflation. But $ETCO_2$ was statistically lower in low pressure pneumoperitoneum group than the standard pressure group, before desufflation of CO_2 ($P=0.001$) (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

International Journal of
Medical Toxicology & Forensic Medicine

Table 2. $ETCO_2$ 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

International Journal of
Medical Toxicology & Forensic Medicine

According to t test, $PaCO_2$ was the only significant different parameter between the two groups, during the two times of arterial blood sampling (before CO_2 insufflation-desufflation). $PaCO_2$ had no significant difference between the two groups before CO_2 insufflation. However, $PaCO_2$ was statistically lower in the low pressure pneumoperitoneum group before CO_2 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 CO_2 insufflation and before the time of CO_2 desufflation (P=0.001, P=0.006 and P=0.001, respectively), while MAP was not statistically different between the two groups before CO_2 insufflation (P=0.55).

4. Discussion

This study assessed the effect of low pressure pneumoperitoneum in $PaCO_2$ during laparoscopic cholecystectomy. Our study showed that after a period of CO_2 insufflation, $PaCo_2$ was significantly higher among the patients who had laparoscopic cholecystectomy under standard pressure of CO_2, compared to those with low pressure pneumoperitoneum. Moreover, $ETCO_2$ trending was compatible with $PaCO_2$, because the value of $ETCO_2$ was less than standard pressure pneumoperitoneum at the time of CO_2 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 pneumoperitueneum group, during the laparoscopic operation.

There are few studies available, about the effects of low pressure pneumoperitoneum on $PaCO_2$. 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, pCO_2,

Table 3. $PaCO_2$ of patients before CO_2 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

International Journal of
Medical Toxicology & Forensic Medicine

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

International Journal of Medical Toxicology & Forensic Medicine

pO_2, Base Excess [BE] and HCO_3) [17]. Another study assessed PH, $PaCO_2$, PaO_2, HCO_3, 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 $PaCO_2$ 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 studies 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 $PaCO_2$ during laparoscopic cholecystectomy. The effects of such outcome should be assessed by further studies in patients with pulmonary diseases in which increased $PaCO_2$ 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 CO_2 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 dismissed in this manuscript.

Reference

[1] Hayden P, Cowman S. Anaesthesia for laparoscopic surgery. Continuing Education in Anaesthesia Critical Care & Pain. 2011; 11(5):177–80. [DOI:10.1093/bjaceaccp/mkr027]

[2] Root B, Levy MN, Pollack S, Lubert M, Pathak K. Gas embolism death after laparoscopy delayed by "trapping" in portal circulation. Anesthesia & Analgesia. 1978; 57(2):232–237. [DOI:10.1213/00000539-197803000-00014]

[3] Cottin V, Delafosse B, Viale JP. Gas embolism during laparoscopy: A report of seven cases in patients with previous abdominal surgical history. Surgical Endoscopy. 1996; 10(2):166–9. [DOI:10.1007/BF00188365] [PMID]

[4] Song SO. Anesthetic management for laparoscopic cholecystectomy. Korean Journal of Anesthesiology. 2004; 47(1):1–11. [DOI:10.4097/kjae.2004.47.1.1]

[5] Cobb WS, Fleishman HA, Kercher KW, Matthews BD, Heniford BT. Gas embolism during laparoscopic cholecystectomy. Journal of Laparoendoscopic & Advanced Surgical Techniques. 2005; 15(4):387–90. [DOI:10.1089/lap.2005.15.387] [PMID]

[6] Diakun TA. Carbon dioxide embolism: Successful resuscitation with cardiopulmonary bypass. Anesthesiology. 1991; 74(6):1151–2. [DOI:10.1097/00000542-199106000-00028] [PMID]

[7] Gutt CN, Oniu T, Mehrabi A, Schemmer P, Kashfi A, Kraus T, et al. Circulatory and respiratory complications of carbon dioxide insufflation. Digestive Surgery. 2004; 21(2):95–105. [DOI:10.1159/000077038] [PMID]

[8] Schietroma M, Carlei F, Mownah A, Franchi L, Mazzotta C, Sozio A, et al. Changes in the blood coagulation, fibrinolysis, and cytokine profile during laparoscopic and open cholecystectomy. Surgical Endoscopy. 2004; 18(7):1090–6. [DOI:10.1007/s00464-003-8819-0]

[9] Ibraheim OA, Samarkandi AH, Alshehry H, Faden A, Farouk EO. Lactate and acid base changes during laparoscopic cholecystectomy. Middle East Journal of Anesthesiology. 2006; 18(4):757–68. [PMID]

[10] Esmat ME, Elsebae MMA, Nasr MMA, Elsebaie SB. Combined low pressure pneumoperitoneum and intraperitoneal infusion of normal saline for reducing shoulder tip pain following laparoscopic cholecystectomy. World Journal of Surgery. 2006; 30(11):1969–73. [DOI:10.1007/s00268-005-0752-z]

[11] Eryılmaz HB, Memiş D, Sezer A, Inal MT. The effects of different insufflation pressures on liver functions assessed with LiMON on patients undergoing laparoscopic cholecystectomy. The Scientific World Journal. 2012; 2012:1–5. [DOI:10.1100/2012/172575]

[12] Nasajiyan N, Javaherfourosh F, Ghomeishi A, Akhondzadeh R, Pazyar F, Hamoonpou N. Comparison of low and standard pressure gas injection at abdominal cavity on postoperative nausea and vomiting in laparoscopic cholecystectomy. Pakistan Journal of Medical Sciences. 2014; 30(5): 1083–7. [PMID] [PMCID]

[13] Gurusamy KS, Samraj K, Davidson K. Low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy. Cochrane Database of Systematic Reviews; 2009. [DOI:10.1002/14651858.cd006930.pub2]

[14] Park JS, Ahn EJ, Ko DD, Kang H, Shin HY, Baek CH, et al. Effects of pneumoperitoneal pressure and position changes on respiratory mechanics during laparoscopic colectomy. Korean Journal of Anesthesiology. 2012; 63(5):419–24. [DOI:10.4097/kjae.2012.63.5.419]

[15] Hasukic S. Postoperative changes in liver function tests: Randomized comparison of low- and high-pressure laparoscopic cholecystectomy. Surgical Endoscopy. 2005; 19(11):1451–5. [DOI:10.1007/s00464-005-0061-5]

[16] Özdemir-van Brunschot DMD, van Laarhoven KCJHM, Scheffer GJ, Pouwels S, Wever KE, Warlé MC. What is the evidence for the use of low-pressure pneumoperitoneum? A systematic review. Surgical Endoscopy. 2015; 30(5):2049–65. [DOI:10.1007/s00464-015-4454-9] [PMID] [PMCID]

[17] Sefr R, Puszkailer K, Jagos F. Randomized trial of different intraabdominal pressures and acid-base balance alterations during laparoscopic cholecystectomy. Surgical Endoscopy. 2003; 17(6):947-50. [DOI:10.1007/s00464-002-9046-9] [PMID]

[18] Hypolito O, Azevedo JL, Gama F, Azevedo O, Miyahira SA, Pires OC, et al. Effects of elevated artificial pneumoperitoneum pressure on invasive blood pressure and levels of blood gases. Brazilian Journal of Anesthesiology. 2014; 64(2):98-104. [DOI:10.1016/j.bjane.]

[19] Atkinson TM, Giraud GD, Togioka BM, Jones DB, Cigarroa JE. Cardiovascular and ventilatory consequences of laparoscopic surgery. Circulation. 2017; 135(7):700–10.[DOI:10.1161/CIRCULATIONAHA.116.023262]

[20] Singh SP, Verma S, Pandey A, Shukla U, Gupta V, Singh P, et al. Comparative evaluation of hemodynamic and capnographic changes in low pressure versus normal pressure pneumoperitoneum in laparoscopic cholecystectomy.International Surgery Journal. 2017; 4(8):2642-7. [DOI:10.18203/2349-2902.isj20173186]

[21] Niu X, Song X, Su A, Zhao S, Li Q. Low-pressure capnoperitoneum reduces stress responses during pediatric laparoscopic high ligation of indirect inguinal hernia sac. A randomized controlled study. Medicine. 2017; 96(14):e6563. [DOI:10.1097/MD.0000000000006563] [PMID] [PMCID]

[22] Gurusamy KS, Vaughan J, Davidson BR. Low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy. Cochrane Database of Systematic Reviews. 2014; (3):CD006930. [PMID]

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