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Original Research Article

Postoperative outcome and hemodynamic changes in high versus low pressure to pneumoperitoneum in patients undergoing laparoscopic cholecystectomy

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ABSTRACT

Background: A pneumoperitoneum is created by insufflating a gas (usually carbon dioxide) into the peritoneal cavity during laparoscopic surgery. Intra-abdominal pressure (IAP) rises as a result of this. At a rate of 4–6 liter min^{-1}, carbon dioxide is insufflated into the peritoneal cavity at a pressure of 10–20 mm Hg. Aim of the research was to compare the hemodynamic effects and the level of post-operative symptoms due to high pressure and low-pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy.
Methods: 60 patients fulfilling inclusion criteria who were posted for elective cholecystectomy under general anaesthesia were divided into two groups, 30 patients in each group. Group L included pneumoperitoneum created with intra-abdominal pressure of 7-10 mmHg, and group H included pneumoperitoneum created with intra-abdominal pressure of 12-14 mmHg. Variables such as the systolic blood pressure, diastolic blood pressure, heart rate, end-tidal CO_2, the level of post-operative abdominal pain, shoulder-tip pain, nausea and vomiting, and the liver function test were compared between the two groups.
Results: Between groups, no statistical difference has been noted in the demographic characters of the patient. There was a statistical difference of intraoperative and post-operative systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) between groups. End-tidal CO_2 was compared between the two groups during the surgery and a significant difference regarding $EtCO_2$. Liver function tests showed a significant difference in all measured factors after surgery between the two groups.
Conclusions: Low-pressure pneumoperitoneum decreases hemodynamic complications. Post-operative abdominal pain, shoulder tip pain, nausea and vomiting are reduced.

Keywords: Gallstone, High-pressure pneumoperitoneum, Laparoscopic cholecystectomy, Low-pressure pneumo-peritoneum

INTRODUCTION

Almost 10% of the population has gallstones, and laparoscopic cholecystectomy is the gold standard surgical method to treat gallstones.[1] The following advantages of this surgical procedure have encouraged patients and surgeons towards it: short hospital stay, less side effects, lower post-surgery pain, rapid return to normal activities and mortality less than 1%.[2,3]

To obtain satisfactory results, the site of surgery should be clearly viewed during laparoscopic cholecystectomy. Pneumoperitoneum is one of these methods to provide this condition. In this method, CO_2 enters the peritoneal cavity

and pressure is kept constant up to the end of the surgery till the ports are removed. The standard pressure in pneumoperitoneum is 12-14 mmHg; it is also associated with complications that usually happen following the prolonged and difficult surgeries due to head-down position and pneumoperitoneum; for example, reduced lung capacity, hemodynamic complications, changes in the concentration of arterial blood gases, increased liver enzymes, renal failure, post-operative abdominal and shoulder-tip pain.[4-6]

Recently, to reduce the complications, surgeons tend to use gases with 7-10 mmHg pressure instead of the standard high pressure. Using lower pressure obtains good results such as less post-op abdominal and shoulder tip pain, less pulmonary complications. On the other hand, using lower pressure limits clear viewing of the surgical site and jeopardizes the surgeon's comfort.[7] Considering the advantages of laparoscopic cholecystectomy, the current study aimed to compare the hemodynamic effects due to high –and low-pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy.

Aim of the research was to compare the hemodynamic effects and the level of post-operative symptoms due to high pressure and low-pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy.

METHODS

The prospective, randomized, single-blind comparative study was done in patients undergoing laparoscopic cholecystectomy at Sree Balaji Medical College and Hospital between December 2019 and May 2020 will be assessed for inclusion and exclusion criteria and will be included in the study after obtaining written informed consent

The sample was determined based on the study "comparative study of low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy" authored by Kanwer et al.[8] In our study, 60 subjects will be chosen (n=30 in group H and n=30 in group L).

Inclusion criteria

The study included patients undergoing laparoscopic cholecystectomy of age between 20 to 50 years, males and females, American Society of Anesthesiologists (ASA) class 1 and 2 and patients who have given valid informed consent.

Exclusion criteria

The study excluded patients not satisfying inclusion criteria, patients with rupture of the gallbladder, patients with empyema, patients with common bile duct stones, patients undergoing extensive upper abdominal surgery, pregnant females, patients with body mass index (BMI) >30 and <19, patients with fatty liver grade 3 and 4 and patients with elevated liver enzymes before the surgery.

Patients were selected after applying inclusion and exclusion criteria and were counselled about the risks and benefits involved in the study. After getting Informed consent, patients who were willing to be included in the study were enrolled and analyzed. A total of 60 patients were included in the study. Patients were divided into two groups of 30 patients each.

Group L consisted of pneumoperitoneum created with intra-abdominal pressure of 7-10 mmHg and group H consisted of pneumoperitoneum created with intra-abdominal pressure of 12-14 mmHg.

The standard four-port method, the same surgical method, and general anesthesia protocol was used in both groups. All subjects would change their position or move, if they could, and start eating 12 hours after the surgery. None of the subjects were aware of the group type.

The arterial blood pressure and heart rate of the subjects were recorded during the surgery and 1, 3, and 6 hours after the surgery. The end-tidal carbon dioxide level was also recorded during surgery.

Abdominal pain at the site of surgery and shoulder-tip pain was evaluated in both the groups based on the verbal rating scale (VRS) within 1, 3, 6, 12 and 24 hours after the surgery in a way that the level of nausea and vomiting was also recorded in the groups within 1, 3, 6, 12 and 24 hours after the surgery.

To evaluate the level of liver enzymes such as aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), and bilirubin (BIL), the blood samples were obtained from the patients.

Descriptive statistics were done for all data and were reported in terms of mean values and percentages. Suitable statistical tests of comparison were done. Continuous variables were analyzed with the unpaired t-test. Categorical variables were analyzed with the Chi-square test. Statistical significance was taken as $p<0.05$. The data was analyzed using statistical package for the social sciences (SPSS) version 16 and Microsoft excel 2007.

RESULTS

In this study, the information of 60 patients was analyzed. In group H, 16 cases (53.3%) were females and 14 cases (46.7%) were males. In group L, 17 cases (56.7%) were females and 13 cases (43.3%) were males. According to the current study results, there was no significant difference regarding age, height, weight, BMI, and ASA-PS. The class between the two groups of $paCO_2$ of 7-10 mmHg (group L) and $paCO_2$ of 12-14 mmHg (group H) ($p>0.05$-not significant).

The mean of systolic and diastolic blood pressure was compared between the two groups intra-operatively and post-operatively 1, 3, and 6 hours after surgery. There was a significant difference regarding the mean systolic blood pressure ($p<0.001$) and the mean diastolic blood pressure ($p<0.001$) at the above-mentioned intervals between the two groups, comparing the hemodynamic variables using repeated measured analysis of variance (ANOVA) test.

There was a significant difference regarding the mean heart rate between the two groups intra-operatively and post-operatively 1, 3, and 6 hours after surgery ($p<0.001$) according to the results obtained by using repeated measures ANOVA test.

End-tidal CO_2 was compared between the two groups during the surgery and a significant difference regarding $EtCO_2$ was observed between the high pressure and low-pressure groups ($p<0.001$).

The frequency of abdominal and shoulder-tip pain was compared between the two groups at 1, 3, 6, 12 and 24 hours after the surgery using the Chi-square test. According to the obtained results, there was a significant difference regarding the frequency of pain between the two groups at all specified intervals ($p<0.001$).

The frequency of nausea and vomiting was compared between the two groups at 1, 3, 6, 12 and 24 hours after the surgery using the Chi-square test. There was a significant difference between the two groups at all-time intervals after the surgery ($p<0.001$).

Liver function tests such as total bilirubin, direct bilirubin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) were compared between the two groups after the surgery. The liver function tests showed a significant difference regarding the mean of all measured factors after surgery between the two groups ($p<0.001$).

Table 1: Comparison of SBP between the groups and overtime.

SBP	HP		LP		P value
	Mean	SD	Mean	SD	
Pre-OP	127.8	4.7	127.5	5	0.836
Intra-OP	161.6	7.5	127	4.5	<0.001
Post-OP 1 hour	155.1	6.9	125.2	5.5	<0.001
Post-OP 3 hours	148	6.6	120.3	4.7	<0.001
Post-OP 6 hours	139.4	4.9	117.3	5.1	<0.001
Between subjects (groups)					<0.001
Within subjects (over time)					<0.001

Table 2: Comparison of DBP between the groups and overtime.

DBP	HP		LP		P value
	Mean	SD	Mean	SD	
Pre-OP	78.7	5.5	75.7	4.3	0.007
Intra-OP	96.6	4.8	74.9	4	<0.001
Post-OP 1 hour	93.4	4.7	73.7	3.5	<0.001
Post-OP 3 hours	90.2	4.7	72.9	2.7	<0.001
Post-OP 6 hours	86.6	4.8	71.6	2	<0.001
Between subjects (groups)					<0.001
Within subjects (over time)					<0.001

Table 3: Comparison of heart rate between the groups and overtime.

HR	HP		LP		P value
	Mean	SD	Mean	SD	
Pre-OP	88.1	5.7	85.1	6.2	0.019
Intra-OP	105.3	3.8	84.8	6.1	<0.001
Post-OP 1 hour	102.8	3.3	83.8	5.5	<0.001
Post-OP 3 hours	100.1	2.8	83.3	5.8	<0.001
Post-OP 6 hours	96.4	3.1	82.6	5.3	<0.001
Between subjects (groups)					<0.001
Within subjects (over time)					<0.001

Table 4: Mean end tidal CO2 between the two groups.

Group	Total	Mean CO_2	SD	P value
High pressure	30	49.9	2.2	<0.001
Low pressure	30	37.3	1.8	

Table 5: Comparison of pre-operative and post-operative liver function tests between the two groups.

Parameter	HP				P value	LP				P value	P value	
	Pre		Post			Pre		Post			Between subjects	Within subjects
	Mean	SD	Mean	SD		Mean	SD	Mean	SD			
Total bilirubin	0.7	0.1	0.8	0.1	<0.001	0.7	0.1	0.7	0	0.21	<0.001	<0.001
Direct bilirubin	0.27	0.1	0.34	0	<0.001	0.24	0	0.26	0	0.052	<0.001	<0.001
ALT	23.2	2	42.9	3.3	<0.001	23.4	1.7	24.2	1.4	0.197	<0.001	<0.001
AST	25	2.5	44.3	4.1	<0.001	20.6	1.4	21.8	1.8	0.077	<0.001	<0.001
ALP	181.7	8.1	202.3	8	<0.001	192.1	8.1	166.4	10.3	<0.001	<0.001	0.104

DISCUSSION

The current study compared the hemodynamic effects and the level of abdominal pain, shoulder tip pain, nausea and vomiting, and liver function tests using low- and high-pressure carbon dioxide in patients undergoing laparoscopic cholecystectomy.

Results of the current study showed that subjects were similar in both the groups regarding age, gender, height and weight. There was a significant difference between the groups regarding the mean of systolic blood pressure, diastolic blood pressure, and heart rate in the same time intervals. The means of the low-pressure group were lower than those of the high-pressure group ($p<0.05$). The frequencies of abdominal pain and shoulder-tip pain were lower in the low-pressure group. There was a significant difference between the groups regarding nausea and vomiting after the surgery ($p<0.05$).

Laparoscopy is a minimally invasive surgery that is nowadays preferred to open surgery. Laparoscopic surgeries are associated with better maintenance of hemostasis than open surgeries due to top benefits such as more rapid hospital discharge, less post-operative complications, and lower costs. Also, there is lower post-operative pain in laparoscopic surgeries compared to open surgeries. Laparoscopy is widely used in many surgeries; one of them is Laparoscopic cholecystectomy. To perform surgery with better results and avoid a second surgery, the surgical site should be viewed clearly; for better viewing of the surgical site, CO_2 is used. High-pressure CO_2 used during the surgery helps in better viewing of the surgical site. But it is also associated with some complications. Accordingly, several studies are conducted using different CO_2 pressures during the surgery to better view the surgical site and fewer complications.

One of the common complications of laparoscopy is the hemodynamic changes during peritoneal insufflation of carbon dioxide associated with decreased cardiac output, increased systemic vascular resistance, hypertension, heart rate changes, reduced respiratory capacity, and increased airway pressure.

Dexter et al compared the post-operative results obtained from surgeries with 15 and 7 mmHg $PaCO_2$. Accordingly, they reported that the decreased cardiac output, stroke volume, and heart rate changes in the low-pressure group were much lower than those of the high-pressure group. Both groups had good surgical results.[9]

Although laparoscopy was a modern step towards surgery quality improvement and lowered its complications, the pain in difficult laparoscopic surgeries still exists. A new step toward controlling the pain can satisfy the patients.

In the study by Vesakis et al that compared the level of pain between the low-pressure and high-pressure groups, there was no significant difference regarding the level of abdominal pain between the groups; but because of prolonged surgery, the shoulder-tip pain was more in the high-pressure group.[10]

In the current study, abdominal and shoulder-tip pain levels were higher in the high-pressure group than the low-pressure one.

In the study by Kanwer et al they reported a significant difference regarding the level of 12 hours post-operative pain between the groups; it was lower in the low-pressure group.[8]

In another study by Al–Dabbagh et al on the level of post-operative pain in patients undergoing laparoscopic cholecystectomy, patients were categorized into two groups as low-pressure of 8 mmHg and high-pressure of 12 mmHg. Comparing the post-operative pain between the groups showed that the level of 4, 8, 12, and 24-hour post-operative pain in the abdomen and shoulder tip were lower

in the low-pressure group, and the significant difference was observed between them (p=0.01); the results of their study are compatible with those of the current study.[11]

In the study by Hasukic, the level of increased liver enzymes were compared between the groups of $PaCO_2$ of 14 and 7 mmHg gas pressure; the result of his study indicated that the levels of liver enzymes were significantly higher in the high-pressure group 24 hours after the surgery compared with those of the low-pressure group and the rates dropped to the initial level after 48 hours.[12]

There was a significant difference in the mean of liver enzymes after the surgery between both groups in the current study. The results were higher in the high-pressure group than those of the low-pressure group ($p<0.05$).

Limitations

The study has a small sample size. It excludes patients who underwent emergency operations and the procedures which converted to open surgery.

CONCLUSION

Considering the advantages of laparoscopy and also the necessity for peritoneal CO_2 insufflation for better viewing the surgical site, results showed that using low-pressure pneumoperitoneum decreases the hemodynamic complications and also the level of post-operative abdominal pain, shoulder tip pain, nausea and vomiting in patients compared to those of the high-pressure pneumoperitoneum.

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