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An Observational Study Comparing the Clinical Effects of Standard Pressure and Low-Pressure Pneumoperitoneum in Patients Undergoing Laparoscopic Cholecystectomy.

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Abstract

Background: One of the most popular minimally invasive surgical techniques is laparoscopic cholecystectomy, which necessitates the use of CO_2 (Carbon Dioxide) to create pneumoperitoneum. Standard pneumoperitoneum pressures of 12–14 mmHg may produce significant hemodynamic alterations, particularly in patients with cardiopulmonary compromise. A safer option that may lessen physiological stress and postoperative pain while preserving suitable surgical circumstances is low-pressure pneumoperitoneum (8–10 mmHg). The purpose of this study was to compare the clinical outcomes of low-pressure and standard-pressure pneumoperitoneum during laparoscopic cholecystectomy. ***Methods:*** Patients undergoing laparoscopic cholecystectomy were divided into two groups for this prospective observational study: standard-pressure pneumoperitoneum (14 mmHg) and low-pressure pneumoperitoneum (10 mmHg). Heart rate, systolic and diastolic blood pressure, mean arterial pressure, SpO_2 (Oxygen Saturation), and $EtCO_2$ (End-tidal Carbon Dioxide) were among the intraoperative parameters that were tracked and compared between the groups. The length of the procedure was noted. The VAS (Visual Analogue Scale) was used to measure postoperative pain, and the use of analgesics during the first 24 hours following surgery was recorded. ***Results:*** Age, weight, height, and body mass index were all similar across the two groups ($P > 0.05$). Heart rate, systolic and diastolic blood pressure, SpO_2, and $EtCO_2$ were among the intraoperative haemodynamic parameters that did not differ statistically significantly between the groups ($P > 0.05$). Additionally, the length of the procedure was comparable (78.00 ± 13.99 min vs. 74.50 ± 15.77 min; $P = 0.37$). However, in the early postoperative period, the low-pressure group had considerably lower postoperative pain assessments ($P < 0.0001$). The low-pressure group consumed somewhat less analgesics, but this difference was not statistically significant ($P = 0.35$). **Conclusion:** Low-pressure pneumoperitoneum provides comparable intraoperative stability and surgical duration while significantly reducing postoperative pain. It may therefore be considered a safer and more comfortable alternative to standard-pressure pneumoperitoneum, particularly in patients at risk of cardiovascular compromise.

Keywords: Laparoscopic Cholecystectomy, Pneumoperitoneum, Low-Pressure Pneumoperitoneum, Hemodynamic Stability, Postoperative Pain.

INTRODUCTION

Due to its lower postoperative pain, shorter hospital stay, quicker recovery, and better cosmetic results than open surgery, laparoscopic cholecystectomy has emerged as one of the most popular minimally invasive surgical procedures and is currently regarded as the standard treatment for gallbladder diseases.[1] Many intra-abdominal surgeries, such as appendectomy, colectomy, hysterectomy, and cholecystectomy, are frequently performed using laparoscopic techniques. In order to create pneumoperitoneum, which gives the surgeon sufficient working space and vision, CO_2 must be insufflated into the peritoneal cavity.[2] However, the increase in IAP (Intra-Abdominal Pressure) produced by pneumoperitoneum can lead to significant physiological alterations, particularly affecting cardiovascular and pulmonary functions.[3]

Pneumoperitoneum has a biphasic effect on venous return and cardiac output. Initially, redistribution of blood from the splanchnic circulation increases venous return and circulating blood volume. However, with further elevation of intra-abdominal pressure, compression of the inferior vena cava occurs, resulting in reduced venous return and decreased cardiac output. Prolonged exposure to elevated intra-abdominal pressures may therefore impair cardiovascular and pulmonary efficiency.[4] Although these physiological changes are generally well tolerated in healthy individuals with adequate cardiopulmonary reserve, elderly patients and those with pre-existing cardiopulmonary disorders may not tolerate them effectively.

In recent years, the use of low-pressure pneumoperitoneum, usually in the range of 8–10 mmHg, has emerged as an alternative approach to minimize the adverse effects associated with standard-pressure pneumoperitoneum. Lower intra-abdominal pressures are believed to reduce cardiopulmonary stress, improve hemodynamic stability, and decrease postoperative pain and analgesic requirements while still providing adequate surgical exposure.[5] Despite these potential advantages, the available evidence remains inconclusive, and the debate regarding the optimal insufflation pressure continues. Therefore, ongoing research aims to evaluate the clinical outcomes of low-pressure pneumoperitoneum, particularly its effects on hemodynamic stability, postoperative pain, and recovery following laparoscopic procedures.[6]

AIMS AND OBJECTIVES

The study aimed to compare the clinical outcomes of low-pressure and standard-pressure pneumoperitoneum in patients having laparoscopic cholecystectomy. The primary objective was to evaluate and compare intraoperative hemodynamic parameters, including HR (Heart Rate), SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure), MAP (Mean Arterial Pressure), SpO_2 (Oxygen Saturation), and $EtCO_2$ (End-tidal Carbon Dioxide), between the two groups. In order to ascertain whether low-pressure pneumoperitoneum provides a safer and more comfortable option without sacrificing surgical efficacy, the secondary goals were to compare postoperative pain scores, analgesic consumption during the first 24 hours following surgery, and the length of surgery at various pneumoperitoneum pressures.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted in the Department of Anaesthesiology at Dr. B. R. Ambedkar Medical College and Hospital, K G Halli, Bangalore, over a period of 18 months from April 2023 to August 2024. The study compared the clinical effects of standard-pressure and low-pressure pneumoperitoneum on patients undergoing elective laparoscopic cholecystectomy under general anaesthesia at the facility.

Inclusion and Exclusion Criteria

The study comprised patients in the American Society of Anaesthesiologists' (ASA) physical status classes I and II who were listed for elective laparoscopic cholecystectomy under general anaesthesia and were at least eighteen years old. The study excluded patients with a body mass index (BMI) of more than 35 kg/m², pregnant or nursing women, and patients with a known history of cardiovascular disease.

Sample Size Calculation

We kept the power at 80% and confidence interval of 95% and took into consideration the data from the previous published study by Goel A, Gupta S et al.[1]

The sample size calculation was done using the formula

n=2(Zα+Z(1-β))2σ2

(d)2

Where:

Zα= Standard table value for 95% CI = 1.96

Z(1-β) = Standard table value for 80% power = 0.84

σ = Standard deviation = 6.1

d = precision or expected difference = 5

n=2(1.96+0.84)2*(6.1)2

(5)2

N = 23 each group

Assuming loss to follow-up, the total sample size in each group will be 30.

Data Collection Procedure

All eligible patients undergoing laparoscopic cholecystectomy under general anaesthesia provided written informed consent following clearance from the Institutional Ethics Committee (EC-300) and registration with the Clinical Trials Registry of India (CTRI/2023/09/057599). Using computer-generated randomisation, patients who met the inclusion criteria were divided into two groups at random: Standard-pressure pneumoperitoneum (14 mmHg) was given to Group S, while low-pressure pneumoperitoneum (10 mmHg) was given to Group L. A specially created proforma with demographic information, surgical indication, anaesthetic details, intraoperative monitoring, and postoperative follow-up was used to collect data. Heart rate, systolic and diastolic blood pressure, mean arterial pressure, SpO_2, and $EtCO_2$ were among the baseline haemodynamic parameters that were measured before and during surgery. Standardised mechanical ventilation and general anaesthesia were administered to every patient. The VAS was used to measure postoperative pain at regular intervals between 0 and 24 hours following surgery. When the VAS score was higher than three, rescue analgesia with intravenous paracetamol was given, and the timing and dosage of analgesic treatment were recorded. Analgesic use, postoperative pain levels, and surgical duration were all measured and compared between the two study groups.

Statistical Analysis

Descriptive statistical techniques, including mean, median, standard deviation, interquartile range, percentages, tables, and graphs as needed, were used to analyse the gathered data. To identify significant differences between research parameters, inferential statistical analysis was carried out using appropriate parametric tests, such as the Student's t-test and Analysis of Variance (ANOVA), as well as non-parametric tests, such as the Mann-Whitney U test and Chi-square test. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

Table 1: Distribution of Patients According to Age

Age Parameter	Low Pressure Group (n=30)	Standard Pressure Group (n=30)	P value
Mean Age (in years)	31.10 ± 6.64	32.87 ± 6.45	0.30

Table 1 illustrates the comparison of age distribution between the low-pressure and standard-pressure pneumoperitoneum groups. The average age was 31.10 ± 6.64 years for the low-pressure group and 32.87 ± 6.45 years for the standard-pressure group. The fact that the difference was statistically insignificant (P = 0.30) suggests that the two groups' ages were similar.

Table 2: Comparison of Weight, Height and BMI

Parameter	Low Pressure Group	Standard Pressure Group	P value
Weight (kg)	60.30 ± 8.67	63.43 ± 6.76	0.09
Height (m)	1.60 ± 0.07	1.58 ± 0.06	0.11
BMI (kg/m²)	26.27 ± 2.57	28.53 ± 1.99	0.23

The anthropometric factors of the two research groups are compared in Table 2. The standard-pressure group had slightly greater mean weight, height, and BMI, but none of these changes were statistically significant (P > 0.05). This demonstrates that before surgery, the two groups' demographics were similar.

Table 3: Comparison of Intraoperative Hemodynamic Parameters

Parameter	Low Pressure Group	Standard Pressure Group	P-Value
Heart Rate (beats/min)	Comparable	Comparable	>0.05
Systolic BP (mmHg)	Comparable	Comparable	>0.05
Diastolic BP (mmHg)	Comparable	Comparable	>0.05
Mean Arterial Pressure	Comparable	Comparable	>0.05
SpO_2 (%)	Comparable	Comparable	>0.05
$EtCO_2$ (mmHg)	Comparable	Comparable	>0.05

Table 3 demonstrates the comparison of intraoperative hemodynamic parameters between low-pressure and standard-pressure pneumoperitoneum groups. No statistically significant differences were observed in heart rate, systolic blood pressure, diastolic blood pressure, oxygen saturation, or end tidal carbon dioxide levels between the two groups. These findings suggest that low-pressure pneumoperitoneum provides hemodynamic stability comparable to standard pressure.

Table 4: Comparison of Duration of Surgery

Parameter	Low Pressure Group	Standard Pressure Group	P-Value
Duration of Surgery (minutes)	78.00 ± 13.99	74.50 ± 15.77	0.37

Table 4 illustrates the comparison of surgery durations between the two groups. The mean duration of surgery was slightly longer in the low-pressure group (78.00 ± 13.99 minutes) compared to the standard-pressure group (74.50 ± 15.77 minutes). However, the difference was statistically not significant (P = 0.37), indicating that low-pressure pneumoperitoneum did not adversely affect operative time.

Table 5: Comparison of Postoperative VAS Pain Scores

Time Interval	Low Pressure Group	Standard Pressure Group	P-Value
Early Postoperative Hours	Lower VAS Scores	Higher VAS Scores	<0.0001
Late Postoperative Hours	Comparable	Comparable	>0.05

The VAS postoperative pain levels are compared in Table 5. Early postoperative pain scores were considerably lower for patients in the low-pressure pneumoperitoneum group than for those in the standard-pressure group ($P < 0.0001$). This finding indicates improved postoperative comfort with low-pressure pneumoperitoneum.

Table 6: Comparison of Postoperative Analgesic Consumption

Parameter	Low Pressure Group	Standard Pressure Group	P value
Mean Analgesic Requirement	1.33	1.50	0.35

Table 6 compares postoperative analgesic consumption between the study groups. The low-pressure group required slightly less rescue analgesia than the standard-pressure group. However, the difference was statistically not significant ($P = 0.35$). This suggests that although pain scores were lower in the low-pressure group, overall analgesic consumption remained comparable.

Table 7: Comparison of Clinical Outcomes between Study Groups

Clinical Outcome	Low Pressure Pneumoperitoneum	Standard Pressure Pneumoperitoneum
Hemodynamic Stability	Maintained	Maintained
Oxygenation	Adequate	Adequate
Surgical Duration	Comparable	Comparable
Postoperative Pain	Reduced	Higher
Analgesic Requirement	Slightly Lower	Slightly Higher
Surgical Feasibility	Good	Good

Table 7 summarizes the overall clinical outcomes observed in the study. Low-pressure pneumoperitoneum was associated with better postoperative pain control while maintaining comparable intraoperative hemodynamic stability, oxygenation, and duration of surgery. These findings support the use of low-pressure pneumoperitoneum as a safe and effective alternative during laparoscopic cholecystectomy.

Table 8: Summary of Statistical Significance of Study Variables

Variable	Statistical Significance
Age	Not Significant
Weight	Not Significant
Height	Not Significant
BMI	Not Significant
Hemodynamic Parameters	Not Significant
Duration of Surgery	Not Significant
VAS Pain Score	Significant
Analgesic Consumption	Not Significant

Table 8 summarizes the statistical significance of various study variables analyzed between the two groups. Demographic variables, hemodynamic parameters, and duration of surgery showed no statistically significant differences. However, postoperative VAS pain scores were significantly lower in the low-pressure group, highlighting the advantage of low-pressure pneumoperitoneum in improving postoperative patient comfort.

DISCUSSION

The clinical effects of standard-pressure pneumoperitoneum (14 mmHg) and low-pressure pneumoperitoneum (10 mmHg) in patients having laparoscopic cholecystectomy were compared in this study. The primary aim was to evaluate intraoperative hemodynamic changes and postoperative pain between the two groups.

In our study, demographic variables such as age, weight, height, and BMI were comparable between both groups, with no statistically significant difference ($P > 0.05$). This ensured homogeneity between the study populations and minimized confounding factors affecting the outcomes.

Pneumoperitoneum during laparoscopic surgery is known to produce cardiovascular and respiratory changes due to increased intra-abdominal pressure and absorption of carbon dioxide. Particularly at higher pressures, increased intra-abdominal pressure can raise systemic vascular resistance, lower cardiac output, and decrease venous return.[4] "Heart rate, systolic and diastolic blood pressure, SpO_2, and $EtCO_2$ were among the intraoperative haemodynamic parameters in the current investigation that did not differ statistically significantly between the low-pressure and standard-pressure groups. These findings suggest that low-pressure pneumoperitoneum provides adequate hemodynamic stability during laparoscopic cholecystectomy."[7]

Our findings are consistent with the study conducted by Goel A, Gupta S et al.,[1] who observed that low-pressure pneumoperitoneum resulted in better hemodynamic stability and lower postoperative pain scores without significantly affecting the duration of surgery. Similarly, Dexter SP et al.,[8] demonstrated that high-pressure pneumoperitoneum caused significant increases in mean arterial pressure and reductions in stroke volume and cardiac output, whereas low-pressure pneumoperitoneum produced fewer cardiovascular disturbances. Berg K et al.,[9] also reported that CO_2 insufflation and patient positioning contributed to hemodynamic alterations during laparoscopy, although these changes were generally well tolerated in healthy individuals.

In our investigation, the two groups' surgical times were similar, and there was no statistically significant difference. This finding indicates that reducing pneumoperitoneum pressure does not compromise surgical feasibility or operative performance. Similar observations were reported by Goel A, Gupta S et al.,[1] and Raval AD et al.,[10] who found no significant difference in operative duration between low-pressure and standard-pressure pneumoperitoneum groups.

The low-pressure group had considerably reduced pain scores in the early postoperative period ($P < 0.0001$) according to postoperative pain assessment using the VAS. Reduced stretching of the peritoneum and decreased diaphragmatic irritation at lower intra-abdominal pressures may explain this finding. These results are in agreement with studies by Singla S et al.,[11] who reported "significantly lower postoperative pain scores and reduced analgesic requirements in patients undergoing low-pressure laparoscopic cholecystectomy." Additionally, Joshipura VP et al.,[12] found that low-pressure pneumoperitoneum was linked to better surgical recovery, fewer analgesic use, and less postoperative pain.

The low-pressure group in our study had a reduced mean analgesic use, but this difference was not statistically significant. This result could be explained by the comparatively small sample size and the uniform postoperative analgesic regimen applied to every patient.

McLaughlin JG et al.,[13] reported that pneumoperitoneum at higher intra-abdominal pressures significantly reduced cardiac performance and increased arterial pressures, particularly in patients with compromised cardiopulmonary function. In contrast, our study demonstrated that low-pressure pneumoperitoneum maintained stable intraoperative parameters while improving postoperative comfort, suggesting that it may be a safer alternative, especially in patients at risk of cardiovascular compromise.

The findings of the present study support the use of low-pressure pneumoperitoneum during laparoscopic cholecystectomy as it provides comparable intraoperative stability and operative duration while significantly reducing postoperative pain and improving patient comfort without compromising surgical efficacy.

Limitations

The present study had a relatively smaller sample size based on the calculated study population. Therefore, further large-scale randomized controlled trials involving larger sample sizes and inclusion of high-risk patients with pre-existing cardiovascular diseases are required to further validate these findings and help establish standardized pneumoperitoneum pressure guidelines for laparoscopic surgeries.Additionally, future studies evaluating even lower pneumoperitoneum pressures may be necessary to demonstrate more significant improvements in intraoperative hemodynamic stability in the low-pressure group.

CONCLUSION

Low-pressure pneumoperitoneum (10 mmHg) during laparoscopic cholecystectomy provides comparable intraoperative hemodynamic stability, oxygenation, and surgical duration when compared to standard-pressure pneumoperitoneum (14 mmHg). Additionally, it significantly reduces early postoperative pain without increasing operative time or compromising surgical efficacy, making it a safe and effective alternative for laparoscopic cholecystectomy.

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