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A Prospective Observational Study of Low-Pressure Pneumoperitoneum in Laparoscopic Surgery

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Abstract: ***Creation of pneumoperitoneum is essential for laparoscopic surgery. Conventional intra-abdominal pressures (12–15 mmHg) are associated with physiological alterations and postoperative pain. Low-pressure pneumoperitoneum (8–10 mmHg) may reduce these adverse effects without compromising surgical safety.***

Keywords: Low-pressure pneumoperitoneum, laparoscopy, cholecystectomy, appendectomy, postoperative pain

1. Introduction

Aim: To evaluate the feasibility and safety of low-pressure pneumoperitoneum during laparoscopic cholecystectomy and appendectomy.

Methods: A prospective observational study was conducted on 100 patients aged 18–60 years undergoing laparoscopic cholecystectomy or appendectomy at a tertiary care center from August 2022 to July 2024. Pneumoperitoneum was maintained at 8–10 mmHg. Hemodynamic parameters (heart rate, mean arterial pressure, $EtCO_2$), operative time, postoperative pain (VAS), and hospital stay were assessed.

Low-pressure pneumoperitoneum is safe and feasible for laparoscopic cholecystectomy and appendectomy, offering advantages of reduced postoperative pain and shorter hospital stay without significant hemodynamic compromise.

2. Details

The physiological effects of increased intra-abdominal pressure during pneumoperitoneum were poorly understood until the mid-20th century. In 1966, Kurt Semm introduced an automatic insufflation device capable of monitoring intra-abdominal pressure, leading to standardized laparoscopic practices. Conventionally, pneumoperitoneum is maintained at pressures of 12–15 mmHg; however, international guidelines recommend using the lowest pressure that provides adequate surgical exposure to minimize physiological disturbances and postoperative pain. Low-pressure pneumoperitoneum, defined as an intra-abdominal pressure of 8–10 mmHg, has been proposed to reduce cardiopulmonary alterations and postoperative discomfort. Concerns regarding low pressure include inadequate visualization, prolonged operative time, and increased risk of conversion to open surgery. Elevated intra-abdominal pressure is directly associated with altered organ function and postoperative pain, particularly shoulder tip pain following laparoscopic cholecystectomy. Several studies have demonstrated that uncomplicated gallstone disease can be safely managed using low-pressure pneumoperitoneum by experienced surgeons. With laparoscopic safety well established, current emphasis is on reducing postoperative morbidity, prompting evaluation of low-pressure techniques in laparoscopic cholecystectomy and appendectomy.

3. Materials and Methods

This prospective observational study was conducted at a tertiary care centre from August 2022 to July 2024. A total of 100 patients undergoing laparoscopic cholecystectomy or laparoscopic appendectomy were enrolled. Patients aged between 18 and 60 years who fulfilled the inclusion criteria were included. Exclusion criteria comprised patients aged below 18 years or above 60 years, body mass index less than 15.5 kg/m² or more than 35.5 kg/m², ASA grade greater than III, pregnancy, seropositive status, and patients with pre-existing causes of shoulder pain such as bursitis or rheumatoid arthritis. Approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants.

All patients underwent detailed clinical evaluation, laboratory investigations, and radiological assessment to confirm diagnosis. Surgeries were performed under general anaesthesia by a single experienced surgeon after administration of prophylactic antibiotics. Pneumoperitoneum was created using carbon dioxide and maintained at a low intra-abdominal pressure of 8–10 mmHg. Conventional four-port laparoscopic cholecystectomy and standard laparoscopic appendectomy techniques were used.

Intraoperative and postoperative monitoring included hemodynamic parameters, operative time, postoperative pain assessment using the Visual Analogue Scale, duration of hospital stay, and surgical outcomes. Data were recorded using a prevalidated case record proforma and analysed using SPSS version 22 with descriptive statistical methods.

3.1 Results

The study included 100 cases, distributed across different age groups, with the highest proportion (40%) in the 31-40 age group, followed by 28% in the 41-50 age group, 24% in the under 31 group, and the lowest proportion (8%) in the 51-60 age group. The gender distribution was nearly balanced, with 52% female and 48% male participants.

The BMI distribution showed that 44% of the subjects had a BMI between 25-29.9 kg/m², 36% had a BMI less than 25 kg/m², and 20% had a BMI of 30 kg/m² or above. Hospital Stays and Operative Time. The mean duration of hospital stay was 3.5 days (±0.6 days), and the mean operating time was 83 minutes (±5.2 minutes), indicating consistent outcomes among study cases.

Types of Surgeries Performed: An equal number of laparoscopic cholecystectomies and appendectomies were performed, each constituting 50% of the total cases.

Heart Rate and Arterial Pressure: The mean heart rate gradually increased during surgery, peaking at 91.2 bpm at 30 minutes after insufflation and slightly decreasing post-exsufflation. The mean arterial pressure also steadily increased, from 75.68 mmHg during intubation to a peak of 88.04 mmHg 10 minutes after exsufflation, indicating a consistent physiological response during surgery. End-Tidal Carbon Dioxide ($EtCO_2$): $EtCO_2$ levels progressively increased during surgery, reaching a peak of 38.0 mmHg 30 minutes after insufflation, and then decreased to 32.1 mmHg 10 minutes after exsufflation, reflecting changes in respiratory dynamics due to pneumoperitoneum.

Pain Assessment (Visual Analogue Scale - VAS):
Pain levels, as measured by the VAS score, were low, starting at 1 at 6 hours, slightly increasing to 1.9 at 12 hours, and completely resolving to 0 by 24 hours postsurgery, suggesting effective pain management. Overall, the study findings highlight the physiological changes during laparoscopic surgeries using low-pressure pneumoperitoneum, showing that patients generally experienced minimal complications, with effective pain control and manageable variations in heart rate, arterial pressure, and $EtCO_2$ levels. The results support the use of low-pressure pneumoperitoneum to enhance patient outcomes in laparoscopic procedures.

Table 1: Distribution of Body Mass Index of Study Groups

BMI (kg/m²)	Number of Subjects	Percentage
Less than 25	36	36
25- 29.9	44	44
30 and above	20	20
Total	100	100

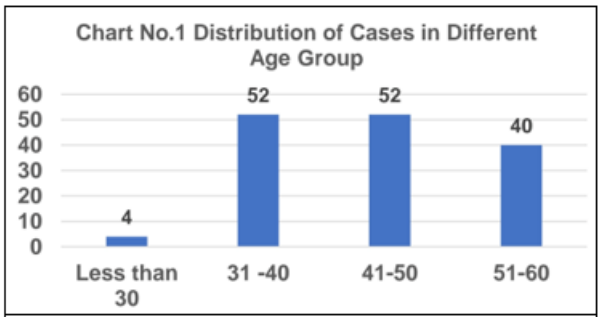

Figure 1: Age Distribution Chart

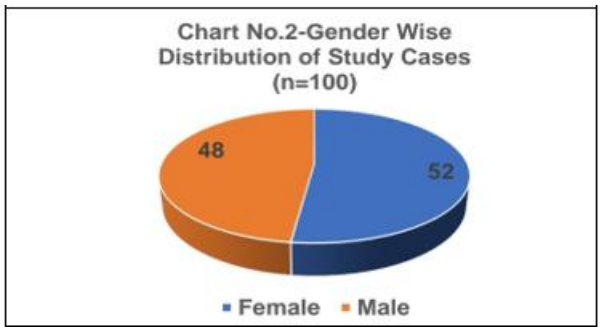

Figure 2: Gender Distribution Graph

Table 2: Mean duration of hospital stay and operation time

	Mean	SD
Duration of Hospital Stay (in Days)	3.5	± 0.6
Operating Time (in minutes)	83	± 5.2

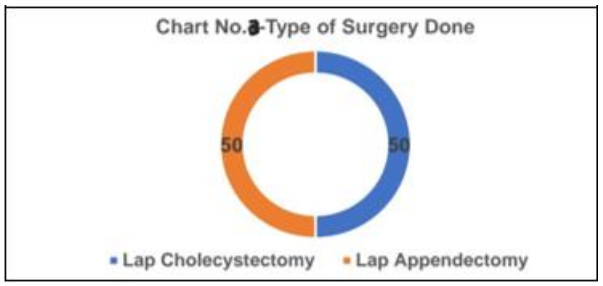

Figure 3: Types of Surgeries Done

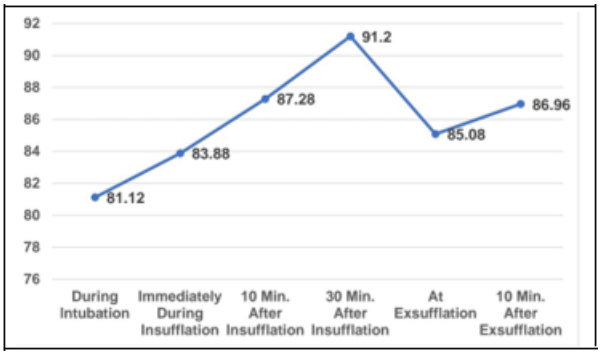

Figure 4: Mean Heart Rate during Surgery

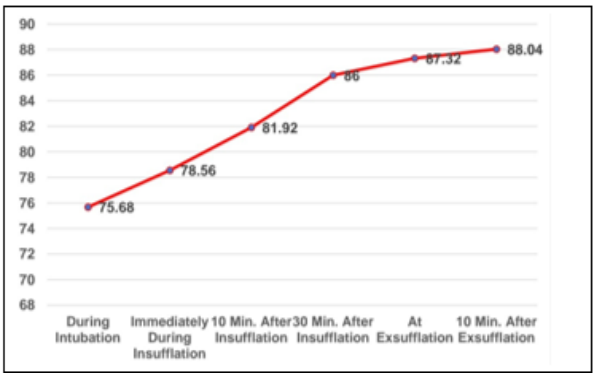

Figure 5: Mean Arterial Pressure during Surgery

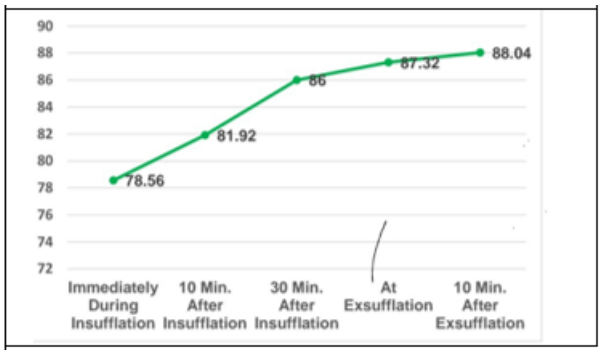

Figure 6: Mean EtCo2 during Surgery

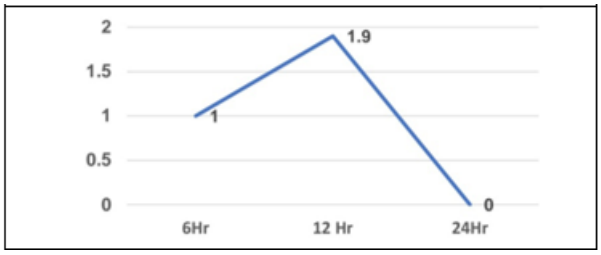

Figure 7: Mean Pain VAs Score

3.2 Discussion

Low-pressure pneumoperitoneum (LPP), defined as maintaining intra-abdominal pressure between 8–10 mmHg, has gained increasing interest as an alternative to standard-pressure pneumoperitoneum (SPP, 12–15 mmHg) in laparoscopic surgery. The rationale for LPP lies in reducing the physiological and pathophysiological disturbances associated with higher insufflation pressures while preserving adequate surgical exposure.

In the present study, the mean age of patients was 37.4 ± 8.3 years, with a slight female predominance, findings consistent with previous studies that report a higher prevalence of gallstone disease in premenopausal women. Hemodynamic changes observed during surgery were modest and transient. Heart rate and mean arterial pressure increased following CO_2 insufflation, peaked during pneumoperitoneum, and decreased after exsufflation, remaining comparable to baseline values. These changes are attributable to reduced venous return, sympathetic stimulation, and CO_2 absorption, and are in agreement with earlier reports. Similarly, end-tidal CO_2 levels increased during insufflation and normalized after exsufflation, reflecting expected physiological responses to CO_2 pneumoperitoneum.

Operative time under LPP was slightly longer compared to SPP, likely due to reduced working space and initial technical adaptation. However, this increase was minimal and not clinically significant, with operative duration comparable to that reported in other studies. Improved surgical experience, optimal patient positioning, and modern instrumentation can further mitigate these challenges.

Hospital stay was comparable or shorter with LPP. Reduced postoperative pain, particularly shoulder tip pain, and fewer cardiopulmonary disturbances contributed to earlier mobilization and recovery. In this study, the average hospital stay was 3.5 days, consistent with existing literature supporting faster recovery with LPP.

Overall, LPP appears to be a safe and effective alternative to standard pressure pneumoperitoneum in selected laparoscopic procedures, offering favorable hemodynamic stability, reduced postoperative discomfort, and comparable surgical outcomes.

3.3 Conclusion

Based on the findings of the present data it can be easily established that low pressure co2 pneumoperitoneum is ideal for laparoscopic cholecystectomy in terms of post-operative pain, length of hospitals stay and minimizes the adverse effect of co2 insufflation. It can be further improved by reducing pressure for pneumoperitoneum thereby reducing the complications related to organ system. The use of low-pressure pneumoperitoneum in laparoscopic cholecystectomy and appendectomy represents a favourable approach for reducing postoperative pain and shortening hospital stays without substantially prolonging surgery duration. With adequate training, proper patient selection, and the use of modern laparoscopic techniques, low-pressure pneumoperitoneum can be effectively utilized to achieve optimal patient outcomes, especially in patients with higher surgical risks or those particularly sensitive to the adverse effects of higher intra-abdominal pressures. Further large-scale studies are warranted to consolidate these findings and guide standardized practices for integrating low-pressure pneumoperitoneum into routine laparoscopic procedures.

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