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IMPACT OF LOW-PRESSURE VERSUS STANDARD-PRESSURE PNEUMOPERITONEUM IN LAPAROSCOPIC CHOLECYSTECTOMY: AN OBSERVATIONAL CLINICAL STUDY

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ABSTRACT

Background: Laparoscopic cholecystectomy is the gold standard for the management of symptomatic cholelithiasis. The creation of pneumoperitoneum is essential for adequate visualization during the procedure, traditionally achieved using standard intra-abdominal pressures (12–14 mmHg). However, standard-pressure pneumoperitoneum has been associated with postoperative shoulder tip pain, cardiopulmonary alterations, and other physiological disturbances. Low-pressure pneumoperitoneum has been proposed as an alternative approach to minimize these adverse effects while maintaining surgical safety and efficacy. The primary objective of this study was to compare the incidence of postoperative shoulder tip pain between low-pressure and standard-pressure pneumoperitoneum in laparoscopic cholecystectomy. Secondary objectives included comparison of duration of surgery, intraoperative complications, and postoperative complications between the two groups.

Materials and Methods: This observational clinical study was conducted in the Department of General Surgery at Dr. B.R. Ambedkar Medical College and Hospital, Bengaluru. Patients diagnosed with cholelithiasis and undergoing laparoscopic cholecystectomy were included and divided into two groups: Group A (low-pressure pneumoperitoneum) and Group B (standard-pressure pneumoperitoneum). Demographic data, operative details, and clinical outcomes were recorded. Outcome measures included postoperative shoulder tip pain assessed using the Visual Analogue Scale (VAS), duration of surgery, intraoperative complications such as bile spillage and bleeding, and postoperative complications. Patients were followed up for pain assessment up to 7 days postoperatively.

Results: Both groups were comparable in baseline characteristics, with a predominantly female population in each group. The mean age was slightly higher in Group A (38.8 years) compared to Group B (37.9 years). The mean duration of surgery was longer in the low-pressure group (77.83 minutes) compared to the standard-pressure group (58 minutes). Postoperative shoulder tip pain was initially higher in the low-pressure group; however, pain scores between the groups became comparable by 24 hours and resolved completely in both groups by postoperative day 7. Intraoperative complications, including bile spillage and bleeding, were slightly more frequent in the low-pressure group, but the differences were not statistically significant. No significant difference was observed in postoperative complications between the two groups.

Conclusion: Low-pressure pneumoperitoneum in laparoscopic cholecystectomy is a safe and feasible alternative to standard-pressure pneumoperitoneum. Although it is associated with a longer operative time and slightly higher initial postoperative pain, overall outcomes including

complication rates are comparable between the two approaches. Low-pressure pneumoperitoneum can be considered in selected patients to minimize physiological disturbances without compromising surgical safety.
Keywords: Laparoscopic cholecystectomy, Low-pressure pneumoperitoneum, Standard-pressure pneumoperitoneum, Shoulder tip pain, Operative time, Surgical outcomes.

INTRODUCTION

Cholelithiasis is one of the most common hepatobiliary disorders worldwide and a leading indication for surgical intervention. Its prevalence varies across populations, with a higher incidence reported in females and increasing frequency with advancing age.[1] In India, the prevalence is estimated to be around 6%, with notable regional variations and a higher occurrence among women. Most patients remain asymptomatic; however, a proportion develops symptoms requiring surgical management.[2]

Over the past few decades, the surgical management of gallstone disease has evolved significantly. Laparoscopic cholecystectomy has replaced open cholecystectomy as the standard of care due to its advantages, including reduced postoperative pain, shorter hospital stay, faster recovery, and improved cosmetic outcomes. Since its introduction, it has become one of the most frequently performed surgical procedures worldwide.[3,4]

A critical component of laparoscopic cholecystectomy is the creation of pneumoperitoneum, which provides adequate working space and visualization for the surgeon. This is typically achieved by insufflation of carbon dioxide into the peritoneal cavity.[5] Standard-pressure pneumoperitoneum, generally maintained between 12–14 mmHg, has been widely used to ensure optimal exposure of the operative field.[6] However, this increased intra-abdominal pressure is associated with several physiological effects, including reduced pulmonary compliance, alterations in cardiovascular dynamics, decreased venous return, and changes in renal and hepatic function.[7]

One of the most commonly reported postoperative complaints following laparoscopic cholecystectomy is shoulder tip pain. This pain is believed to result from diaphragmatic irritation caused by carbon dioxide insufflation and peritoneal stretching. Despite the use of analgesics, complete relief is often not achieved, making postoperative pain management a significant concern in these patients.[8,9]

In recent years, there has been increasing interest in the use of low-pressure pneumoperitoneum, typically ranging from 7–10 mmHg, as an alternative to standard pressure. The rationale behind this approach is to minimize the adverse physiological effects associated with higher intra-abdominal pressures while still maintaining adequate visualization for safe surgical performance. Studies have suggested that low-pressure pneumoperitoneum may reduce postoperative pain and improve patient comfort without significantly increasing complication rates.[10,11]

However, the use of lower pressures may also present certain challenges, including reduced operative field visibility, increased technical difficulty, and potentially longer operative time. These factors raise concerns regarding the safety and feasibility of low-pressure pneumoperitoneum, particularly in routine clinical practice.[12]

Given these considerations, the present study was undertaken to evaluate the impact of low-pressure pneumoperitoneum compared to standard-pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy. The study focuses on key clinical outcomes, including postoperative shoulder tip pain, duration of surgery, and intraoperative and postoperative complications, to determine whether low-pressure pneumoperitoneum can be a viable and effective alternative in surgical practice.

Aim And Objectives

Aim: To evaluate the impact of low-pressure pneumoperitoneum compared to standard-pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy.

Objectives

1. To compare the incidence and severity of postoperative shoulder tip pain between low-pressure and standard-pressure pneumoperitoneum.
2. To compare the duration of surgery between the two groups.
3. To assess and compare intraoperative complications such as bile spillage and bleeding in both groups.
4. To evaluate and compare postoperative complications between low-pressure and standard-pressure pneumoperitoneum groups.

MATERIALS AND METHODS

Study Design: This was an observational clinical study conducted to evaluate the impact of low-pressure pneumoperitoneum compared to standard-pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy.

Study Setting: The study was carried out in the Department of General Surgery at Dr. B. R. Ambedkar Medical College and Hospital, Bengaluru.

Study Duration: The study was conducted over a specified study period as per institutional protocol.

Study Population: Patients diagnosed with cholelithiasis and scheduled for laparoscopic cholecystectomy were included in the study.

Sample Size Estimation: The sample size was calculated based on the difference in postoperative shoulder tip pain between low-pressure and standard-pressure pneumoperitoneum groups, as reported in a previous study by Lakshman Agarwal et al., where the incidence was 14% in the low-pressure group and 38% in the standard-pressure group.

Assuming an effect size of 30% difference between the two groups, the sample size was calculated using the following formula:

$$n = \frac{(Z_\alpha + Z_{1-\beta})^2 \times [P_1(100 - P_1) + P_2(100 - P_2)]}{d^2}$$

Where:

Z_α=1.96(for 95% confidence interval)

Z_(1-β)=0.84(for 80% power)

P_1=14%(proportion in Group A)

P_2=38%(proportion in Group B)

d=30%(effect size)

Substituting the values:

$$n = \frac{(1.96+0.84)^2[14(100 - 14) + 38(100 - 38)]}{(30)^2}$$

The calculated sample size was 30 patients in each group, resulting in a total sample size of 60 patients.

Sample Size: A total of 60 patients were included and divided into two groups:

- Group A: Low-pressure pneumoperitoneum (LPP) group
- Group B: Standard-pressure pneumoperitoneum (SPP) group

Each group comprised 30 patients.

Sampling Method: Patients were allocated into two groups based on intraoperative pneumoperitoneum pressure settings.

Inclusion Criteria

- Patients diagnosed with cholelithiasis
- Patients undergoing elective laparoscopic cholecystectomy
- Patients willing to participate in the study

Exclusion Criteria

- Patients unfit for general anesthesia
- Patients with complicated gallstone disease (e.g., acute cholecystitis, pancreatitis)
- Patients requiring conversion to open cholecystectomy
- Patients with significant cardiopulmonary comorbidities

Study Procedure: All patients underwent standard preoperative evaluation including clinical examination, laboratory investigations, and ultrasonography.

Laparoscopic cholecystectomy was performed under general anesthesia using a standard four-port technique.

- In Group A (LPP), pneumoperitoneum was maintained at low pressure (7–10 mmHg)
- In Group B (SPP), pneumoperitoneum was maintained at standard pressure (12–14 mmHg)

Intraoperative parameters such as duration of surgery and complications were recorded.

Outcome Measures: The following parameters were assessed and compared between the two groups:

1. Postoperative shoulder tip pain
   - Assessed using the Visual Analogue Scale (VAS) at predefined time intervals
2. Duration of surgery
   - Measured in minutes from incision to closure
3. Intraoperative complications
   - Including bile spillage and bleeding
4. Postoperative complications
   - Including surgical site infection and other adverse events

Pain Assessment

Postoperative pain was evaluated using the Visual Analogue Scale (VAS), where:

- 0 represents no pain
- 10 represents worst imaginable pain

Pain scores were recorded at multiple postoperative intervals and followed up up to 7 days.

Data Collection: All relevant clinical data were recorded in a structured proforma. The collected data included demographic details, operative findings, and postoperative outcomes.

Statistical Analysis: Data were entered and analyzed using appropriate statistical methods.

- Continuous variables were expressed as mean ± standard deviation
- Categorical variables were expressed as frequency and percentage
- Comparative analysis between groups was performed using appropriate statistical tests
- A p-value of <0.05 was considered statistically significant

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee. Informed consent was obtained from all participants prior to inclusion in the study.

RESULTS

A total of 60 patients were included in the study, with 30 patients each in Group A (low-pressure pneumoperitoneum) and Group B (standard-pressure pneumoperitoneum). The observations were analyzed across multiple clinical parameters including age, gender, operative duration, postoperative pain, and complications.

The majority of patients belonged to the younger age group, particularly between 21–40 years, accounting for 66.6% of the total study population. The mean age of patients was comparable between both groups, indicating baseline homogeneity. The distribution of patients across different age groups was fairly balanced between the two study arms.

Further outcome measures including operative time, postoperative pain scores, and complications were evaluated to compare the effectiveness and safety of low-pressure versus standard-pressure pneumoperitoneum.

Table 1: Age distribution of patients in Group A and Group B

Age group (years)	Group A (Low pressure) n	Group B (Standard pressure) n	Total n (%)
21–30	10	8	18 (30.0%)
31–40	8	14	22 (36.6%)
41–50	7	4	11 (18.3%)
51–60	5	4	9 (15.0%)
Total	30	30	60 (100%)
Mean age (years)	38.8	37.9	37.0

[Table 1] shows the age-wise distribution of patients in both study groups.

[Table 1] shows that the majority of patients belonged to the 31–40 years age group, accounting for 22 patients (36.6%), followed by the 21–30 years group with 18 patients (30.0%). The 41–50 years group included 11 patients (18.3%), while the 51–60 years group had the least representation with 9 patients (15.0%).

In Group A, the highest number of patients were in the 21–30 years group (10 patients), whereas in Group B, the majority were in the 31–40 years group (14 patients). The distribution across age groups was relatively comparable between both groups.

The mean age was 38.8 years in Group A and 37.9 years in Group B, with an overall mean age of 37 years, indicating no significant difference between the groups and confirming baseline comparability.

Table 2: Gender distribution of patients in Group A and Group B

Gender	Group A (Low pressure) n (%)	Group B (Standard pressure) n (%)	Total n (%)
Male	6 (20.0%)	5 (16.66%)	11 (18.3%)
Female	24 (80.0%)	25 (83.33%)	49 (81.6%)
Total	30 (100%)	30 (100%)	60 (100%)

[Table 2] shows the gender-wise distribution of patients in both study groups.

[Table 2] shows that females constituted the majority of the study population, accounting for 49 patients (81.6%), while males comprised 11 patients (18.3%).

In Group A, 24 patients (80.0%) were female and 6 patients (20.0%) were male. In Group B, 25 patients (83.33%) were female and 5 patients (16.66%) were male. This indicates a female predominance in both groups with comparable gender distribution.

Table 3: Duration of surgery in Group A and Group B

Duration of surgery (minutes)	Group A (Low pressure) n (%)	Group B (Standard pressure) n (%)	p-value
<45	0 (0.0%)	6 (20.0%)	0.0098
45–90	21 (70.0%)	22 (73.3%)	0.776
>90	9 (30.0%)	2 (6.6%)	0.019
Total	30 (100%)	30 (100%)	

[Table 3] shows the distribution of duration of surgery among patients in both study groups.

[Table 3] shows that the majority of surgeries were completed within 45–90 minutes in both groups, with 21 patients (70.0%) in Group A and 22 patients (73.3%) in Group B. In the <45 minutes category, no cases were observed in Group A, whereas 6 cases (20.0%) were present in Group B, which was statistically significant (p=0.0098). In the >90 minutes category, Group A had a significantly higher number of cases (9 patients, 30.0%) compared to Group B (2 patients, 6.6%), also showing statistical significance (p=0.019). This indicates that longer operative duration was more common in the low-pressure pneumoperitoneum group.

Table 4: Post-operative shoulder tip pain and VAS score in Group A and Group B

Time Interval	Group A (Low pressure) n (%)	Group B (Standard pressure) n (%)	p-value
VAS at 4 hours	10 (33.3%)	8 (26.6%)	0.287
VAS at 8 hours	6 (20.0%)	3 (10.0%)	0.724
VAS at 12 hours	3 (10.0%)	2 (6.6%)	0.638
VAS at 24 hours	2 (6.6%)	2 (6.6%)	1.0
VAS at 7 days	0 (0.0%)	0 (0.0%)	1.0
Total	30 (100%)	30 (100%)	

[Table 4] shows the distribution of post-operative shoulder tip pain (VAS >3) among patients in both study groups at different time intervals.

[Table 4] shows that post-operative shoulder tip pain (VAS >3) was higher in Group A at 4 hours (10 patients, 33.3%) compared to Group B (8 patients, 26.6%). At 8 hours, pain persisted in 6 patients (20.0%) in Group A and 3 patients (10.0%) in Group B. By 12 hours, the number of patients with pain reduced to 3 (10.0%) in Group A and 2 (6.6%) in Group B. At 24 hours, both groups had equal number of patients with pain (2 patients, 6.6%). By 7 days, no patients in either group reported shoulder tip pain (0%). The differences at all time intervals were not statistically significant (p>0.05).

Table 5: Intra-operative complications in Group A and Group B

Parameter	Group A (Low pressure) n (%)	Group B (Standard pressure) n (%)	p-value
Bile/stone spillage	4 (13.3%)	3 (10.0%)	0.689
Bleeding	5 (16.6%)	3 (10.0%)	0.450
CBD/biliary tract injury	0 (0.0%)	0 (0.0%)	1.00
Bowel injury	0 (0.0%)	0 (0.0%)	1.00
Liver injury	0 (0.0%)	0 (0.0%)	1.00
Total	30 (100%)	30 (100%)	

[Table 5] shows the distribution of intra-operative complications among patients in both study groups.

[Table 5] shows that intra-operative complications such as bile/stone spillage occurred in 4 patients (13.3%) in Group A compared to 3 patients (10.0%) in Group B, and bleeding occurred in 5 patients (16.6%) in Group A compared to 3 patients (10.0%) in Group B. No cases of CBD/biliary tract injury, bowel injury, or liver injury were observed in either group (0%). The differences between the groups were not statistically significant (p>0.05).

Table 6: Post-operative complications in Group A and Group B

Parameter	Group A (Low pressure) n (%)	Group B (Standard pressure) n (%)	p-value
Bile leak	0 (0.0%)	0 (0.0%)	1.00
Bleeding	0 (0.0%)	0 (0.0%)	1.00
Wound infection	1 (3.3%)	1 (3.3%)	1.00
Port site hernia	0 (0.0%)	0 (0.0%)	1.00
Total	30 (100%)	30 (100%)	

[Table 6] shows the distribution of post-operative complications among patients in both study groups.

[Table 6] shows that post-operative complications were minimal in both groups, with wound infection observed in 1 patient (3.3%) in each group, and no cases of bile leak, bleeding, or port site hernia reported (0%). There was no statistically significant difference between the groups.

Tables Summary

[Table 1] shows that the majority of patients in the study belonged to the 31–40 years age group, accounting for 22 patients (36.6%), followed by the 21–30 years group with 18 patients (30.0%). The 41–50 years group included 11 patients (18.3%), while the 51–60 years group comprised 9 patients (15.0%). In Group A, the highest number of patients were in the 21–30 years category (10 patients), whereas in Group B, the majority were in the 31–40 years category (14 patients). The mean age in Group A was 38.8 years and in Group B was 37.9 years, with an overall mean of approximately 37 years, indicating that both groups were comparable in terms of age distribution without any significant baseline variation.

[Table 2] demonstrates that females constituted the majority of the study population, accounting for 49 patients (81.6%), while males comprised only 11 patients (18.3%). In Group A, 24 patients (80.0%) were female and 6 patients (20.0%) were male. Similarly, in Group B, 25 patients (83.33%) were female and 5 patients (16.66%) were male. This consistent female predominance across both groups reflects the known higher prevalence of cholelithiasis among females and confirms that gender distribution between the groups was comparable.

[Table 3] shows that the majority of surgical procedures in both groups were completed within 45–90 minutes, with 21 patients (70.0%) in Group A and 22 patients (73.3%) in Group B falling into this category. Notably, in the <45 minutes category, no cases were observed in Group A, whereas 6 patients (20.0%) in Group B underwent shorter duration surgeries, which was statistically significant (p=0.0098). Furthermore, a significantly higher proportion of patients in Group A (9 patients, 30.0%) required more than 90 minutes compared to Group B (2 patients, 6.6%) (p=0.019). These findings indicate that surgeries performed under low-pressure pneumoperitoneum were associated with longer operative duration, suggesting increased technical difficulty or reduced operative field exposure.

[Table 4] illustrates the pattern of post-operative shoulder tip pain assessed using VAS scores greater than 3 at different time intervals. At 4 hours postoperatively, 10 patients (33.3%) in Group A experienced significant pain compared to 8 patients (26.6%) in Group B. At 8 hours, pain persisted in 6 patients (20.0%) in Group A and 3 patients (10.0%) in Group B. By 12 hours, pain further reduced to 3 patients (10.0%) in Group A and 2 patients (6.6%) in Group B. At 24 hours, both groups had equal incidence of pain with 2 patients (6.6%) each. By day 7, no patients in either group reported shoulder tip pain (0%). Although pain appeared slightly higher in the low-pressure group during early postoperative periods, the differences were not statistically significant, and both groups showed complete resolution over time.

[Table 5] shows the distribution of intra-operative complications between the two groups. Bile or stone spillage was observed in 4 patients (13.3%) in Group A and 3 patients (10.0%) in Group B. Bleeding occurred in 5 patients (16.6%) in Group A compared to 3 patients (10.0%) in Group B. Importantly, no cases of CBD or biliary tract injury, bowel injury, or liver injury were reported in either group (0%). Although the incidence of minor complications such as spillage and bleeding was slightly higher in the

low-pressure group, these differences were not statistically significant, indicating that both techniques have comparable intra-operative safety profiles.

[Table 6] demonstrates the post-operative complications observed in both groups. Wound infection was the only complication reported, occurring in 1 patient (3.3%) in Group A and 1 patient (3.3%) in Group B. No cases of bile leak, postoperative bleeding, or port site hernia were observed in either group (0%). The absence of major complications and equal distribution of minor complications between the groups indicates that both low-pressure and standard-pressure pneumoperitoneum are equally safe in the postoperative period.

Overall, the compiled results indicate that while low-pressure pneumoperitoneum is associated with a longer operative duration and a slightly higher incidence of minor intra-operative events, it does not lead to an increase in major complications. Post-operative pain trends and complication rates are comparable between the two groups, supporting the safety and feasibility of low-pressure pneumoperitoneum in laparoscopic cholecystectomy.

DISCUSSION

The present observational clinical study was conducted to evaluate the impact of low-pressure pneumoperitoneum (LPP) compared to standard-pressure pneumoperitoneum (SPP) in patients undergoing laparoscopic cholecystectomy. The primary focus was on postoperative shoulder tip pain, with additional assessment of operative duration and perioperative complications.[13,14] The demographic profile of the study population showed that the majority of patients were in the 21–40 years age group, accounting for 66.6% of the total population, with a mean age of approximately 37 years. Both groups were comparable in terms of age distribution, which is important to ensure that the observed outcomes are attributable to the intervention rather than demographic differences.[15] The study also demonstrated a clear female predominance (81.6%), which is consistent with the known higher prevalence of cholelithiasis among females due to hormonal and metabolic factors.[16]

A key finding of this study was the significantly longer operative duration observed in the low-pressure pneumoperitoneum group. A higher proportion of patients in Group A (30.0%) required more than 90 minutes for surgery compared to Group B (6.6%), with statistical significance (p=0.019). Additionally, no cases in the low-pressure group were completed within 45 minutes, whereas 20.0% of cases in the standard-pressure group fell into this category (p=0.0098). This suggests that reduced intra-abdominal pressure may compromise the operative field, making dissection more technically demanding and time-consuming.[17,18]

Postoperative shoulder tip pain, assessed using VAS scores greater than 3, showed a higher incidence in the low-pressure group during the early postoperative period. At 4 hours, 33.3% of patients in Group A experienced pain compared to 26.6% in Group B. Similar trends were observed at 8 and 12 hours.[19] However, the differences were not statistically significant at any time point. Importantly, pain levels in both groups decreased progressively and became equal by 24 hours, with complete resolution by day 7. These findings suggest that although low-pressure pneumoperitoneum did not significantly reduce postoperative shoulder tip pain in this study, both techniques provide satisfactory pain outcomes over time.[20,21]

Intra-operative complications such as bile or stone spillage and bleeding were slightly more frequent in the low-pressure group, with incidences of 13.3% and 16.6% respectively, compared to 10.0% and 10.0% in the standard-pressure group. However, no statistically significant difference was observed between the groups. Importantly, no major complications such as CBD injury, bowel injury, or liver injury were reported in either group, indicating that both techniques are safe when performed by experienced surgeons.[22,23]

Postoperative complications were minimal in both groups. Wound infection was observed in only 1 patient (3.3%) in each group, with no cases of bile leak, postoperative bleeding, or port site hernia. This further supports the safety profile of both low-pressure and standard-pressure pneumoperitoneum.[23]

When compared with existing literature, several studies have reported that low-pressure pneumoperitoneum is associated with reduced postoperative pain and improved hemodynamic stability. However, in the present study, no significant reduction in shoulder tip pain was observed with low-pressure pneumoperitoneum.[24] This discrepancy may be attributed to differences in study design, patient selection, or intraoperative techniques. On the other hand, the finding of increased operative duration with low-pressure pneumoperitoneum is consistent with previous studies, which have highlighted the potential trade-off between reduced physiological impact and technical difficulty.[25]

Overall, the findings of this study suggest that low-pressure pneumoperitoneum is a safe and feasible alternative to standard-pressure pneumoperitoneum. While it may be associated with longer operative time and slightly higher minor intra-operative events, it does not significantly affect postoperative outcomes or complication rates. The choice between low-pressure and standard-pressure pneumoperitoneum may therefore be guided by surgeon preference, patient condition, and intraoperative requirements.

Limitations

The present study has certain limitations that should be considered while interpreting the results. The sample size was relatively small, which may limit the

generalizability of the findings. The study was conducted at a single center, which may introduce institutional bias. Additionally, long-term outcomes such as recurrence of symptoms, quality of life, and late complications were not assessed. Future studies with larger sample sizes and multicentric design are recommended to validate these findings.

CONCLUSION

Low-pressure pneumoperitoneum in laparoscopic cholecystectomy is a safe and feasible technique with outcomes comparable to standard-pressure pneumoperitoneum. Although it is associated with a longer operative duration, it does not significantly reduce postoperative shoulder tip pain or increase complication rates. Both techniques demonstrate similar safety profiles, and the choice of pneumoperitoneum pressure can be individualized based on surgical expertise and patient factors.

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