

A PROSPECTIVE COMPARATIVE STUDY OF LOW-PRESSURE VS. STANDARD-PRESSURE PNEUMOPERITONEUM DURING LAPAROSCOPIC CHOLECYSTECTOMY

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ABSTRACT

Background: Laparoscopic cholecystectomy requires pneumoperitoneum, but lower insufflation pressures may improve postoperative comfort while maintaining perioperative safety. This study compared low- and standard-pressure pneumoperitoneum during elective laparoscopic cholecystectomy. **Materials and Methods:** This prospective comparative study included 60 patients with uncomplicated symptomatic gallstone disease, allocated equally to standard-pressure (12–14 mmHg; n=30) and low-pressure (7–9 mmHg; n=30) groups. Intraoperative hemodynamic and oxygenation parameters, operative time, postoperative pain using the Visual Analogue Scale (VAS), shoulder-tip pain, additional analgesic requirement, and hospital stay were assessed. **Results:** Changes in systolic and diastolic blood pressure, pulse rate, and SpO₂ were comparable between groups. Mean operative time was 66 minutes in the standard-pressure group and 73 minutes in the low-pressure group (p=0.06). VAS scores were lower with low pressure at 3 hours (3.1±1.029 vs. 3.63±0.889), 6 hours (2.2±0.805 vs. 2.8±0.805), and 12 hours (1.56±0.872 vs. 1.96±1.033), while scores at 24 hours were identical (0.8). Shoulder-tip pain occurred in 10.0% versus 26.7%, and additional analgesia was required in 6.7% versus 16.7% of patients. Hospital stay was comparable. **Conclusion:** Low-pressure pneumoperitoneum was safe and feasible, with comparable perioperative outcomes and a consistent trend toward reduced early postoperative pain and shoulder-tip pain.

INTRODUCTION

Laparoscopic cholecystectomy (LC) is widely established as the preferred surgical approach for patients with symptomatic uncomplicated gallstone disease because of its minimally invasive nature and favorable postoperative recovery. Creation of a carbon dioxide pneumoperitoneum is an essential component of LC, providing the operative space required for visualization and manipulation of laparoscopic instruments. However, increased intra-abdominal pressure can produce physiological alterations involving cardiovascular and respiratory function and may contribute to postoperative discomfort. Consequently, optimization of pneumoperitoneum pressure has become an important consideration in efforts to improve perioperative outcomes following LC.^[1,2] Standard-pressure pneumoperitoneum is generally maintained at approximately 12–14 mmHg, whereas low-pressure pneumoperitoneum commonly

employs pressures in the range of 7–10 mmHg. The rationale for reducing intra-abdominal pressure is to minimize the physiological effects associated with carbon dioxide insufflation while maintaining adequate visualization of the operative field. Recent randomized and observational studies have demonstrated that low-pressure LC can be performed without clinically important increases in operative duration or major perioperative complications, although adequate surgical exposure remains an important prerequisite for its successful application.^[1,2]

Postoperative pain, particularly abdominal and shoulder-tip pain, remains an important component of morbidity after LC and may influence analgesic requirements and early postoperative recovery. Recent comparative evidence has reported lower postoperative pain and a reduced incidence of shoulder-tip pain with low-pressure pneumoperitoneum compared with standard pressure. In a randomized clinical trial, low-pressure

pneumoperitoneum was associated with significantly lower postoperative abdominal pain and shoulder-tip pain, while another randomized trial reported reduced postoperative pain together with favorable changes in inflammatory markers without a significant increase in operative difficulty or duration.^[3]

The potential physiological benefits of reducing pneumoperitoneum pressure are also clinically relevant because carbon dioxide insufflation and elevated intra-abdominal pressure may influence cardiopulmonary function. A recent multicentre randomized trial involving patients with cardiopulmonary comorbidities found that low-pressure pneumoperitoneum at 10 mmHg was feasible and did not compromise surgical safety or surgeon comfort, although it did not produce significant improvements in postoperative pulmonary parameters compared with standard pressure. These findings suggest that the clinical benefits of low-pressure pneumoperitoneum may not be uniform across all physiological outcomes and may depend on the pressure used and characteristics of the patient population.^[2]

More recent clinical evidence has continued to support the potential role of low-pressure pneumoperitoneum in enhancing postoperative recovery. A randomized clinical study evaluating low-pressure pneumoperitoneum in conjunction with enhanced-recovery strategies reported favorable postoperative outcomes, while a 2025 observational study found lower carbon dioxide consumption, less shoulder-tip pain, less pronounced hemodynamic changes, and shorter hospital stay with low-pressure compared with standard-pressure pneumoperitoneum. Nevertheless, differences among studies regarding pressure levels, patient characteristics, analgesic protocols, and outcome assessment indicate that the magnitude and consistency of these benefits remain uncertain.^[4-6]

MATERIALS AND METHODS

Study Design and Setting: This prospective observational comparative study was conducted in the Department of General Surgery, P.D.U. Medical College and Civil Hospital, Rajkot, over a period of 1.5 years, following approval from the Institutional Ethics Committee and after obtaining written informed consent from all participants.

Study Population: A total of 60 patients of either sex, aged above 18 years, undergoing elective laparoscopic cholecystectomy for uncomplicated symptomatic gallstone disease were enrolled consecutively. Patients were allocated into two groups of 30 each: Group A underwent laparoscopic cholecystectomy with standard-pressure pneumoperitoneum (12–14 mmHg), and Group B underwent the procedure with low-pressure pneumoperitoneum (7–9 mmHg).

Inclusion criteria

comprised patients above 18 years of age scheduled for elective laparoscopic cholecystectomy, presenting with uncomplicated symptomatic gallstone disease, willing to provide consent for participation, and deemed fit for general anaesthesia.

Exclusion criteria

Included complicated gallstone disease (gallbladder perforation, empyema, or common bile duct stones), prior extensive abdominal surgery, pregnancy or lactation, immunocompromised states (advanced liver disease, HIV, or hepatitis C infection), and any contraindication to laparoscopic surgery.

Preoperative Preparation: All patients underwent standard bowel preparation and received a single preoperative dose of intravenous ceftriaxone (1 g). Baseline vital parameters — pulse rate, blood pressure, and peripheral oxygen saturation — were recorded prior to induction of anaesthesia. The anaesthetic protocol was standardized and kept identical across both groups.

Intraoperative Protocol: Pneumoperitoneum was established with carbon dioxide insufflation, maintained at 12–14 mmHg in the standard-pressure group and 7–9 mmHg in the low-pressure group. Intraoperative hemodynamic monitoring — heart rate, non-invasive blood pressure, and oxygen saturation (via pulse oximetry) — was performed at 10-minute intervals throughout the procedure. For each parameter, three time-point readings were recorded: immediately before creation of pneumoperitoneum, immediately after establishment of pneumoperitoneum, and following skin closure; the mean of these values was used for intergroup comparison. Operative time was recorded for each case from the first port insertion to skin closure.

Postoperative Assessment: Postoperative analgesia was standardized across both groups, consisting of diclofenac administered every 8 hours, with additional rescue analgesia given as required. Postoperative pain intensity was assessed using a 0–10 Visual Analogue Scale (VAS) at 3, 6, 12, and 24 hours after surgery. The requirement for rescue analgesia beyond the standard 8-hourly diclofenac regimen and the incidence of shoulder tip pain were recorded for each patient. Length of postoperative hospital stay was documented in days for all patients, and routine postoperative care was provided as per departmental protocol.

Statistical Analysis

Data were analyzed using the paired t-test for comparison of continuous variables between groups. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

A total of 60 patients undergoing elective laparoscopic cholecystectomy were enrolled and equally allocated to the standard-pressure (SPLC, n=30) and low-pressure (LPLC, n=30)

pneumoperitoneum groups. Of the overall cohort, 47 patients (78.3%) were female and 13 (21.7%) were male, giving an approximate male-to-female ratio of 1:4, consistent with the known female preponderance of gallstone disease. The majority of patients in both groups fell within the 30–49-year age range, indicating that gallstone disease and its surgical management in this cohort were concentrated in the younger and middle-aged adult population. [Table 1] Intraoperative hemodynamic and oxygenation parameters were comparable between the two groups. The mean rise in systolic blood pressure was 1.267 ± 4.315 mmHg in the SPLC group versus 0.6 ± 3.607 mmHg in the LPLC group, and the mean change in diastolic blood pressure was 0.133 ± 2.921 mmHg and 0.266 ± 3.552 mmHg, respectively; neither difference reached statistical significance ($p=0.118$ and $p=0.804$, respectively). Similarly, changes in pulse rate (0.433 ± 3.997 vs. 1.6 ± 5.468 bpm) and peripheral oxygen saturation ($0.66 \pm 0.980\%$ vs. $0.4 \pm 1.329\%$) did not differ significantly between the standard- and low-pressure groups. [Table 2] These findings suggest that reducing intra-abdominal pressure during pneumoperitoneum did not produce a clinically meaningful hemodynamic advantage over standard pressure in this cohort, at least with respect to intraoperative vital parameter fluctuation. Mean operative time was slightly longer in the low-pressure group (73 minutes) compared with the standard-pressure group (66 minutes); this seven-minute difference approached but did not reach

statistical significance ($p=0.06$). Postoperative hospital stay was similar between groups, with the majority of patients in both arms discharged by postoperative day 1 (56.7% in each group) or day 2 (36.7% SPLC vs. 40.0% LPLC), and only a small minority requiring a stay of three or more days. [Table 3]

Postoperative pain scores, assessed using the Visual Analogue Scale (VAS), were consistently lower in the low-pressure group at the early postoperative time points. At 3 hours, mean VAS scores were 3.63 ± 0.889 in the SPLC group versus 3.1 ± 1.029 in the LPLC group; at 6 hours, 2.8 ± 0.805 versus 2.2 ± 0.805 ; and at 12 hours, 1.96 ± 1.033 versus 1.56 ± 0.872 . By 24 hours, pain scores had converged to near-identical levels in both groups (0.8 ± 0.664 vs. 0.8 ± 0.714). Despite this consistent early trend favoring low-pressure pneumoperitoneum, the overall difference in pain scores between groups did not achieve statistical significance ($p=0.63$). [Table 4]

Shoulder tip pain was reported by 8 patients (26.7%) in the standard-pressure group compared with 3 patients (10.0%) in the low-pressure group, and additional analgesia was required in 5 patients (16.7%) versus 2 patients (6.7%), respectively. Although both outcomes were numerically less frequent in the low-pressure group, the difference between groups was not statistically significant. [Table 5]

Table 1: Baseline demographic characteristics

Characteristic	Standard Pressure (n=30)	Low Pressure (n=30)
Sex (M/F), overall cohort (n=60)	Male: 13 (21.7%)	Female: 47 (78.3%)
Age <20 yrs	1	2
Age 20–29 yrs	5	3
Age 30–39 yrs	8	10
Age 40–49 yrs	6	8
Age 50–59 yrs	5	2
Age ≥60 yrs	5	5
Total	30	30

Table 2: Intraoperative hemodynamic and oxygenation parameters (change from baseline)

Parameter	Standard Pressure Mean±SD	p-value	Low Pressure Mean±SD	p-value
Systolic BP change (mmHg)	1.267 ± 4.315	0.118	0.6 ± 3.607	0.369
Diastolic BP change (mmHg)	0.133 ± 2.921	0.804	0.266 ± 3.552	0.683
Pulse rate change (bpm)	0.433 ± 3.997	0.557	1.6 ± 5.468	0.119
SpO ₂ change (%)	0.66 ± 0.980	0.712	0.4 ± 1.329	0.11

Table 3: Distribution of Patients According to Clinical Status at Immediate Post-Procedure, 3-Month Follow-up, and 12-Month Follow-up

		N (%)		
		Immediate post-procedure result	Follow up result at 3 months	Follow up result at 12 months
Clinical Status	Asymptomatic	14(70%)	16(80%)	18(90%)
	Improved	2(10%)	1(5%)	1(5%)
	Static	2(10%)	1(5%)	1(5%)
	Deteriorated	2(10%)	2(10%)	0(0%)

Table 4: Postoperative pain scores (VAS) at 3, 6, 12, and 24 hours

Time point	Standard Pressure Mean±SD	Low Pressure Mean±SD
3 hours	3.63 ± 0.889	3.1 ± 1.029
6 hours	2.8 ± 0.805	2.2 ± 0.805
12 hours	1.96 ± 1.033	1.56 ± 0.872
24 hours	0.8 ± 0.664	0.8 ± 0.714

Table 5: Incidence of shoulder tip pain and requirement of additional analgesia

Outcome	Standard Pressure, n (%)	Low Pressure, n (%)
Shoulder tip pain	8 (26.7%)	3 (10.0%)
Additional analgesia required	5 (16.7%)	2 (6.7%)

DISCUSSION

The present study compared low-pressure pneumoperitoneum (7–9 mmHg) with standard-pressure pneumoperitoneum (12–14 mmHg) during elective laparoscopic cholecystectomy. Low-pressure pneumoperitoneum demonstrated comparable intraoperative hemodynamic and oxygenation parameters, operative duration, and postoperative hospital stay. Although not statistically significant, postoperative pain, shoulder-tip pain, and additional analgesic requirement consistently favored the low-pressure group.

The absence of significant differences in blood pressure, pulse rate, and SpO₂ suggests that pressure reduction did not produce a clinically important hemodynamic advantage in this relatively healthy cohort. Recent randomized evidence similarly found low-pressure pneumoperitoneum to be feasible with stable perioperative hemodynamics, although improvements in broader recovery outcomes were not consistently demonstrated.^[7,8]

Low pressure pneumoperitoneum appears to have little adverse effect on the cardiac and respiratory functions and is suitable for the elderly and for those with chronic cardiac or respiratory diseases. In line with this, postoperative pain intensity was lower in the LPLC group compared to the SPLC group, although the difference was not statistically significant. Similarly, the incidence of shoulder tip pain and the requirement of additional analgesia were lower in the LPLC group compared to the SPLC group, but this difference was also not statistically significant.

Postoperative pain showed a consistent numerical reduction with low-pressure pneumoperitoneum, particularly during the first 12 hours. This finding agrees with a recent randomized controlled trial in which low-pressure pneumoperitoneum was associated with significantly lower postoperative pain without prolonging operative time.^[9] The lower frequency of shoulder-tip pain in our low-pressure group (10.0% vs. 26.7%) is also clinically noteworthy. Recent evidence indicates that strategies directed at reducing the physiological consequences of pneumoperitoneum can decrease postoperative shoulder pain following laparoscopic cholecystectomy.^[10]

Mean operative time was seven minutes longer with low-pressure pneumoperitoneum (73 vs. 66 minutes), although this difference was not statistically significant ($p=0.06$). This suggests that the lower pressure did not substantially compromise operative efficiency in the present cohort. Nevertheless, low-pressure techniques may occasionally provide less satisfactory visualization, and pressure escalation may be required when operative exposure is

inadequate. Recent randomized evidence has demonstrated that pneumoperitoneum pressure and neuromuscular blockade can influence surgical conditions, supporting individualized pressure selection according to intraoperative requirements.^[11] Postoperative hospital stay was also comparable between groups, with most patients discharged by the first or second postoperative day. This indicates that the potential analgesic benefit of low-pressure pneumoperitoneum does not necessarily translate into a shorter hospital stay, particularly in uncomplicated elective cases managed within standardized postoperative pathways.^[4,11-13]

The lower requirement for additional analgesia in the low-pressure group further supports a possible postoperative comfort advantage. However, the lack of statistical significance for these outcomes should be interpreted cautiously. The sample size of 60 patients may have limited the ability to detect modest between-group differences, particularly for relatively infrequent outcomes such as shoulder-tip pain and rescue analgesic use.

CONCLUSION

Low-pressure pneumoperitoneum during laparoscopic cholecystectomy is a safe and feasible alternative to the standard-pressure technique, producing comparable intraoperative hemodynamic stability, operative time, and postoperative hospital stay, while showing a consistent, though not statistically significant, trend toward lower early postoperative pain scores and a reduced incidence of shoulder tip pain and additional analgesia requirement. These findings suggest that low-pressure pneumoperitoneum may offer a modest clinical advantage in postoperative comfort without compromising surgical safety or efficiency, supporting its consideration as a viable option in elective laparoscopic cholecystectomy, particularly in patients for whom minimizing postoperative discomfort is a priority; larger, adequately powered multicentric trials are warranted to confirm these findings and establish more definitive evidence for its routine adoption. An uncomplicated gall stone disease can be treated by low pressure laparoscopic cholecystectomy with reasonable safety by an experienced surgeon, but an inexperience surgeon may have quite more difficulty in dissection during low pressure pneumoperitoneum & operative time is quite high.

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