A Clinical Study Comparing Postoperative Shoulder Pain Between Low- and Standard-Pressure Pneumoperitoneum in Laparoscopic Cholecystectomy: A Randomized Trial

Author's name: DR. ARSHPREET KAUR

ABSTRACT

Introduction:

Postoperative shoulder tip pain (STP) is a common complication following laparoscopic cholecystectomy, primarily due to diaphragmatic irritation caused by carbon dioxide (CO_2) pneumoperitoneum.

Aim and Objective:

This study aimed to evaluate the effect of low-pressure (10 mmHg) versus standard-pressure (14 mmHg) pneumoperitoneum on the incidence and severity of STP in patients undergoing laparoscopic cholecystectomy under spinal anaesthesia.

Materials and Methods:

A hospital-based randomized controlled trial was conducted at Tej Bahadur Sapru Hospital, Prayagraj, involving 200 patients scheduled for elective laparoscopic cholecystectomy. Participants were randomized into two groups: Group A (low pressure, 10 mmHg) and Group B (standard pressure, 14 mmHg). Postoperative pain was assessed using the Visual Analogue Scale (VAS) and the Brief Pain Inventory (BPI) at defined intervals. Additional analgesic requirements and duration of hospital stay were also recorded. Statistical analysis was performed using the chi-square test and the Mann-Whitney U test.

Results:

The incidence of STP was significantly lower in Group A (0%) compared to Group B (20.4%) ($p = 4.80 \times 10^{-6}$). Group B reported higher postoperative pain scores and a greater need for supplemental analgesia. However, no significant differences were observed between the groups in terms of hospital stay duration or intraoperative/postoperative complications.

Conclusion:

Low-pressure CO_2 pneumoperitoneum during laparoscopic cholecystectomy under spinal anaesthesia significantly reduces the incidence and severity of postoperative shoulder tip pain without increasing surgical risk. This technique may be considered a preferable alternative to standard-pressure pneumoperitoneum in clinical practice.

Keywords: Shoulder tip pain, laparoscopic cholecystectomy, low-pressure pneumoperitoneum, spinal anaesthesia, carbon dioxide, postoperative pain, randomized controlled trial

INTRODUCTION

Laparoscopic cholecystectomy (LC) has become the standard procedure for gallbladder removal, offering multiple advantages over open surgery, including reduced postoperative pain, shorter hospital stay, lower infection risk, and improved cosmetic outcomes [1,2]. A critical component of LC is the creation of pneumoperitoneum using carbon dioxide (CO_2), which improves intra-abdominal visibility and working space for surgical instruments. However, CO_2 insufflation can lead to postoperative complications such as shoulder tip pain (STP), commonly attributed to diaphragmatic irritation and phrenic nerve stimulation by residual gas [3,4].

Shoulder tip pain is a frequent postoperative complaint following laparoscopic cholecystectomy (LC), primarily caused by diaphragmatic irritation from retained CO_2, which stimulates the phrenic nerve and leads to referred shoulder discomfort. Chemical irritation of the peritoneum can also activate pain receptors and prolong the sensation. The intensity and duration of this pain are influenced by residual gas volume and the intra-abdominal pressure used during surgery. Though typically self-limiting, shoulder tip pain can negatively impact postoperative recovery.

The level of CO_2 insufflation pressure significantly affects both surgical effectiveness and patient comfort. Lower pressures (6–8 mmHg) can minimize postoperative pain and support hemodynamic stability but may compromise the surgical field. Standard pressures (12–15 mmHg) offer better visibility and maneuverability but increase the risk of cardiovascular stress and shoulder pain. Pressures above 15 mmHg are avoided due to potential adverse effects on organ perfusion. Tailoring insufflation pressures to individual patient profiles helps achieve optimal surgical and recovery outcomes.

Traditionally performed under general anesthesia, LC is now also being conducted under spinal anesthesia with sedation, especially in patients with elevated anesthetic risk. This method avoids intubation, reduces airway complications, and provides more stable hemodynamics. It also lowers the incidence of postoperative nausea and vomiting by reducing reliance on volatile agents and opioids. Additionally, spinal anesthesia allows for the use of lower intra-abdominal pressures, potentially reducing shoulder tip pain. Faster recovery and earlier mobilization make this technique a promising alternative in selected cases. Overall, LC remains the preferred approach for gallbladder removal, and adjusting pneumoperitoneum pressure—especially under spinal anesthesia—can significantly enhance patient outcomes.

This study aims to assess postoperative shoulder tip pain in patients undergoing laparoscopic cholecystectomy using low-pressure (10 mmHg CO_2) versus standard-pressure (14 mmHg CO_2) pneumoperitoneum under spinal anesthesia. Conducted as a one-year hospital-based randomized controlled trial, the objectives include comparing shoulder tip pain between the two pressure groups and evaluating the influence of spinal anesthesia with bupivacaine combined with pentazocine sedation on pain outcomes across different pneumoperitoneum pressures.

MATERIALS AND METHODS

This prospective, randomized controlled trial was conducted over one year at Tej Bahadur Sapru Hospital, Prayagraj, to assess postoperative shoulder tip pain in patients undergoing laparoscopic cholecystectomy under spinal anesthesia, comparing low-pressure (10 mmHg) and standard-pressure (14 mmHg) CO_2 pneumoperitoneum. Two hundred patients aged 25–65 years with gallstone disease and normal hepatobiliary function were randomized into two groups. Exclusion criteria included major comorbidities and conversion to open surgery. Standardized surgical and anesthetic protocols were followed, with pain assessed using the Visual Analogue Scale (VAS) and Brief Pain Inventory (BPI) at defined intervals. Additional outcomes included analgesic use, CO_2 insufflation time, and hospital stay. Data were analyzed using appropriate statistical tests ($p < 0.05$). Ethical approval and informed consent were obtained in accordance with the Declaration of Helsinki.

RESULT

Out of 200 patients undergoing laparoscopic cholecystectomy, 138 (69%) were female and 62 (31%) were male (Figure 1). Among those receiving low-pressure pneumoperitoneum (L group), 71 were female and 31 were male (n = 102), while in the standard-pressure group (S group), 67 were female and 31 were male (n = 98). Chi-square analysis showed no statistically significant difference in gender distribution between the groups ($\chi^2 = 0.036$, **p** = 0.85), indicating that gender was not a determining factor in pressure group assignment.

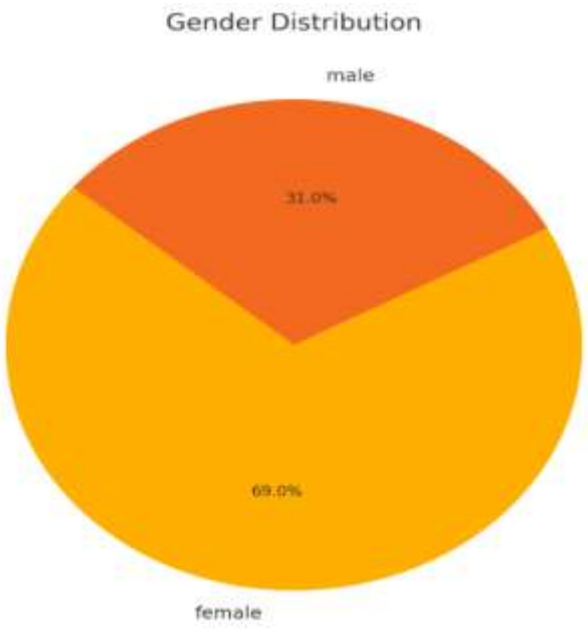

Figure 1: Percentage distribution of sex

The patients' ages ranged from 25 to 70 years, with a mean age of 43.05 ± 10.10 years and a median age of 42 years (**Figure 2**). Most patients were between 31–50 years of age. The mean age in the low-pressure group was 43.2 ± 10.22 years. These differences were not statistically significant, confirming a comparable age distribution across both groups.

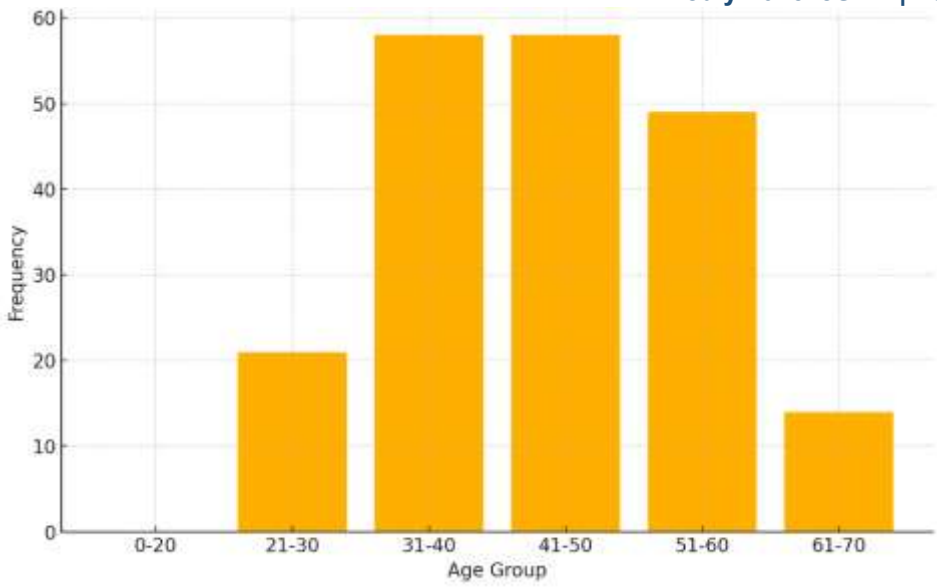

Figure 2: Distribution of Age group

The distribution of comorbid conditions such as diabetes, hypertension, and thyroid disorders was similar in both groups (**Table 1**). Among low-pressure patients, the most common comorbidities included diabetes (13 cases) and hypertension (15 cases). In the standard-pressure group, 18 patients had hypertension and 9 had diabetes. Chi-square analysis revealed no statistically significant difference in comorbidity distribution between the groups (χ^2 = 7.32, **p** = 0.60), indicating preoperative health conditions were equally represented in both cohorts.

Table 1: Pre-Op workup with patients undergoing N and L pressure group

Finding in Preoperative workup	Low pressure	Standard pressure
Diabetes	13	9
Hypertension	15	18
Hypertension + diabetes	2	0
Hypertension +Diabetes	1	0
Hypertension +diabetes	1	1
Hypertension +hypothyroidism	0	1
Hyperthyroid	0	1
Hypothyroidism	5	6

The mean CO_2 insufflation time was 29.73 ± 5.52 minutes in the low-pressure group, 27.14 ± 6.36 minutes in converted cases (low-to-standard), and 30.36 ± 5.60 minutes in the standard-pressure group (**Figure 3**). The Mann-Whitney U test showed no statistically significant difference in insufflation time between groups (U = 4319.0, **p** = 0.43). A wider interquartile range and the presence of outliers in the low-pressure group indicated greater variability, likely due to differences in surgical complexity or individual patient factors.

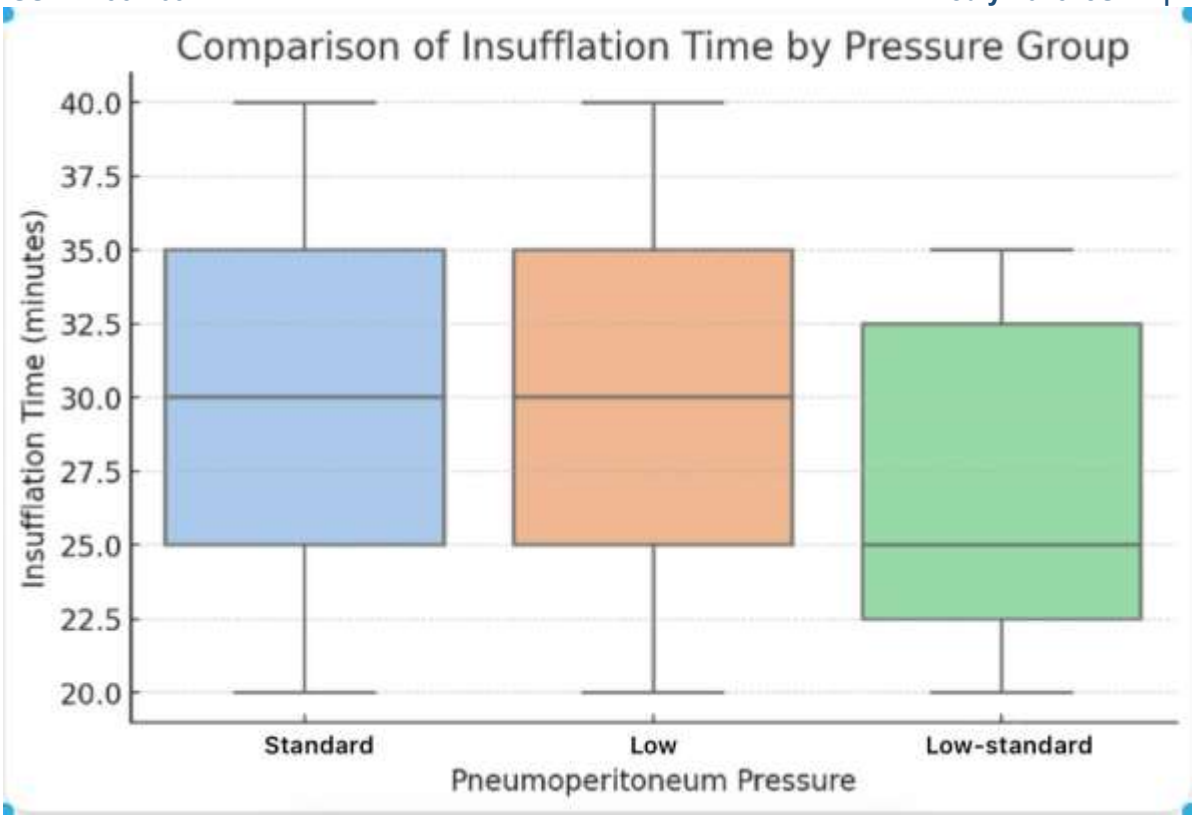

Figure 3: Comparison of Insufflation Time by Pressure Group

Postoperative drain placement occurred in 5 patients (5.26%) in the low-pressure group and 4 patients (4.08%) in the standard-pressure group (**Figure 4**). Seven patients initially started with low pressure but were converted to standard pressure; all were male, and none required drains. The overall incidence of drain placement did not differ significantly between the groups ($\chi^2 = 0.499$, $\mathbf{p} = 0.77$), suggesting pressure setting did not influence the need for postoperative drainage.

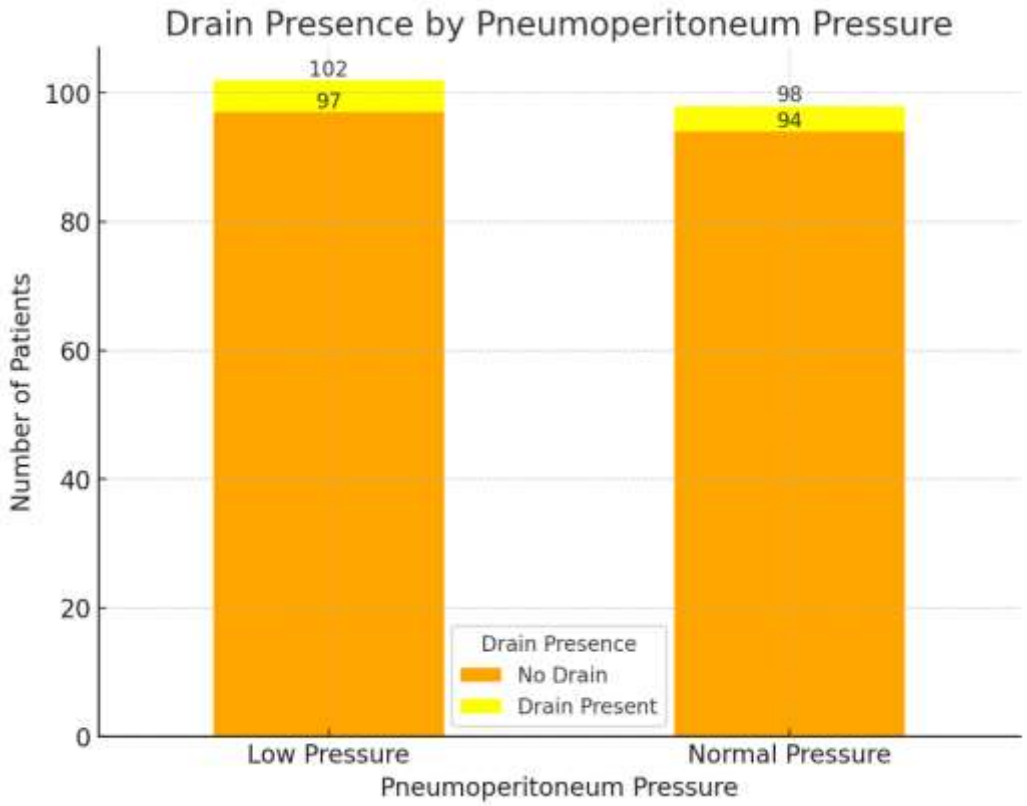

Figure 4: Drain Presence by Pneumoperitoneum Pressure

No significant association was found between drain placement and the incidence of postoperative shoulder tip pain ($\chi^2 = 0.0$, $\mathbf{p} = 1.0$). Similarly, insufflation time did not significantly differ between patients with and without shoulder tip pain (Mann-Whitney U = 1629.5, $\mathbf{p} = 0.498$). These findings indicate that neither variable significantly contributes to shoulder tip pain development.

Shoulder tip pain was reported by 20 patients (20.4%) in the standard-pressure group, while none of the patients in the low-pressure group experienced this complication (**Figure 5**). This difference was statistically significant ($\chi^2 = 20.92$, $\mathbf{p} = 4.8 \times 10^{-6}$), strongly indicating that low-pressure pneumoperitoneum is associated with a lower incidence of postoperative shoulder pain.

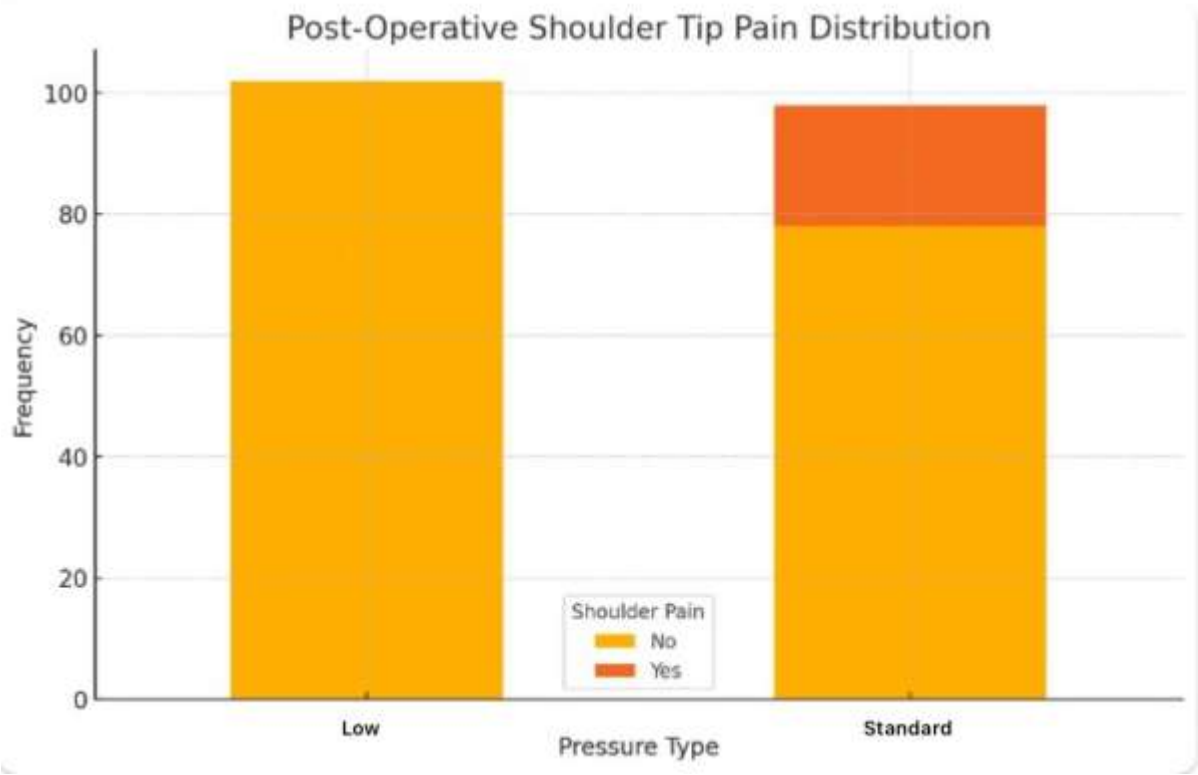

Figure 5: Post-Operative Shoulder Tip Pain Distribution

Table 2 compares the age distribution of patients in the low- and standard-pressure pneumoperitoneum groups. The mean age was similar between the groups—43.21 years (low-pressure) and 42.88 years (standard-pressure)—with a standard deviation of approximately 10 years in both, indicating moderate variability. The minimum ages were 26 and 25 years, respectively. The 25th percentile values were 36 (low-pressure) and 37 (standard-pressure), while the medians were nearly identical at 42 and 41.5 years. The 75th percentile and maximum age (50 and 65 years) were available only for the low-pressure group. Overall, the age profiles between groups were comparable

Table 2: Low and Standard pressure age statistics

	Low pressure age statistics	**Standard Pressure Age Statistics**
count	102	98
mean	43.20588	42.87755
std	10.22067	10.02293
min	26	25
25%	36	37
50%	42	41.5
75%	50	-
max	65	-

Among the 20 patients who reported shoulder tip pain, 11 required additional analgesia and 9 did not (**Table 3**). The association between shoulder tip pain and the need for extra analgesia was not statistically significant ($\chi^2 = 0.0$, **p** = 1.0), suggesting variability in individual pain tolerance or response to standard pain management protocols.

Table 3: Post-operative need for additional analgesia in patients suffering from shoulder pain

Shoulder pain	no	yes
yes	9	11
Chi-Square Value: 0.0, P value: 1.0		

Only 3 out of 20 patients with shoulder tip pain had a prolonged hospital stay exceeding 24 hours, while the remaining 17 were discharged within 24 hours (Table 4). There was no significant association between shoulder tip pain and extended hospitalization ($\chi^2 = 0.0$, **p** = 1.0), indicating that shoulder pain, though discomforting, did not substantially delay recovery or discharge.

TABLE 4: Patients staying more than 24 hr post-surgery due to shoulder tip pain

Prolonged Stay (>24 hours)	**Count**
No	17
Yes	3
Chi-Square Value: 0.0, P value: 1.0	

4. DISCUSSION

Shoulder tip pain (STP) is a common complication following laparoscopic surgeries, particularly cholecystectomy, affecting nearly one-third of patients [1,2]. First documented during laparoscopic sterilization procedures, this referred pain typically resolves within 2–3 days and is generally managed with simple analgesics such as paracetamol and codeine [3].

The most widely accepted cause of STP is diaphragmatic irritation from carbon dioxide (CO_2) pneumoperitoneum, which stimulates the phrenic nerve and results in referred pain to the shoulder [4,5]. Other contributing factors include peritoneal stretching, inadvertent diaphragmatic trauma, and prolonged shoulder abduction during surgery [6,7].

To mitigate STP, several interventions have been explored, including low-pressure CO_2 insufflation, warmed gas, slower insufflation rates, subdiaphragmatic suctioning, and local anaesthetic application [8,9]. The present study evaluates the effectiveness of low-pressure (10 mmHg) versus standard-pressure (14 mmHg) CO_2 pneumoperitoneum in reducing STP during laparoscopic cholecystectomy under spinal anaesthesia. Conducted as

a one-year randomized controlled trial, this research aims to improve patient outcomes through optimized insufflation techniques [10,11].

Additionally, gender distribution in the study cohort (N = 200) included 69% females (n = 138) and 31% males (n = 62), with no statistically significant difference ($\chi^2 = 0.036$, $p = 0.85$), consistent with previous findings that gallbladder disease is more prevalent among females [12]. This study aligns with previous literature, reinforcing that lower pneumoperitoneum pressure may effectively reduce STP without affecting surgical efficacy.

In our study, the majority of participants were middle-aged, with 29% each in the 31–40 and 41–50-year age groups. The mean age was 43.05 ± 10.10 years, and the median was 42, indicating a predominantly middle-aged cohort. This aligns with previous studies (Singla et al., 2018; Scott et al., 2001), which also observed a higher prevalence of gallbladder disease in this age group. Some studies suggest that younger individuals may experience more postoperative pain due to faster recovery and increased diaphragmatic sensitivity. Our study showed no significant age-related bias, making it comparable to similar trials.

We also assessed the impact of comorbidities on postoperative outcomes. Both low- and standard-pressure groups had similar distributions of hypertension, diabetes, and thyroid disorders, with no significant differences (Chi-square = 7.32, p = 0.60). This suggests that comorbidities did not influence recovery or shoulder tip pain. Previous studies (Hepatectomy LL, Pruthvi R, Paajanen et al.) also found no strong link between comorbidities and postoperative pain or complications.

Insufflation time was comparable between groups—29.73 minutes for the low-pressure and 30.36 minutes for the standard-pressure group (p = 0.43)—indicating that duration of CO_2 insufflation does not significantly impact shoulder tip pain. Supporting studies (Pavan GS, Al-Dabbagh AA) also emphasize pressure levels and diaphragmatic irritation over insufflation time.

Drain placement was similar in both groups (5.26% vs. 4.08%; p = 0.77), suggesting that pneumoperitoneum pressure does not influence the need for drains. Instead, surgical factors like bleeding or complications guide this decision. Previous literature (Armellin G, Mohan T, Wong SC) also found no consistent link between pressure settings and drain placement, advising against routine drain use.

Importantly, the incidence of postoperative shoulder tip pain was significantly lower in the low-pressure group (0%) compared to the standard-pressure group (20.4%) (Chi-square = 20.92, $p = 4.80 \times 10^{-6}$). This highlights that lower-pressure CO_2 pneumoperitoneum (10 mmHg) effectively reduces diaphragmatic irritation and associated shoulder pain, supporting its use in laparoscopic cholecystectomy.

Our findings align with existing evidence supporting low-pressure pneumoperitoneum to reduce postoperative shoulder tip pain. Studies by Sao CH et al. (2019) and Variawa M (2015) similarly found that lower insufflation pressures decrease diaphragmatic irritation and CO_2-related phrenic nerve stimulation. Reduced peritoneal distension at 10 mmHg minimizes pain without compromising surgical visibility, reinforcing the clinical value of low-pressure settings for improved patient comfort [21,22].

The reduced incidence of shoulder tip pain (STP) at lower insufflation pressure (10 mmHg) is likely due to decreased peritoneal stretch and diaphragmatic irritation, minimizing phrenic nerve stimulation. Lower pressure also reduces CO_2 retention and inflammation, supporting its role as a key modifiable factor in postoperative pain management.

While our findings support the benefits of low-pressure insufflation, Dey et al. (2015) reported no significant link between pneumoperitoneum pressure or surgery duration and shoulder tip pain, suggesting other factors like anatomy, technique, or pain sensitivity may be more influential. These conflicting results underscore the need for larger randomized trials to clarify the role of insufflation pressure in postoperative pain.

In our study, the low-pressure group had a mean age of 43.21 years, with most patients aged between 30–50 years, reflecting the typical demographic for gallbladder disease. Age distribution was consistent across both pressure groups, supporting the established link between middle age and cholelithiasis. However, age did not significantly influence postoperative shoulder tip pain, which was more strongly associated with CO_2 insufflation pressure, gas retention, and diaphragmatic irritation, as also noted by Variawa M et al. (2015) and Ranganathan P (2017).

Both groups showed similar age distributions, mostly between 30–50 years, aligning with prior studies. However, higher insufflation pressure (14 mmHg) led to increased shoulder tip pain, while low pressure (10 mmHg) significantly reduced it. Although analgesic use did not vary significantly ($\chi^2 = 0.0$, $p = 1.0$), literature suggests greater analgesic needs with standard pressure. These results indicate that insufflation pressure—not age—is the primary factor affecting postoperative pain and recovery, with lower pressures associated with less discomfort and reduced analgesic demand [26].

CONCLUSION

Laparoscopic cholecystectomy is the preferred treatment for gallstone disease, but postoperative shoulder tip pain (STP) remains common due to CO_2-induced diaphragmatic irritation. This randomized controlled trial at Tej Bahadur Sapru Hospital, Prayagraj, evaluated the effect of pneumoperitoneum pressure on STP in 200 patients undergoing the procedure under spinal anesthesia. Patients were randomized to low-pressure (10 mmHg) or standard-pressure (14 mmHg) CO_2 groups. STP was assessed using the Visual Analogue Scale (VAS) and Brief Pain Inventory (BPI), along with secondary outcomes like analgesic needs and hospital stay. Results showed that low-pressure pneumoperitoneum significantly reduced STP without affecting surgical safety or recovery, supporting its use for improved postoperative comfort and patient outcomes.

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