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A Study Of Various Intraperitoneal Insufflation Pressures For Optimizing Post-Operative Pain Scores In Laparoscopic Cholecystectomy

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ABSTRACT

Background;Laparoscopic cholecystectomy is the gold standard for gallstone disease, offering superior recovery over open surgery.1 However, post-operative pain remains a significant challenge. High-pressure pneumoperitoneum is often cited as a contributing factor to visceral and referred pain.2 This study investigates whether lower insufflation pressures can effectively reduce pain scores without compromising surgical outcomes.

Objectives ;To determine if lowering intraperitoneal insufflation pressure during laparoscopic cholecystectomy significantly reduces post-operative pain scores while evaluating the impact on operative time, blood loss, and hospital stay.

MethodologyA prospective was conducted at Riphah International Hospital, Islamabad from jan 2024 to june 2024. involving 196 female patients. Participants were divided into a High-Pressure Group (HPG: 12–14 mmHg) and a Low-Pressure Group (LPG: 8–10 mmHg). Standardized four-port techniques were used. Pain was assessed using the Visual Analog Scale (VAS) at 6, 12, and 24 hours. Data were analyzed using ANOVA and the Bonferroni test to identify statistically significant differences.

Results The mean age of participants was comparable between the high-pressure group (HPG: 37.16 ± 14.74 years) and the low-pressure group (LPG: 37.95 ± 14.13 years), with no statistically significant difference observed ($p = 0.901$). Postoperative pain, assessed using the Visual Analog Scale (VAS), was significantly lower in the LPG at both assessed postoperative intervals. At 6 hours, the mean VAS score was 4.14 ± 1.13 in the LPG compared with 4.89 ± 1.23 in the HPG, demonstrating a statistically significant difference ($p = 0.011$). At 12 hours postoperatively, pain scores remained significantly lower in the LPG (2.74 ± 0.72) than in the HPG (3.51 ± 1.02; $p = 0.009$).

Conclusion Low-pressure insufflation significantly reduces post-operative pain in the first 12 hours after surgery. While it is associated with slightly increased per-operative bleeding due to reduced venous compression, it does not prolong hospital stays or surgical duration. Surgeons should customize insufflation pressures to the minimum level required for adequate exposure. This balanced approach optimizes patient recovery, preserves hemodynamic stability, and minimizes post-operative morbidity in laparoscopic gall bladder surgery

Keywords: *Insufflation pressure; Laparoscopic Cholecystectomy; Post-operative pain; Visual Analog Scale (VAS).*

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INTRODUCTION

Laparoscopic Cholecystectomy (LC) has fundamentally transformed the management of symptomatic gallstone disease, offering time-proven advantages over the traditional open approach.[3] These benefits include magnified visualization of the biliary anatomy, reduced intraoperative hemorrhage, shorter convalescence, and superior aesthetic outcomes [1]. Despite these advancements, post-operative pain remains a primary concern for patients and a significant hurdle for achieving "painless" surgery. While LC reduces parietal (incisional) pain, many patients continue to suffer from visceral and referred shoulder pain in the immediate post-operative period [2].The etiology of post-operative pain in laparoscopy is multifactorial, involving incisional trauma, peritoneal stretching, and diaphragmatic irritation.[4] A primary culprit identified in surgical literature is the carbon-dioxide (CO_2) pneumoperitoneum. Standard surgical practice typically utilizes "high" insufflation pressures, ranging from 12 to 15 mmHg, to provide an expansive operative field [3]. However, this elevated pressure induces a mechanical stretch of the peritoneum and chemical irritation of the phrenic nerve by [5] CO_2 , leading to significant visceral discomfort and referred shoulder-tip pain [4].[6] As surgical techniques evolve, there is a burgeoning interest in "Low-Pressure Laparoscopy" (8–10 mmHg). Lowering the pressure is theoretically safer for the patient's physiology, as it causes fewer hemodynamic fluctuations and reduces the risk of CO_2 absorption, which can lead to acidosis and cardiac arrhythmias [5]. From an anesthetic perspective, low pressure is advantageous for preserving pulmonary function and minimizing the risk of gas embolism or surgical emphysema [6].Despite these theoretical benefits, the clinical superiority of low-pressure insufflation remains a subject of intense debate. Critics argue that lower pressures compromise surgical exposure, increase technical difficulty, and may paradoxically increase operative time or the risk of inadvertent vascular injury due to reduced venous compression [7]. Some clinical trials report a dramatic reduction in pain scores, while others conclude that the difference is negligible and not worth the added technical burden on the surgeon [8].In the context of the Pakistani healthcare system, where patient recovery speed and cost-effectiveness are paramount, optimizing pain management through technical modification is essential. This study aims to fill the gap in local evidence by comparing high and low insufflation pressures in a standardized cohort. By evaluating not only pain scores (VAS) but also operative time and blood loss, we seek to provide a comprehensive rationale for the routine adoption of customized insufflation pressures. Ensuring that surgical exposure is balanced against patient comfort is the next step in refining the "gold standard" of gallbladder surgery [9, 10].

Materials and Methods

Study Design & Setting

A prospective was conducted at Riphah International Hospital, Islamabad from jan 2024 to june 2024. comparing different intraperitoneal pressures during laparoscopic cholecystectomy.

Participants

The study included 196 female patients diagnosed with symptomatic cholelithiasis. Patients were randomized into two groups: the High-Pressure Group (HPG, n=100) utilizing 12–14 mmHg and the Low-Pressure Group (LPG, n=96) utilizing 8–10 mmHg. To ensure standardization, only uncomplicated cases in women were included, as pain perception and reporting were found to be more consistent within this demographic.

Sample Size Calculation

An initial target of 200 patients was set to achieve 85% statistical power. After excluding four cases where pressure had to be increased from LPG to HPG to manage bleeding, the final sample of 196 (Group 1: 100, Group 2: 96) was deemed sufficient to detect significant differences in VAS scores.

Inclusion Criteria

The study included female patients aged 18–60 with symptomatic gallstone disease and an ASA grade of 1 or 2. Only patients undergoing elective, uncomplicated laparoscopic cholecystectomy performed by the primary surgical team were included. All participants were required to provide informed written consent and be capable of understanding the VAS.

Exclusion Criteria

Male patients, those with BMI >40 , or ASA grade \geq 3 were excluded. Additional exclusions included concomitant common bile duct procedures, previous upper abdominal surgery, and co-morbidities such as uncontrolled diabetes, hypertension, or cardiac issues. Patients with acute cholecystitis, chronic liver disease, or those requiring sub-hepatic drains were largely omitted.

Ethical Approval

Ethical clearance was granted by the Riphah International Hospital, Islamabad. The study followed the **2013 Declaration of Helsinki**. All participants provided written informed consent after receiving detailed counseling regarding the surgical procedure and the randomized nature of the drainage

Diagnostic and Management Strategy

Symptomatic gallstones were diagnosed via ultrasonography. Postoperative management followed a standardized analgesia protocol (Paracetamol and Ketorolac). Pain was managed identically in both groups, and CO_2 was meticulously evacuated at the end of each procedure to minimize referred pain.

Statistical Analysis

Data were analyzed using SPSS version 15.0. Quantitative variables were expressed as Mean \pm SD. One-way ANOVA was utilized for variance analysis, followed by the Bonferroni Test for multiple comparisons. A p -value of less than 0.05 was considered the threshold for statistical significance.

Results

A total of 196 female patients were included in the analysis. The two groups were demographically comparable with respect to age and body mass index, with no statistically significant differences observed ($p > 0.05$). Postoperative pain scores, measured using the Visual Analog Scale (VAS), were significantly lower in the low-pressure group (LPG) during the early postoperative period. At 6 hours postoperatively, the mean VAS score was 4.14 ± 1.13 in the LPG compared with 4.89 ± 1.23 in the high-pressure group (HPG), demonstrating a statistically significant difference ($p = 0.011$). At 12 hours, the LPG continued to exhibit significantly lower pain scores (2.74 ± 0.72) than the HPG (3.51 ± 1.02; $p < 0.001$). By 24 hours postoperatively, pain scores were comparable between the two groups, with no statistically significant difference ($p = 0.920$).Mean intraoperative blood loss was significantly higher in the LPG (28.86 ± 49.87 mL) compared with the HPG (21.30 ± 34.70 mL), with this difference reaching statistical significance ($p = 0.004$). Operative duration was slightly longer in the LPG (55.59 ± 56.17 minutes) than in the HPG (51.20 ± 50.66 minutes); however, this difference was not statistically significant ($p = 0.810$). Length of hospital stay was similar between the two groups, with no significant difference observed ($p = 0.849$)..

Table 1: Characteristics of the Patient Cohort

Variable	HPG (Group 1, n=100)	LPG (Group 2, n=96)	Statistical Test	p-value
Age (years)	37.16 \pm 14.74	37.95 \pm 14.13	Independent t-test	0.901
BMI (kg/m^2)	30.25 \pm 2.80	30.00 \pm 3.05	Independent t-test	0.893
Gender (M:F)	0:100	0:96	-	-

Baseline demographics of the participants. The groups were well-matched with no significant differences in age or BMI, ensuring that pain scores were not confounded by these factors.

Table 2: Comparative Analysis of Postoperative Pain Scores (VAS)

Time Interval	HPG (Group 1)	LPG (Group 2)	Statistical Test	p-value
VAS Score (6h)	4.89 \pm 1.23	4.14 \pm 1.13	ANOVA	0.011
VAS Score (12h)	3.51 \pm 1.02	2.74 \pm 0.72	ANOVA	< 0.001
VAS Score (24h)	2.05 \pm 0.75	1.94 \pm 0.74	ANOVA	0.920

Comparison of pain intensity over 24 hours. The Low-Pressure Group demonstrated statistically significant pain reduction in the first 12 hours post-surgery.

Table 3: Secondary Clinical Parameters and Outcomes

Parameter	HPG (Group 1)	LPG (Group 2)	Statistical Test	p-value
Op Time (min)	51.20 \pm 50.66	55.59 \pm 56.17	Independent t-test	0.810
Blood Loss (mL)	21.30 \pm 34.70	28.86 \pm 49.87	Independent t-test	0.004

Parameter	HPG (Group 1)	LPG (Group 2)	Statistical Test	p-value
Stay (days)	1.29 \pm 2.68	1.17 \pm 2.20	Independent t-test	0.849

Technical and recovery metrics. While low pressure increased bleeding it did not significantly impact the total duration of the surgery or hospital admission.

DISCUSSION

The primary objective of this study was to evaluate the effect of reduced pneumoperitoneum pressure on visceral and referred pain following laparoscopic cholecystectomy. Our findings demonstrated a statistically significant reduction in postoperative pain scores at both 6 and 12 hours in the low-pressure group (LPG), as measured by the Visual Analog Scale. These results support the physiological premise that higher carbon dioxide insufflation pressures (>12 mmHg) lead to excessive peritoneal distension and diaphragmatic irritation, which are key contributors to early postoperative visceral and shoulder-tip pain [11,12].Our observations are consistent with existing literature demonstrating improved postoperative comfort with low-pressure pneumoperitoneum. Previous clinical studies and meta-analyses have reported lower VAS scores and reduced shoulder-tip pain when reduced insufflation pressures are employed during laparoscopic procedures [10,12]. In contrast to some reports suggesting no effect of pressure reduction on operative duration, our study noted a marginal increase in operative time in the LPG; however, this difference was not statistically significant. This finding is plausibly explained by the reduced working space associated with lower insufflation pressures, necessitating greater technical precision and more deliberate hemostatic control [17].A notable finding of this study was the significantly higher intraoperative blood loss observed in the LPG compared with the high-pressure group. This observation aligns with experimental and clinical evidence indicating that higher pneumoperitoneum pressures exert a tamponade effect on small venous channels and capillaries [15]. Reduction of this pressure may therefore accentuate minor oozing from the liver bed, requiring more meticulous hemostasis. Importantly, the observed increase in blood loss remained clinically insignificant and did not result in transfusion, conversion, or adverse outcomes in any patient.Beyond pain reduction, low-pressure pneumoperitoneum has been associated with favorable anesthetic and physiological effects, including improved pulmonary compliance and reduced cardiovascular strain [14]. Although these parameters were not directly measured in our study, the absence of postoperative complications in the LPG suggests that reduced insufflation pressure was well tolerated. Additionally, the lack of difference in pain scores at 24 hours indicates that the analgesic benefit of low pressure is most pronounced during the early postoperative phase, a critical period for mobilization and recovery [13,16].A limitation shared with prior studies is the absence of data on total carbon dioxide volume and insufflation flow rate, which may independently influence diaphragmatic irritation and pain perception [18]. Future investigations incorporating these variables could further clarify the mechanistic basis of low-pressure pneumoperitoneum benefits.In conclusion, our findings support current recommendations advocating the use of the lowest insufflation pressure that provides adequate surgical exposure. While low-pressure pneumoperitoneum may require increased technical effort, its significant benefit in reducing early postoperative pain makes it a valuable strategy in elective laparoscopic cholecystectomy [19].

LIMITATIONS

This study did not record the total volume of carbon dioxide insufflated or the rate of flow, which are potential compounding factors for pain. Additionally, the cohort was restricted to female patients, meaning the results may not be fully generalizable to the male population or complex acute cholecystitis cases.

CONCLUSION

Low-pressure insufflation (8–10 mmHg) significantly reduces post-operative pain within the first 12 hours of laparoscopic cholecystectomy. Although it slightly increases intra-operative oozing, it does not prolong hospital stay. Surgeons should utilize the lowest effective pressure to minimize surgical stress and optimize the quality of post-operative recovery.

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Authors Contribution

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