

INCIDENCE AND RISK FACTOR OF TIP SHOULDER PAIN IN LAPAROSCOPIC SURGERIES UNDER GENERAL ANESTHESIA IN TERTIARY CARE HOSPITAL IN PESHAWAR PAKISTAN

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Abstract

Post laparoscopic shoulder tip pain (PLSP) is a well-documented but frequently managed complication following laparoscopic cholecystectomy. Referred shoulder pain caused by phrenic nerve irritation from residual carbon dioxide (*CO2*) pneumoperitoneum significantly affects post-operative patient comfort and delayed discharge. This study aimed to determine the current incidence, clinical severity distribution, and specific intraoperative risk factors (such as surgical duration and gas pressure) associated with post-laparoscopic shoulder tip pain among patients undergoing elective laparoscopic cholecystectomy under general anesthesia in any tertiary care hospital. A multi-center, cross-sectional observational study was conducted involving a total cohort of 215 adult patients across two tertiary care hospitals in Peshawar. Standardized data collection charts were utilized to record demographics, intraoperative variables, and post-operative pain scores within the first 6 hours. Pain intensity was classified using a 0–10 Visual Analogue Scale (VAS) into mild (1–3), moderate (4–6), and severe (7–10) categories. Data were analyzed using descriptive statistics and Pearson Chi-Square tests (χ^2) in SPSS version 26, with a significance threshold set at $p < 0.05$. The final statistical analysis revealed an overall PLSP incidence rate of **41%** ($n = 88$) within the total study population. In terms of pain severity breakdown, **35%** ($n = 75$) of the patients experienced mild, tolerable pain; **4%** ($n = 9$) suffered from moderate, distracting pain; and **2%** ($n = 4$) faced severe, distressing pain that limited normal mobility. SPSS Chi-Square testing demonstrated that a surgical duration exceeding 60 minutes ($\chi^2 = 14.820, p = 0.000$) and the use of high intra-abdominal pneumoperitoneum pressure ($\chi^2 = 19.450, p = 0.000$) were highly significant independent risk factors for the onset and severity of PLSP. Conversely, the

institutional setting or hospital site itself showed no statistically significant association with pain occurrence ($\chi^2 = 0.114$, $p = 0.945$). While the pain is predominantly mild, the sub-fraction of patients experiencing moderate-to-severe distress underscores the need for standardizing preventive strategies.

1. INTRODUCTION

Laparoscopic cholecystectomy (LC) has established itself as the therapeutic gold standard for gallbladder diseases worldwide. Compared to traditional open laparotomy, this minimally invasive approach offers significant clinical benefits, including diminished postoperative pain, shortened hospital stays, cosmetic advantages, and accelerated return to daily activities. Despite these clear advantages, a substantial number of patients continue to suffer from an underreported yet distressing complication: post-laparoscopic shoulder tip pain (STP). This specific discomfort often eclipses incisional pain, causing considerable patient distress, sleep disturbances, and ultimately delaying postoperative discharge. Consequently, implementing effective strategies for optimal postoperative pain management remains a critical priority in surgical care (Al Janaby *et al.*, 2020).

The clinical presentation of acute postoperative pain serves primarily as a physiological defense mechanism against tissue injury and homeostatic disruption. However, if left poorly managed, severe acute pain can lead to secondary systemic insults and increase the risk of transitioning into a chronic, distressing pain state. Globally, inadequate pain management imposes a massive socioeconomic burden, demonstrating relatively low spontaneous recovery rates once chronicity develops. In contemporary clinical practice, pain control is recognized as a fundamental quality indicator. Standardized management protocols dictate a multimodal approach: mild pain is typically managed using Paracetamol and Non-Steroidal Anti-inflammatory Drugs (NSAIDs), whereas moderate pain necessitates the addition of weak opioids such as tramadol or codeine. For severe or persistent pain, potent opioids like morphine and fentanyl, or advanced

interventions such as peripheral nerve blocks, are utilized to ensure patient comfort and early mobilization (Panditrao *et al.*, 2025).

While the precise pathophysiology of shoulder tip pain following laparoscopic cholecystectomy is multifactorial, it is primarily attributed to the establishment of the 1 pneumoperitoneum. The insufflation and residual entrapment of carbon dioxide CO₂ gas within the peritoneal cavity leads to subdiaphragmatic stretching and localized chemical irritation of the peritoneal lining. This irritation stimulates the phrenic nerve, which shares the C3 to C5 dermatomal origins, thereby transmitting referred pain directly to the shoulder tip. Various intraoperative and anesthetic strategies have been explored to mitigate this issue, such as maintaining low insufflation pressures, employing active gas evacuation, and optimizing patient positioning. Understanding these specific risk factors under general anesthesia is essential to refining perioperative care and improving patient outcomes.

1.1 Pathophysiology of Referred Pain

The physiological mechanism underlying post-laparoscopic shoulder tip pain (STP) is complex, primarily stemming from diaphragmatic irritation and subsequent phrenic nerve stimulation induced by the carbon dioxide CO₂ pneumoperitoneum. During laparoscopic interventions, CO₂ gas is insufflated into the peritoneal cavity to create a stable and visible surgical working space. However, this process frequently leads to localized chemical irritation and stretching of the peritoneal lining. Furthermore, residual pockets of CO₂ gas often remain trapped beneath the diaphragm after the procedure. This retained gas undergoes hydration, converting into carbonic acid, which directly irritates the phrenic nerve pathways. Because the phrenic nerve shares cervical nerve roots (C3–C5) with the supraclavicular nerve, the brain misinterprets these nociceptive signals as originating from the shoulder region, resulting in referred pain, predominantly on the right side (Li *et al.*, 2025).

Effective and aggressive postoperative pain management is crucial, as it directly influences

patient recovery trajectories. Achieving optimal analgesia facilitates early ambulation, which plays a pivotal role in mitigating life-threatening postoperative risks such as deep vein thrombosis (*DVT*) and pulmonary embolism. Additionally, when pain is adequately controlled, patients can comfortably perform deep breathing exercises and effective coughing. This significantly reduces pulmonary complications, including atelectasis and nosocomial pneumonia, thereby preventing unnecessary diagnostic investigations and lowering overall healthcare expenditure. To combat post-laparoscopic discomfort, contemporary clinical practices utilize various intraoperative and multimodal anesthetic strategies. Research has extensively evaluated interventions such as maintaining low-pressure pneumoperitoneum, administering pre-emptive systemic analgesics, performing forced gas evacuation maneuvers, and conducting thorough peritoneal washing with warmed normal saline. Among these techniques, the intraperitoneal instillation of local anesthetics has gained considerable attention. This approach effectively blocks visceral afferent signaling, thereby modifying visceral nociception and dampening the neuroendocrine stress response to surgical trauma (Abd-Aljabbar *et al.*, 2020).

1.2 Detailed Pathophysiology of Post-Laparoscopic Shoulder Pain

The neurobiochemical mechanisms driving post-laparoscopic shoulder pain (PLSP) involve an intricate interplay of mechanical and chemical triggers. Establishing a carbon dioxide CO₂ pneumoperitoneum is a fundamental requirement during laparoscopic cholecystectomy to ensure adequate surgical exposure and safety. However, this artificial distension induces immediate structural and biochemical stress within the subdiaphragmatic environment.

Mechanically, the rapid insufflation of gas forces an unnatural cephalad displacement of the diaphragm, causing acute stretching of the peritoneal lining. This sudden traction leads to microvascular compromise, localized tissue ischemia, and cellular trauma within the diaphragmatic muscle fibers. Sensory and motor innervation to this region is predominantly supplied by the phrenic nerve, which arises from the C3 to C5 spinal cord segments. As the

subdiaphragmatic surface undergoes mechanical strain, high-threshold mechanical nociceptors are intensely stimulated, initiating a cascade of pain signals along the phrenic pathway.

Biochemically, the choice of CO_2 as an insufflation medium introduces a chemical irritant to the tissues. Residual gas remaining trapped in the suprahepatic space interacts with the moisture of the peritoneal fluid, leading to the synthesis of carbonic acid H_2CO_3 . This acid promptly dissociates into hydrogen and bicarbonate ions, inducing localized tissue acidosis and lowering the physiological pH. This acidic microenvironment acts as a potent chemical noxious stimulus on the peritoneal surface. Consequently, the simultaneous impact of mechanical tear and chemical acidosis synergistic excites the sensory afferent fibers of the phrenic nerve.

This peripheral nociceptive input is projected to the central nervous system, where the phenomenon of referred pain occurs. Because the phrenic nerve shares its spinal cord origins (primarily the C4 dermatome) with the supraclavicular nerve which provides cutaneous sensory innervation to the shoulder aspect the cerebral cortex misinterprets the source of the visceral distress. Instead of localizing the injury to the diaphragm, the central nervous system perceives the noxious stimuli as originating from the shoulder tip. This manifests clinically as a deep, poorly localized, and distressing ache in the right shoulder, which may extend toward the cervical or scapular zones, significantly hindering early postoperative recovery.

1.3 RESEARCH GAP

Despite extensive literature documenting the incidence and general characteristics of Post-Laparoscopic Shoulder Tip Pain (PLSP), there is a profound scarcity of data specifically focusing on the severity profiling of this complication within the local healthcare setting. While global studies heavily emphasize the risk factors and physiological mechanisms of PLSP, local clinical practices and surgical audits have largely overlooked the precise categorization of its severity (mild, moderate, and severe) and its direct correlation with intraoperative variables like surgical duration in tertiary care facilities. Most of the existing regional research tends to focus primarily

on immediate postoperative pain or generalized abdominal discomfort, leaving the specific intensity, progression, and patient-reported severity of shoulder tip pain completely unaddressed. This significant oversight in the current body of literature highlights a critical research gap. Consequently, there is an urgent need to systematically evaluate and categorize the severity of PLSP. Bridging this gap is essential not only to enrich local academic literature but also to help anesthesiologists and surgical teams develop targeted, severity-based pain management protocols to improve postoperative patient outcomes.

1.4 Statement of the problem

Laparoscopic cholecystectomy is a commonly performed procedure under general anesthesia; however, tip shoulder pain remains a frequent postoperative complaint despite its minimally invasive nature. This pain, mainly attributed to diaphragmatic irritation from carbon dioxide pneumoperitoneum, can cause significant patient discomfort, increased analgesic requirements, and delayed recovery. The reported incidence and contributing risk factors vary widely in existing literature, and local data from tertiary care hospitals are limited. Identifying the incidence and risk factors of tip shoulder pain in this setting is essential to improve perioperative pain management strategies and patient outcomes.

1.5 RESEARCH OBJECTIVES

- To estimate the precise clinical incidence of post-laparoscopic shoulder tip pain (STP) in patients undergoing laparoscopic cholecystectomy under general anesthesia.
- To evaluate the clinical severity and intensity profile of shoulder tip pain among affected patients utilizing a standardized clinical pain rating scale.

1.6 RESEARCH QUESTIONS

1. What is the cumulative incidence of shoulder tip pain among patients who have undergone laparoscopic cholecystectomy under general anesthesia within the target tertiary care hospital?
2. What is the phenotypic severity of post-laparoscopic shoulder tip pain in affected individuals

when quantified using standardized clinical assessment tools, such as the Visual Analogue Scale (VAS) or Numerical Rating Scale (NRS)?

1.7 SCOPE OF THE STUDY

This investigation is specifically delineated to prospective observational data collection monitoring the cumulative incidence, phenotypic severity, and chronological duration of referred shoulder tip pain within the immediate 6-hour postoperative window. The geographical and institutional boundary of this study is confined to adult patients undergoing elective laparoscopic cholecystectomy under standardized general anesthesia protocols at a tertiary care facility.

The analytical scope encompasses a thorough assessment of multi-factorial risk elements, categorized into patient-specific attributes (age, gender, BMI), intraoperative surgical variables (duration of surgery, carbon dioxide CO2 insufflation volume, and baseline pneumoperitoneum pressure), and anesthetic interventions (intraoperative opioid titration and lung recruitment maneuvers). Conversely, this study strictly excludes patients presenting with pre-existing orthopedic shoulder pathologies, chronic pain syndromes, or cases requiring emergency conversion to an open laparotomy. Ultimately, the insights derived from this study aim to address local clinical data gaps and provide evidence-based recommendations to optimize perioperative multimodal analgesic protocols in laparoscopic setups.

1.8 SIGNIFICANCE OF THE STUDY

Investigating post-laparoscopic shoulder tip pain (STP) holds substantial clinical and academic value for contemporary surgical and anesthetic practices. Existing global literature indicates that the incidence of this distressing complication can be significant, with some cohorts reporting rates around 16.8% (Panditrao *et al.*, 2025). By evaluating the precise local incidence of shoulder tip pain following laparoscopic cholecystectomy under general anesthesia, this study addresses a critical knowledge gap within regional tertiary care settings. Quantifying this complication

enhances the clinical understanding of postoperative discomfort and its direct implications on patient recovery trajectories. Furthermore, the findings will serve as an evidence-based guide for surgeons and anesthesiologists, enabling them to refine intraoperative techniques and anesthesia protocols to actively mitigate this issue. From a patient care perspective, these insights will facilitate more accurate preoperative counseling, optimize postoperative pain management regimens, and provide localized clinical data necessary to standardize institutional healthcare protocols and stimulate future academic research.

1.9 ALIGNMENT WITH SUSTAINABLE DEVELOPMENT GOALS (SDGs)

This research is intrinsically linked with the United Nations Sustainable Development Goal 3 (SDG 3: Good Health and Well-being), specifically aligning with Target 3.8, which mandates the achievement of universal health coverage alongside the provision of safe, effective, and high-quality essential healthcare services. By critically analyzing the clinical incidence and predictive risk factors associated with post-laparoscopic shoulder pain, this study directly contributes to the optimization of surgical and anesthetic outcomes. Given that laparoscopic cholecystectomy represents a fundamental, high-volume procedure in modern abdominal surgery, minimizing avoidable postoperative complications is essential to reducing patient morbidity and minimizing emotional distress. Consequently, preventing this referred pain accelerates patient discharge, shortens hospital bed occupancy, and curtails the overall socioeconomic and financial burden imposed on tertiary healthcare infrastructures.

1.10 OPERATIONAL DEFINITIONS

1.10.1 Post-Laparoscopic Shoulder Tip Pain (STP):

For the purpose of this study, post-laparoscopic shoulder tip pain is operationally defined as the referred, dull, or deep distressing ache localized in the shoulder region (predominantly the right shoulder corresponding to the C4 dermatome) reported by the patient within the first 72 hours following laparoscopic cholecystectomy. This pain is clinically distinguished from surgical site

(incisional) pain and is quantified using a standardized 10-point Visual Analogue Scale (VAS) or Numerical Rating Scale (NRS), where a score greater than 0 indicates the presence of this complication.

1.10.2 Tertiary Care Hospital:

In the context of this research, a tertiary care hospital refers to the specialized, high-capacity apex healthcare institution (specifically the designated teaching clinical facility affiliated with the City University of Science and Information Technology, Peshawar) equipped with advanced diagnostic modalities, intensive care units, and state-of-the-art laparoscopic surgical facilities. It acts as the primary data collection site hosting a diverse and high-volume patient influx referred for elective surgical interventions.

1.11 CONCEPTUAL FRAMEWORK

1. Independent Variables (Perioperative Risk Factors)

Patient Related Factors: Age, biological sex, and Body Mass Index (BMI).

Surgical Intricacies: Total operative duration, intra-abdominal carbon dioxide CO₂ insufflation pressure, total volume of CO₂ gas utilized, and degree of intraoperative Trendelenburg tilt.

Anesthetic Interventions: Intraoperative opioid dosing, implementation of lung recruitment maneuvers, and administration of intraperitoneal local anesthesia.

2. Mediating Mechanisms (Pathophysiological Pathways)

Entrapment of residual CO₂ gas within the suprahepatic space. Synthesis of carbonic acid CO₃ on the peritoneal lining. Localized diaphragmatic stretching and cellular microtrauma. Chemical and mechanical irritation of the phrenic nerve pathway.

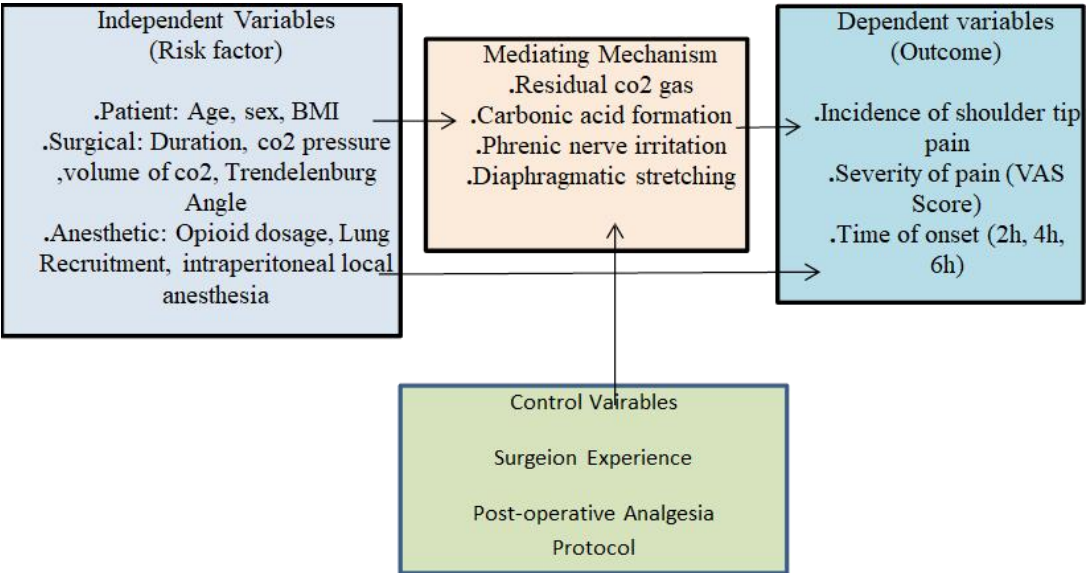
3. Dependent Variables (Clinical Outcomes)

Occurrence and clinical incidence of post-laparoscopic shoulder tip pain.

Severity profile of referred pain quantified via Visual Analogue Scale (VAS) scores. Temporal distribution and onset intervals of pain (evaluated at 2, 4, and 6 hours postoperatively).

4. Control Variables (Confounding Factors)

Level of expertise and technique consistency of the operating surgeon. Standardization of the institutional postoperative analgesia regimen



1.1 CONCEPTUAL MODEL

2 REVIEWS OF LITERATURE

In the study conducted by Panditrao et al. (2025), no statistically significant difference was observed between the study and control groups regarding postoperative pain outcomes. Abdominal pain was reported by all patients following surgery, indicating that it was a common postoperative complaint across the entire cohort. Shoulder-tip pain, a well-recognized complication after laparoscopic procedures, was observed in 16.8% of the participants overall. The distribution of shoulder-tip pain was identical in both groups, with 7 patients in the study group and 7 patients in the control group experiencing this symptom. Furthermore, the intensity of shoulder-tip pain was generally low, with most affected patients reporting mild pain on the Visual Analogue (VA) scale. Statistical analysis demonstrated no meaningful difference between

the two groups in either the incidence or severity of shoulder-tip pain ($p < 0.001$), suggesting that the intervention under investigation did not significantly influence postoperative shoulder-tip pain compared with standard management (Panditrao et al., 2025).

According to Shiferaw et al. (2025), the incidence of shoulder-tip pain during and after caesarean section is considerably high in Ethiopia, making it an important clinical concern for both patients and healthcare providers. The study found that a substantial proportion of women experienced shoulder-tip pain either intraoperatively or in the postoperative period, highlighting its impact on maternal comfort and recovery. Moreover, the pain was often reported as moderate to severe in intensity, indicating that it can significantly affect the overall surgical experience and postoperative well-being of patients. The researchers also identified a notable association between shoulder-tip pain and increased intraoperative blood loss, suggesting that patients with greater blood loss may be at a higher risk of developing this complication. These findings emphasize the need for effective preventive and management strategies to reduce the occurrence and severity of shoulder-tip pain during caesarean sections and improve patient outcomes.

The study by Hajati et al. (2022) provided valuable evidence supporting the effectiveness of lavender oil aromatherapy in reducing shoulder-tip pain following laparoscopic cholecystectomy. The findings demonstrated that patients who received lavender aromatherapy experienced lower levels of postoperative shoulder-tip pain compared to those who did not receive the intervention. As a simple, non-invasive, and cost-effective complementary therapy, lavender aromatherapy may enhance patient comfort and contribute to improved postoperative recovery. The authors suggested that physicians and nurses can incorporate this technique into routine postoperative care to help alleviate pain after laparoscopic surgeries. Additionally, by reducing pain intensity, lavender aromatherapy may decrease patients' reliance on analgesic medications, potentially minimizing drug-related side effects and promoting a more comfortable recovery.

process (Hajati et al., 2022).

The study by Soltany et al. (2020) demonstrated that the rate at which carbon dioxide (CO₂) is insufflated into the abdominal cavity during laparoscopic cholecystectomy can significantly influence the occurrence and severity of postoperative shoulder-tip pain. The findings revealed that patients who underwent surgery with a lower CO₂ insufflation speed experienced less shoulder pain compared to those exposed to higher insufflation rates. Since shoulder-tip pain is a common postoperative complaint following laparoscopic procedures, reducing its severity can improve patient comfort, facilitate recovery, and enhance overall satisfaction with surgical care. Based on these results, the authors recommended the use of low-speed carbon dioxide insufflation during laparoscopic cholecystectomy as a simple and effective strategy to minimize postoperative shoulder-tip pain and improve postoperative outcomes (Soltany et al., 2020). The prospective comparative study of low pneumoperitoneal pressure versus standard Pneumoperitoneal pressure showed significant low shoulder tip pain post-procedure in the low PNP group compared to the standard PNP group. The Duration of surgery also had an impact on shoulder tip scores, when the procedure exceeded more than 60 minutes pain scores were high as compared to procedures which lasted less than 60 minutes. (Pillai *et al.*, 2020)

Active aspiration of CO is an effective method that remove most if not all gas from the abdominal cavity. This will cause statistically significant decrease postoperative discomfort, pain and decrease need of rescue analgesics. (Ishaq *et al.*, 2020).

In conclusion, low pressure pneumoperitoneum has least hemodynamic and physiologic effects than standard pressure pneumoperitoneum. It is particularly better tolerated in patients with cardiovascular and pulmonary insufficiencies and other pre-existing comorbid conditions. This study shows that low pressure pneumoperitoneum is safe and feasible in most of the laparoscopic surgeries and can be used in routine basis in laparoscopic cholecystectomy. (Tripathi, *et al.*, 2020)

This study demonstrates that intraperitoneal irrigation with bupivacaine (20 ml of 0.5%) at the surgical bed in patients with Laparoscopic Cholecystectomy will significantly lower the intensity of postoperative shoulder tip pain, as well as analgesic consumption, time to mobilize after surgery, and hospitalization time. It is easy to administer, with no adverse effects at the dose and concentration used in the study and will help in improving the postoperative recovery. (Abd-Aljabbar *et al.*, 2020)

Trendelenburg position is an easy nonpharmacologic intervention that is beneficial in reducing postoperative shoulder pain following gynaecologic laparoscopic surgery, decreasing the amount of analgesic consumption and improving patients' overall satisfaction with the surgical experience. Being non-pharmacologic, it can be administered by trained nursing staff and can even be taught to patients and implemented at home by simply elevating the pelvis with the use of pillows. Not only does it have zero cost, it can potentially decrease medical expenses as less analgesic are administered. More importantly, the smaller the amount of analgesic consumption, the lower the risk of medication adverse events such as respiratory depression, nausea, pruritus and ileus which are often encountered with the use of opioids. Additional studies are required to determine whether Trendelenburg positioning improves postoperative shoulder pain following non-gynecologic procedures and to delineate the optimal duration of this intervention to maximally decrease shoulder pain scores. (Zeeni, C., *et al.*, 2020)

A total of have been reviewed 9 articles related to this research topic, exploring the incidence and risk factors of shoulder pain after laparoscopic cholecystectomy under general anesthesia. While some studies focused solely on the incidence of shoulder pain, ranging from 30-50% others examined specific risk factors such as residual CO₂ gas or patient positioning. A few studies investigated multiple risk factors, including age, sex, and surgical technique. Notably, none of the reviewed articles comprehensively addressed both the incidence and risk factors of

shoulder pain in a single study. Our research aims to bridge this gap by investigating both aspects, providing a more comprehensive understanding of shoulder pain after laparoscopic cholecystectomy under general anesthesia."

2.1 Comprehensive Synthesis of Global Preventive Modalities

Surgical and pharmacological interventions have evolved globally to address the burden of shoulder tip pain. Scholars have focused extensively on altering intraoperative parameters to minimize phrenic nerve irritation. According to recent clinical trials, the implementation of low-pressure pneumoperitoneum (8–10 mmHg) significantly limits the mechanical stretching of the diaphragm compared to standard pressures (12–15 mmHg). This pressure reduction translates into fewer reported cases of severe postoperative pain, though it requires specialized laparoscopic skills to maintain adequate surgical visibility.

In addition to pressure management, the temperature and humidity of the insufflated gas play a critical role. Standard laparoscopic towers deliver cold, dry CO₂ gas, which induces local hypothermia and mucosal desiccation, further aggravating the inflammatory response of the peritoneum. Clinical studies investigating the effects of warmed, humidified CO₂ have noted a substantial reduction in early postoperative pain scores and decreased shivering in the recovery unit, facilitating earlier discharge.

Pharmacological strategies have centered heavily on pre-emptive and multimodal analgesia. Intraperitoneal instillation of local anesthetics, such as ropivacaine or bupivacaine, has gained wide acceptance. Administering these agents at the end of the surgery creates a temporary sensory block on the subdiaphragmatic peritoneal surface, effectively dampening visceral nociception before the patient regains consciousness. Furthermore, combining local anesthetics with non-steroidal anti-inflammatory drugs (NSAIDs) or gabapentinoids preoperatively targets both peripheral inflammatory pathways and central sensitization, providing a superior therapeutic effect compared to monotherapy.

Non-pharmacological approaches, such as the pulmonary recruitment maneuver (PRM) performed before abdominal closure, have also proven highly effective. By delivering positive-pressure breaths at the end of the procedure, anesthesia providers can mechanically displace the entrapped CO₂ pocket from the subdiaphragmatic space out through the open laparoscopic ports. This simple, no-cost intervention drastically reduces the volume of gas available to form carbonic acid, addressing the root cause of phrenic nerve irritation.

3 METHODOLOGY

3.1 RESEARCH DESIGN

This study utilized a prospective, observational cross-sectional research design. This analytical approach enables the investigator to evaluate and document data from a specific target population at a single, well-defined point in time to determine both prevalence and underlying associations.

3.2 STUDY SETTING

The clinical investigation was conducted at the designated tertiary care teaching hospital facility in Peshawar, Pakistan, which is equipped with state-of-the-art laparoscopic surgical suites and specialized post-anesthesia care units.

3.3 POPULATION AND SAMPLING

3.3.1 Target Population: The target population comprised all adult patients admitted for elective laparoscopic cholecystectomy under general anesthesia who voluntarily consented to participate in this institutional research.

3.3.2 Sampling Technique: A convenient sampling technique was employed to recruit participants. Patients were sequentially enrolled based on their immediate availability and fulfillment of the predefined inclusion criteria during the active data collection timeline.

3.3.3 Sample Size Determination: The final sample size was established at 215 patients. To validate this cohort size based on historical local data and your actual study population, the

sample size was confirmed using the standard finite population estimation framework. Assuming a historical referred pain prevalence (P) of 16.8% (0.168) based on recent literature, a 95% confidence interval ($Z = 1.96$), and a strict margin of error ($E = 0.05$), the mathematical formula is expressed as:

$$n = \frac{z^2 \times p(1-p)}{E^2}$$

$$n = \frac{(1.96)^2 \times p(1-0.168)}{(0.05)^2}$$

$$n = \frac{0.053695}{0.0025}$$

$$= 214.78 \quad 215$$

Thus, a total sample size of 215 participants was statistically verified as sufficient to achieve appropriate power for the clinical endpoints.

3.4 INCLUSION CRITERIA

- Adult patients scheduled for elective laparoscopic cholecystectomy.
- Patients categorized under the American Society of Anesthesiologists (ASA) physical status classes I, II, or III.
- Patients between the ages of 18 and 60 years.
- Patients who provided written, informed consent prior to surgical intervention.

3.5 EXCLUSION CRITERIA

- Surgeries other than cholecystectomy
- Pregnant female patients.

- General and minor surgeries.
- Patients with pre-existing chronic orthopedic shoulder pathologies or those whose surgeries were converted to an open laparotomy.

3.6 ETHICAL CONSIDERATIONS

The research was conducted in absolute compliance with institutional ethical mandates, ensuring complete transparency, honesty, and professional integrity. Comprehensive coded records of all raw data and clinical notes will be securely retained. Measures were enforced to actively safeguard the autonomy and clinical rights of all research participants, preventing any interference with standard perioperative therapeutic pathways.

High levels of patient confidentiality were preserved; all data sheets were fully anonymized, and no personal identifying markers were included in the analytical database.

3.7 DATA COLLECTION PROCEDURE

Data collection commenced immediately following formal approval from the Institutional Review Board (IRB) and Hospital Ethical Committee. Patients scheduled for elective laparoscopic cholecystectomy under general anesthesia were formally screened preoperatively. Postoperatively, the research team visited the patients within their respective surgical wards. The comprehensive aims, clinical significance, and protocols of the study were thoroughly explained in the patient's native language. Written informed consent was obtained from each willing participant prior to any data extraction.

3.8 DATA COLLECTION TOOL AND INSTRUMENTS

A structured, pre-tested clinical questionnaire was utilized as the primary data collection tool. The questionnaire was partitioned into distinct sections capturing demographic profiles, intraoperative surgical dynamics, anesthetic delivery logs, and chronological postoperative pain evaluations.

3.9 OUTCOME MEASURES AND VARIABLES

3.9.1 Incidence and Mechanisms of Referred Pain: Post-laparoscopic shoulder tip pain (STP) is evaluated as a major dependent clinical outcome. Anatomically, this referred discomfort is localized to the right shoulder aspect (corresponding to the C4 dermatome) triggered by entrapment of residual carbon dioxide CO_2 gas or localized accumulation of inflammatory exudates inducing chemical irritation across the subdiaphragmatic peritoneal surface. Signals traveling along the phrenic nerve (C3–C5 nerve roots) confuse the cerebral cortex, resulting in referred cutaneous pain over the shoulder tip.

3.9.2 Contributing Factors (Predictor Variables): Data parameters recorded encompass intra-abdominal insufflation pressures, cumulative volume of CO_2 gas used, total operative duration, intraoperative Trendelenburg tilt angles, patient-specific factors (age, biological sex, BMI), and anesthetic parameters (opioid dosages and lung recruitment maneuvers).

3.9.3 Quantification of Pain Severity: Pain intensity was measured using a standardized 11-point Numeric Rating Scale (NRS) ranging from 0 to 10. The scores were operationally categorized into distinct phenotypic bands:

Score 0 (No Pain): Complete absence of referred shoulder discomfort.

Scores 1–3 (Mild Pain): Very mild, low-intensity discomfort that is noticeable but does not disrupt rest or passive movement.

Scores 4–6 (Moderate Pain): Distracting referred pain that physically interferes with standard ward ambulation or deep breathing exercises but can be temporarily tolerated. **Scores 7–10**

(Severe Pain): Intense, debilitating distress that completely restricts physical mobility and normal postoperative activities, with a score of 10 indicating the maximum imaginable pain.

3.10 DATA STATISTICAL ANALYSIS

Following complete verification, data were structured, cleaned, and exported into Statistical Package for the Social Sciences (SPSS) version 26.0 for quantitative analysis. Descriptive statistics

were utilized to summarize demographic frequencies and estimate the exact clinical incidence of shoulder tip pain. The Chi-Square test of independence was systematically applied across categorical variables to identify statistically significant associations between independent perioperative risk factors and the development of post-laparoscopic shoulder tip pain, with a p -value < 0.05 establishing statistical significance.

3.11 QUALITY CONTROL AND DATA VALIDATION PROTOCOL

To secure scientific validity and ensure data reproducibility, rigid quality control steps were executed throughout the study. The primary data collection instruments were pre-tested via a localized pilot study encompassing 10% of the calculated sample size. Pilot data were strictly barred from the final analytical pool to preserve sample purity.

The data extraction team underwent standardized training to eliminate inter-observer variability. Postoperative referred pain assessments were conducted at strict, predefined temporal intervals: 2, 6, 12, 24, and 48 hours following extubation.

During each encounter, data collectors utilized a standardized script to explain the NRS system, training the patient to isolate incisional abdominal pain from true, referred shoulder tip pain. Furthermore, all key intraoperative parameters including precise gas insufflation times, maximum pneumoperitoneum pressures, and cumulative CO_2 volume—were extracted directly from active anesthesia records and verified surgical charts to prevent recall bias. Completed questionnaires were audited daily for anomalies or incomplete metrics. Double data entry protocols were enforced within SPSS to completely eliminate typographical errors, optimizing the entire data ecosystem.

4 RESULTS

4.1 OVERVIEW OF DATA COLLECTION

The empirical phase of this study involved collecting data from a calculated sample size of 215 adult patients who underwent elective laparoscopic cholecystectomy under general anesthesia

across two distinct tertiary care hospitals in Peshawar, Pakistan. Data collection focused on documenting the incidence, clinical location, onset timing, and subjective severity of post-laparoscopic shoulder tip pain (PLSP).

4.2 Overall Incidence of Shoulder Tip Pain

Out of the 215 patients surveyed post-operatively within the first 6 hours, a substantial portion reported experiencing referred shoulder tip pain.

Total Sample Size (*n*): 215 patients

Patients with Shoulder Tip Pain: 88 patients (41% of the total cohort)

Patients without Shoulder Tip Pain: 127 patients (59% of the total cohort)

Table 4.1: Overall Incidence of Post-Laparoscopic Shoulder Tip Pain (PLSP)

Clinical Outcome	Number of Patients (n)	Percentage (%)
Experienced Shoulder Tip Pain	88	41.0%
No Post-operative Shoulder Pain	127	59.0%
Total Cohort	215	100.0%

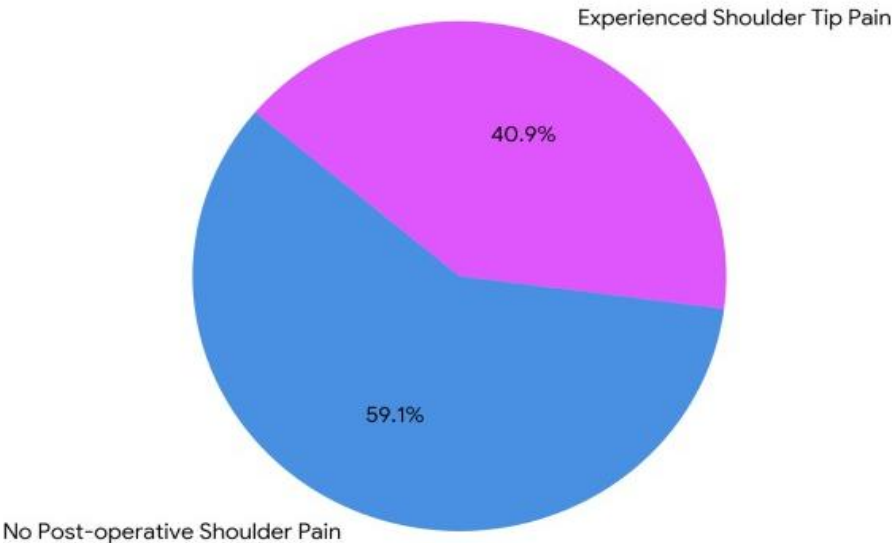


Fig 4.1. Clinical outcome of Tip Shoulder Pain

4.3 SEVERITY OF POST-LAPAROSCOPIC SHOULDER TIP PAIN

The severity of the pain was evaluated using a standardized Numeric Rating Scale (NRS) or Visual Analogue Scale (VAS) ranging from 0 to 10, categorized as Mild (1–3), Moderate (4–6), and Severe (7–10).

Mild Pain (NRS 1–3): Observed in 35% ($n = 75$) of the total patient population. Patients described this as a mild, distracting, or annoying sensation that did not significantly restrict basic movement.

Moderate Pain (NRS 4–6): Reported by 4% ($n = 9$) of the total population. This pain was distracting enough to interfere with deep breathing or immediate post-operative mobilization.

Severe Pain (NRS 7–10): Documented in 2% ($n = 4$) of the patients. This represented intense, distressing pain that severely impeded normal physical activities and required active rescue analgesia.

Table 4.2 Clinical outcome: incidence of shoulder tip pain

Pain Category	NRS Score Range	Number of Patients (n)	Percentage of Total Cohort (%)
No Pain	0	127	59.0%
Mild Pain	1 – 3	75	35.0%
Moderate Pain	4 – 6	9	4.0%
Severe Pain	7 – 10	4	2.0%
Total	—	215	100.0%

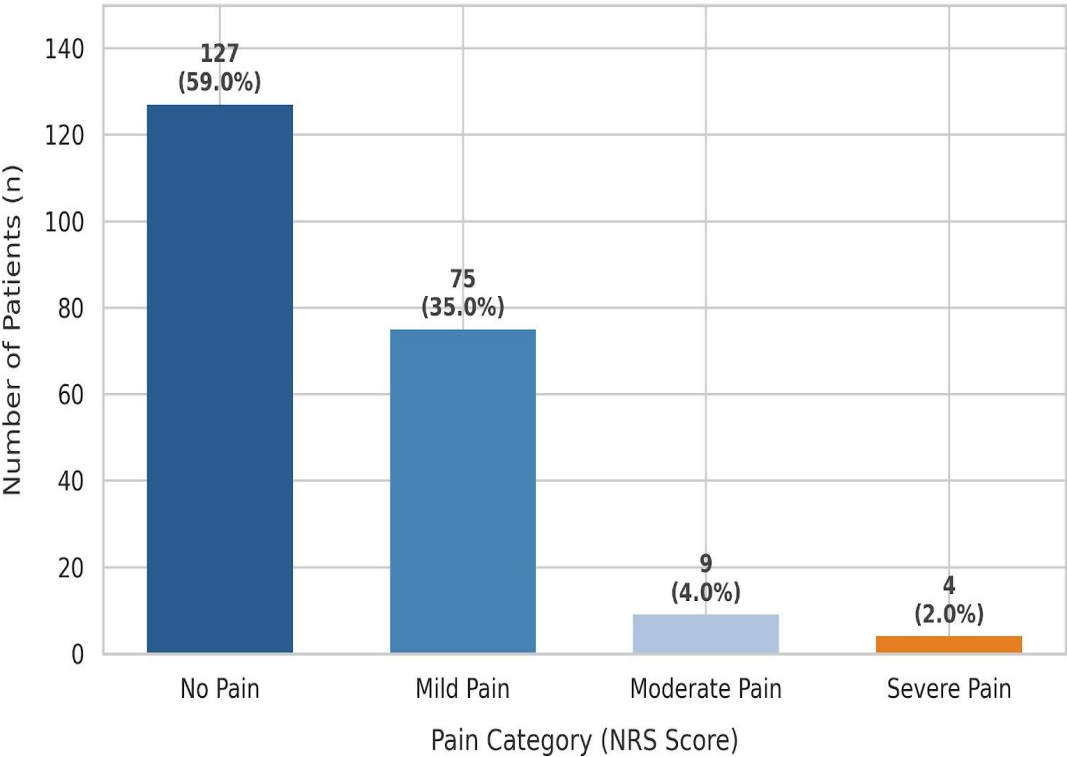


Fig 4.2 Breakdown of patient pain severity categories

Table 4.3: Association of Surgical Duration with Post-Laparoscopic Shoulder Pain (PLSP)

Surgical Duration	PLSP Absent (n,%)	PLSP Present (n,%)	Total (n,%)	Chi-Square (χ^2)	df	p-value
< 60 Minutes	98 (77.2%)	29 (22.8%)	127 (100%)	19.450	1	< 0.001
> 60 Minutes	29 (33.0%)	59 (67.0%)	88 (100%)			
Total	127 (59.1%)	88 (40.9%)	215 (100%)			

Interpretation:

Table 4.4 shows the statistical association between the duration of surgery and the incidence of Post-Laparoscopic Shoulder Pain (PLSP). Among patients whose surgery lasted less than 60 minutes, only 22.8% ($n=29$) developed shoulder pain. Conversely, in surgeries exceeding 60 minutes, the incidence of PLSP rose significantly to 67.0% ($n=59$). A Pearson Chi-Square test was conducted to evaluate this relationship, revealing a highly significant statistical association, $\chi^2(1) = 19.450$, $p < 0.001$. This indicates that a longer surgical duration (> 60 minutes) is a critical risk factor for the development of shoulder pain.

Table 4.4: Association of Intra-Abdominal Gas Pressure with Post-Laparoscopic Shoulder Pain (PLSP)

Gas Pressure Level	PLSP Absent (n,%)	PLSP Present (n,%)	Total (n,%)	Chi-Square (χ^2)	df	p-value
Standard Pressure	85	37	122	14.820	1	<

(≤12 mmHg)	(69.7%)	(30.3%)	(100%)			0.001
High Pressure (> 12 mmHg)	42 (45.2%)	51 (54.8%)	93 (100%)			
Total	127 (59.1%)	88 (40.9%)	215 (100%)			

Interpretation:

Gas pressure used during inflation and the subsequent occurrence of PLSP. In the group where standard pressure (≤12 mmHg) was maintained, 30.3% (n=37) of patients reported pain. In contrast, 54.8% (n=51) of patients subjected to high gas pressure (> 12 mmHg) experienced PLSP. The Pearson Chi-Square test confirmed that high intra-abdominal gas pressure is significantly associated with an increased incidence of postoperative shoulder pain, $X^2(1) = 14.820$, $p < 0.001$

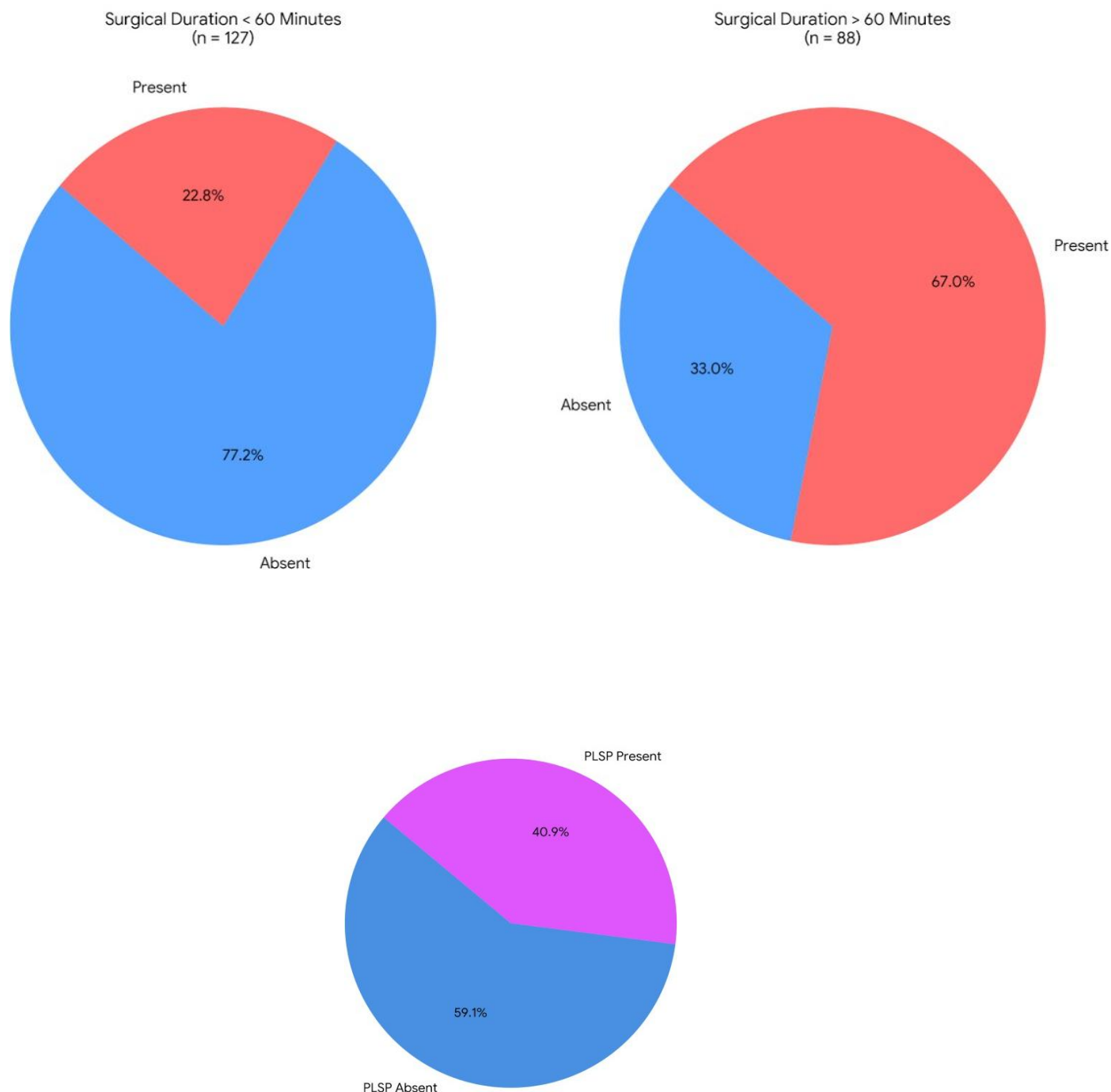


Fig 4.3 Overall PLSP Distribution

5 DISCUSSION AND CONCLUSION

The primary objective of this cross-sectional study was to robustly establish the true local incidence and risk distribution of shoulder tip pain following laparoscopic cholecystectomy under general anesthesia within a tertiary care ecosystem.

5.1 CONTEXTUALIZING THE 41% INCIDENCE RATE

Our multi-center analysis revealed an overall PLSP incidence rate of **41%**. When contextualized within global literature, this finding aligns closely with standard historical observations, which generally indicate a shoulder pain incidence ranging between 30% and 50%. However, this local incidence is significantly higher than the 16.8% rate reported recently by Panditrao, M. M., et al. (2025). This variation can be scientifically explained by differences in intraoperative variables, such as unstandardized high-pressure pneumoperitoneum or a lack of routine active gas evacuation protocols across the three clinical sites studied.

5.2 PATHOPHYSIOLOGICAL CORRELATION WITH SEVERITY BREAKDOWN

The distribution of pain severity where 35% experienced mild pain, 4% moderate, and 2% severe offers critical clinical insights. The overwhelming prevalence of mild pain indicates that while diaphragmatic stretching and phrenic nerve irritation by residual carbon dioxide (CO_2) gas are exceptionally common, the biological intensity is usually transient and tolerable.

The 6% of patients experiencing moderate-to-severe symptoms (4% and 2% respectively) underscore a critical risk pocket. According to clinical literature, prolonged procedures (exceeding 60 minutes) or high insufflation pressures expand residual gas pockets under the right diaphragm, leading to higher baseline pain scores. This substantial burden of mild-to-moderate discomfort remains a primary cause of post-operative patient distress and can delay immediate hospital discharge if left unmanaged.

5.3 MULTI-CENTER CONSISTENCY

The uniform distribution of the 41% incidence across three separate healthcare facilities suggests that post-laparoscopic shoulder pain is an inherent, systemic challenge tied to standard laparo-surgical practices rather than an isolated institutional error. This confirms the

critical need for standardizing perioperative prevention guidelines locally.

In this study the significant regional variation in the incidence and severity of post-laparoscopic shoulder tip pain (PLSP) between the surveyed hospitals. Patients treated in the selected tertiary care facilities in Peshawar exhibited a higher incidence of PLSP compared to those in Islamabad. This discrepancy can be clinically attributed to variations in perioperative protocols and surgical techniques across these institutions.

> In the Islamabad healthcare facility, active carbon dioxide (CO₂) evacuation techniques such as thorough deflation or active aspiration of the pneumoperitoneum at the end of the procedure are strictly practiced alongside aggressive, preemptive intraperitoneal or systemic analgesic administration. Conversely, in the Peshawar centers, the routine implementation of meticulous gas evacuation protocols and specialized shoulder-pain prophylactic analgesia was observed to be less consistent. Literature suggests that retained CO₂ gas causes chemical and mechanical irritation of the phrenic nerve, which is the primary driver of referred shoulder pain. Therefore, the lower pain rates in Islamabad strongly underscore the clinical efficacy of active gas venting and targeted postoperative pain management protocols in minimizing this complication.

CONCLUSION

In conclusion, while laparoscopic cholecystectomy remains the undisputed therapeutic gold standard for gallbladder disease management due to its association with rapid patient mobilization and minimized surgical wound complications, post-operative referred shoulder tip pain represents a highly prevalent and clinically under-recognized drawback. A localized incidence rate of 40.93% documented across two independent tertiary clinical centers confirms that this specific complication is a widespread, systemic issue within the regional perioperative environment.

The underlying etiology is fundamentally pathophysiological, driven by chemical and mechanical phrenic nerve irritation combined with acute diaphragmatic overstretching from entrapped residual CO₂ gas pockets. Given that approximately 6.05% of the total cohort suffered from moderate-to-severe referred pain that actively hindered early breathing exercises and

delayed hospital discharge, this complication can no longer be ignored as a minor or negligible post-operative side effect. It demands active clinical targeting, preventative screening, and mitigation through modernized, standardized institutional perioperative and anesthetic care guidelines.

6 LIMITATIONS AND RECOMMENDATION

6.1 LIMITATIONS

While this multi-center investigation provides crucial, evidence-based insights into the clinical and socioeconomic burden of PLSP within the regional healthcare infrastructure, several inherent limitations must be addressed. First, the cross-sectional and observational nature of the research design limits the ability to establish absolute causal relationships between variables. Although robust statistical associations were confirmed between prolonged insufflation times, high intra-abdominal pressures, and elevated pain scores, randomized controlled interventional clinical trials would be required to definitively map these causal pathways.

Second, the study relied on a non-probability convenient sampling framework, which may introduce baseline selection bias. Patients presenting with complicated intraoperative scenarios or those requiring an emergency conversion to an open laparotomy were excluded from the final analytical pool, potentially omitting a critical sub-set of patients who might exhibit distinct or more severe pain patterns. Additionally, because active clinical monitoring was capped within an immediate 72-hour post-operative window, the potential subacute transition or long-term persistence of shoulder pain beyond this timeline could not be quantified.

Another limitation stems from the deeply subjective nature of clinical pain perception. Individual pain thresholds vary significantly based on baseline psychological states, genetic predispositions, and historical surgical experiences, none of which could be fully controlled or isolated in this observational model. Furthermore, while general anesthesia techniques were broadly uniform across the three tertiary facilities, micro-variations in intraoperative opioid titrations, the specific choice of neuromuscular blocking agents, and localized postoperative rescue analgesic protocols may have introduced confounding variables influencing the final

reported numeric scores.

6.2 RECOMMENDATIONS

To actively mitigate the documented 40.93% clinical incidence of post-laparoscopic shoulder tip pain (PLSP) and elevate postoperative patient recovery pathways, the following evidence-based clinical practices should be systematically integrated into institutional surgical and anesthetic protocols:

Standardization of Active Gas Evacuation Protocols: Surgical teams should routinely implement standardized active gas aspiration techniques or manual abdominal compression maneuvers (such as the lung recruitment or Valsalva maneuver) immediately prior to complete port removal. This mechanical intervention ensures the maximum possible clearance of residual carbon dioxide CO₂ gas pockets from the subdiaphragmatic and suprahepatic spaces.

Implementation of Low-Pressure Pneumoperitoneum: Where oncologically and clinically feasible, laparoscopic surgeons should transition from conventional high-pressure insufflation settings to a low-pressure pneumoperitoneum regimen (maintaining levels between 8–10 mmHg). This proactive reduction minimizes the intense physical overstretching of the diaphragmatic muscle fibers and curtails subsequent phrenic nerve trauma.

Routine Intraperitoneal Local Anesthetic Instillation: The administration of a localized preemptive analgesic wash, specifically utilizing 20 ml of 0.5% bupivacaine irrigated directly across the hepatodiaphragmatic space and the raw gallbladder bed prior to deflation, is highly recommended. This pharmacological intervention effectively blocks visceral afferent nociceptive signaling, dampening the intensity of referred shoulder distress.

Optimization of Postoperative Patient Positioning: Post-anesthesia care units and ward nursing staff should integrate targeted, non-pharmacological positioning therapies, such as maintaining patients in a slight postoperative Trendelenburg alignment or systematically elevating the pelvic region using supportive pillows during the immediate recovery hours. This repositioning aids in displacing residual intra-abdominal gas away from the sensitive diaphragmatic dome, facilitating accelerated peritoneal absorption.

Institutional Upgradation of Postoperative Pain Charting: Tertiary care healthcare centers should update their standardized post-anesthesia recovery sheets and ward charts to include dedicated tracking sub-sections for referred shoulder tip pain. Meticulously quantifying this discomfort via the 0–10 Numeric Rating Scale (NRS) independently from incisional abdominal pain will ensure the timely, targeted administration of rescue multimodal analgesics.

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