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Early Postoperative Pain Trajectory and Functional Recovery Following Open Versus Laparoscopic Cholecystectomy: A Prospective Observational Study

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ABSTRACT

Background: Cholecystectomy is one of the most frequently performed gastrointestinal surgeries worldwide, primarily indicated for symptomatic gallstone disease. This study aimed to examine differences in early postoperative pain trajectory, recovery milestones, and short-term complications between open and laparoscopic cholecystectomy (OC, LC) under current standardized perioperative care in a local Pakistani population.

Methods: The study was a prospective observational study (May 2023 to September 2023) included 100 patients with gallstones divided into OC and LC groups equally, based on the discretion of the surgeons and surgical timing. Pain was assessed using the Visual Analogue Scale (VAS) at the 6, 12, and 24 hours. The selected parameters were analyzed using T-tests and chi-square tests (SPSS v26.0); the p-value of below 0.05 was deemed significant.

Results: At 6 hours (4.1 ± 1.2 vs. 6.8 ± 1.5), 12 hours (3.2 ± 1.0 vs. 5.4 ± 1.3), and 24 hours (2.1 ± 0.8 vs. 3.9 ± 1.1), VAS scores were significantly lower in LC. LC patients had shorter hospital stay (9.2 ± 3.1 vs. 18.7 ± 5.4 days) and spent less time in the hospital (2.3 ± 0.9 vs. 5.6 ± 2.3 days) with $p < 0.001$). Seven OC patients (14%) experienced complications, including 3 (6%) in wound infection, 2 (6%) in bile leak, 1(2%) in respiratory infection, and 1(2%) in hemorrhage; four LC patients (8%) experienced complications, including 2 (4%) in wound/port infection, 1(2%) in bile leak, and 1(2%) hemorrhage ($p = 0.344$).

Conclusion: LC was associated with less early pain, shorter hospital stay, and faster recovery than OC, supporting it as the preferred approach when feasible.

Keywords: Cholecystectomy, Laparoscopic, Pain Postoperative, Minimally Invasive Surgical Procedures

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INTRODUCTION

Gallstone disease is a prevalent gastrointestinal disorder, affecting up to 15% of the adult population across the globe, with cholecystectomy (open and laparoscopic) being the gold standard cure for managing symptomatic patients [1]. Although open cholecystectomy (OC) used to be a primary method, laparoscopic cholecystectomy (LC) is now widely preferred because it can significantly minimize surgical trauma, shorten the hospitalization period, reduce postoperative complications, and increase functional improvement outcomes [2]. Intraoperative safety in LC has been significantly improved by introducing the so-called critical view of safety (CVS), which has contributed to a considerable reduction in the risk of bile duct injury [3]

Although LC is widely used, OC is still being conducted routinely in specific clinical conditions, particularly in complicated biliary anatomy and advanced inflammation [4]. The most recent developments like low-pressure pneumoperitoneum and structured analgesic regimens have affected the preoperative outcomes, but most of the comparative studies were constructed on the older perioperative guidelines [5].The impact of current practices on pain, recovery, and complication rates has not been addressed in studies that compared OC and LC without incorporating these modern practices [6].

No current local data exists that explicitly compares postoperative pain, recovery and complication in OC and LC in the context of the standardized perioperative care [7]. As the principles of enhanced recovery become more and more widespread in the world, new comparisons are still possible [8]. Well-developed data about pain and recovery may allow optimizing perioperative pathways, decreasing length of stay, and ensuring cost-efficient care [9].

To evaluate the impact of surgical approach on early postoperative pain trajectory, duration of hospital stay, and time to functional recovery in patients undergoing cholecystectomy.

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METHODS

This observational prospective study (May 2023 to September 2023) carried out in the Department of the General Surgery at Al-Aleem Medical College and ASMDC Lahore, (Ref: 2178/MS/AST) after an informed consent. OpenEpi version 3.0.0 (Atlanta, GA, USA) was used to determine the sample size, considering a 5% margin of error, 80% power, and a 95% confidence level [10]. A total sample size of 100 participants was used based on previously documented differences in postoperative VAS pain scores between OC and LC [11]. Adult patients aged 18-65 years scheduled to perform elective cholecystectomy due to symptomatic gallstone disease were recruited using a non-probability consecutive sampling method. The inclusion criterion was participants who were eligible

of American Society of Anesthesiologists (ASA) physical status I-II and medically fit to undergo general anesthesia. The exclusion criteria were acute cholecystitis, malignancy of the gallbladder, common bile duct stones, previous surgery of the upper abdomen, ASA class 3 or more, coagulopathy, and severe cardiopulmonary comorbidity.

The patients were assigned to either the open Cholecystectomy (OC) or Laparoscopic cholecystectomy (LC) groups based on the operating surgeon's clinical judgment, patient anatomy, comorbidity, and surgical scheduling (non-randomized, consecutive sampling). Since the allocation was not random, the method represents a real-life practice but can be subject to selection bias, thus, the results must be taken as associative and not causal. Every patient received a standard preoperative assessment, such as routinely performed laboratory tests, abdominal ultrasonography, and anesthesia clearance. LC was done by the conventional four-port technique with the pneumoperitoneum kept at 12-14 mmHg, and OC was carried at a standard right subcostal (Kocher) incision. The general surgeons who performed all procedures were consultants with a minimum of five years of independent operating experience.

Perioperative care was standardized in both the groups. Prophylactic antibiotics, non-steroidal anti-inflammatory agents (NSAIDs) as initial analgesics, and rescue opioids were used by all patients. All patients received intravenous paracetamol 1g every 8 hours and diclofenac 75mg IM every 12 hours as initial analgesics. Rescue analgesia was intravenous tramadol 50mg on patient request or if VAS > 4. Antibiotic prophylaxis was single-dose cefazolin 1g IV at induction. All patients were encouraged to receive standard intravenous fluid therapy and early mobilization. Selective drainage was made depending on intraoperative findings. During hospitalization and follow-up visits, complications during the postoperative period such as wound infection, bile leak, chest infection were recorded. The Visual Analogue Scale (VAS), a validated 0-10 scoring scale (0 = no pain, 10 = worst imaginable pain), was used to evaluate postoperative pain recorded by trained nursing staff at 6, 12 and 24 hours postoperative. For this study, 'early postoperative' was defined as the first 24 hours after surgery, with pain assessed at 6, 12, and 24 hours. Recovery outcomes were length of hospital stay and time taken to resume normal activity, which is the capacity of the patient to resume normal self-care and domestic chores without support, which was measured during a scheduled clinic follow-up visit at 2 weeks post-discharge. Patients were also contacted by telephone at 30 days for any delayed complications.

The analysis of the data was conducted in SPSS version 26.0 (IBM Corp., Armonk, NY). Means and standard deviation were used to indicate continuous variables and compare them with independent t-tests. Frequencies and percentages were used to show the occurrence of categorical variables, which

were compared with chi-square tests. A p-value of below 0.05 was regarded as significant. Considering that group allocation is non-random and that no adjustment was made to control the possibility of confounding issues, the findings are not causal, but merely association

RESULTS

Table 1: Comparison of Baseline Characteristics Between OC and LC

Parameter	OC (n=50)	LC (n=50)	Test Value	Significance (p-value)
Mean Age (years) Mean ± SD	45.7 ± 12.4	43.9 ± 11.8	t = 0.73	0.467
Male (%)	27 (54.0%)	26 (52.0%)	$\chi^2 = 0.08$	0.778
Mean BMI (kg/m²) Mean ± SD	26.8 ± 3.7	27.1 ± 3.5	t = -0.34	0.735
ASA Status I	22 (44.0%)	28 (56.0%)	$\chi^2 = 1.92$	0.166
ASA Status II	**28 (56.0%)**	**22 (44.0%)**		

n = Number of Participants, OC = Open Cholecystectomy, LC = Laparoscopic Cholecystectomy, BMI = Basal Metablic Index SD = Standard Deviation, % = Percentage, * = Significance at p-value <0.05, Chi-square test was used for categorical values, Independent t-tests were used for continuous variables, ASA = American Society of Anesthesiologists Physical Status Classification (I–II).

This study was conducted on 100 patients undergoing cholecystectomy, where 50 patients were categorized in the OC group, and the other 50 patients were in the LC group. It was designed to compare postoperative pain, duration of recovery, and complication rates of the two procedures. LC patients had significantly lower pain scores at 6, 12, and 24 hours after surgery. They also experienced a reduced stay at hospitals and quicker recovery. The LC group had a lower complication rate, though it was not statistically significant.

The average age was 45.7 years in the OC group and 43.9 years in the LC group (p=0.467). There was also no significant gender difference (27 (54%) vs 26 (52%) males; p = 0.778) and BMI distribution (26.8 kg/m^2 vs 27.1 kg/m^2; p = 0.735). **Table 1** compares baseline clinical characteristics between the two groups. Baseline demographical features like age, sex distribution, and body mass index (BMI) were comparable between groups, ensuring an equal comparison.

Table 2. Comparison of Visual Analog Scale scores at 6, 12, and 24 hours

Time After Surgery	OC, Mean ± SD	LC Mean ± SD	Test Value	Significance (p-value)
VAS score after 6 hours	6.8 ± 1.5	4.1 ± 1.2	t = 8.19	<0.001*
VAS score after 12 hours	5.4 ± 1.3	3.2 ± 1.0	t = 8.35	<0.001*
VAS score after 24 hours	3.9 ± 1.1	2.1 ± 0.8	t = 8.42	<0.001*

n = Number of Participants, VAS = Visual Analog Scale (scores ranging from 0 (no pain) to 10 (worst pain possible), OC = Open Cholecystectomy, LC = Laparoscopic Cholecystectomy, SD = Standard Deviation, * = Significance at p-value <0.05, Independent t-tests were used for continuous variables

Table 2 shows the postoperative pain assessment on the Visual Analogue Scale (VAS) at 6, 12, and 24 hours. The LC group had significantly lower levels of pain at all-time points. On average, the pain scores were 4.1 and 6.8 in the LC and OC groups, respectively, at 6 hours post-surgery ($p<0.001$). This pattern persisted at 12 h (3.2 vs. 5.4, $p<0.001$) and 24 h (2.1 vs. 3.9, $p<0.001$) with significantly fewer descriptions of pain after the laparoscopic procedure, supporting its use as the desired method for patient comfort.

Table 3: Comparison of recovery outcomes and complication rates between OC and LC

Parameter	OC (n=50)	LC (n=50)	Test Value	p-value
Hospital Stay (days), Mean ± SD	5.6 ± 2.3	2.3 ± 0.9	t = 8.62	<0.001*
Time to Return to Activities (days), Mean ± SD	18.7 ± 5.4	9.2 ± 3.1	t = 10.7	<0.001*
Overall Complication Rate (%)	7 (14%)	4 (8%)		
Wound Infection (%)	3 (6%)	2 (4%)	$\chi^2 = 0.91$	0.344
Bile Leak (%)	2 (4%)	1 (2%)		
Chest Infection (%)	2 (4%)	1 (2%)		

n = Number of Participants, OC = Open Cholecystectomy, LC = Laparoscopic Cholecystectomy, SD = Standard Deviation, % = Percentage, * = Significance at p-value <0.0, Chi-square test was used for categorical values, Independent t-tests were used for continuous variables**.**

Comparison of recovery outcomes and complication rates between the two groups is presented in **Table 3**. Outcomes of recovery also supported LC with significantly shorter duration of hospital stay (2.3 vs. 5.6 days, p<0.001) and faster return to normal activities (9.2 vs. 18.7 days, p<0.001). Wound infection, bile leak, and chest infection were among the fewer complications that the LC group experienced (4 (8%) compared to 7 (14%), though the difference was not statistically significant (p=0.344). Complications among the OC group included two bile leaks (4%), two chest infections (4%), and three wound infections (6%). Wound infection occurred in 2 patients (4%), bile leak in 1 patient (2%), and chest infection in 1 patient (2%), all of whom were in the LC group.

It suggests that LC may lead to earlier discharge and resumption of functions, which may decrease healthcare expenditure and improve patient satisfaction. While the direction of benefit for LC is not novel, this study provides contemporary, quantified magnitude of difference (e.g., 2.7-day shorter hospital stay, 9.5-day faster return to activities) under current perioperative protocols in a Pakistani cohort, which has not been previously reported.

DISCUSSION

This was a prospective observational study that compared the postoperative pain, recovery rates and complications of open cholecystectomy (OC) and laparoscopic cholecystectomy (LC). These results indicate that LC offers definite benefits during the postoperative period such as a significantly reduced score of pain at 6, 12, and 24 hours, a reduced hospital stay, and a faster recovery rate. The rates of complications were less in the LC group, but the difference was not statistically significant.

The significant improvement in postoperative pain in the patients undergoing laparoscopic surgery is consistent with the previous clinical trials, which indicated reduced VAS scores and increased mobilization in laparoscopy surgery over open surgery [12,13,14]. Other researchers have also indicated comparable results during earlier research that LC produces less tissue damage, less inflammatory reaction and faster restoration of physiological functions [15,16]. The results also supplement the guidelines that suggest the use of low-pressure pneumoperitoneum and multimodal analgesia, which are linked with enhanced patient comfort following LC [17]. Moreover, our findings complement current findings that LC enables quicker discharge and sooner reintegration to regular life, in line with systematic reviews indicating significantly reduced hospitalization and improved patient-reported outcome [18,19]. Despite the well-established benefits of LC, the novelty of this study lies in:

(1) providing contemporary pain trajectory data using standardized VAS, (2) quantifying functional recovery (return to activities) rather than just hospital stay, and (3) offering the first such comparative data from a Pakistani tertiary care setting under current ERAS-like protocols.

Even though there were no significant differences in overall complication rates between groups, the pattern of complications observed is consistent with existing literature [20,21]. OC was linked to an increased wound infection, which aligns with bigger incision and exposure of tissues in open surgery. On the contrary, LC demonstrated less wound-related complications and only a few separate cases of bile leak and chest infection, which can be attributed to laparoscopic benefits in the reduction of surgical trauma and postoperative pulmonary compromise. The systematic recording of the postoperative events in this research gives more relevance to comparability with previous observational cohorts that had also given superior safety trends to LC [22,23].

Based on the surgeon's judgment and the patient's suitability, allocation to OC or LC may have introduced selection bias [24]. Results might have been affected by unmeasured elements like the degree of inflammation, anesthesia protocols, intraoperative difficulty, and inter-surgeon variability. Although the statistical techniques employed permit legitimate group comparisons, it is not possible to determine causality [25,26]. However, the external validity is improved by the real-world allocation approach, which mirrors the standard surgical workflow and decision-making in clinical practice [27].

The single-center design, small sample size, observational methodology, and absence of long-term follow-up are some of the study's limitations. This study did not assess advanced technologies such as intraoperative imaging, AI-assisted safety views, or formal ERAS pathways. Therefore, the results of this study apply to standard cholecystectomy without these adjuncts. Future studies should examine LC under ERAS protocols.

Despite these shortcomings, the results reveal the helpful nature of LC in reducing morbidity of postoperative cases, recovery time, and pain. Further research should focus on multicenter randomized experiments that would be run using AI-driven intra-operative safety systems, ERAS guidelines, and stratified tests on the high-risk patients such as obese and elderly individuals. Long-term effects like cost-effectiveness and quality of life should be also investigated in order to direct broader implementation.

CONCLUSION

In this prospective observational study, laparoscopic cholecystectomy (LC) was associated with significantly lower early postoperative pain scores at 6, 12, and 24 hours, shorter hospital stay (2.3 vs. 5.6 days), and faster

return to normal activities (9.2 vs. 18.7 days) compared to open cholecystectomy (OC). Although complication rates were lower in the LC group (8% vs. 14%), this difference was not statistically significant. These findings reinforce that LC is the preferred surgical approach when clinically feasible, as it offers better early pain control and faster functional recovery, even under standard perioperative protocols. Future multicenter randomized studies with longer follow-up and formal enhanced recovery pathways are recommended to further validate these outcomes.

LIST OF ABBREVIATIONS

n = Number of Participants, OC = Open Cholecystectomy, LC = Laparoscopic Cholecystectomy, BMI = Basal Metablic Index, SD = Standard Deviation

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CONFLICT OF INTEREST

None.

ETHICAL APPROVAL

This observational prospective study (May 2023 to September 2023) carried out in the Department of the General Surgery at Al-Aleem Medical College and ASMDC Lahore, (Ref: 2178/MS/AST) after an informed consent.

AUTHORS' CONTRIBUTION

AR: Study conceptualization, patient recruitment, clinical data collection, drafting the introduction and discussion, and final approval.

UA: Methodology design, surgical/experimental procedures, data curation, statistical analysis, drafting the methodology and results, and final approval.

KKP: Patient follow-up, laboratory/radiological investigations, data validation, critical revision of the manuscript for intellectual content, and final approval.

MH: Project administration, supervision, provision of resources/patients, critical evaluation of statistical outputs, final review, and final approval.

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