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Comparative Analysis of Early Clinical Outcomes in Patients Experience Open vs. Laparoscopic Cholecystectomy

Aleem Ullah Qureshi [1*], Muhammad Umar Saleem [1], Muhammad Umar [1], Arqam Zubair [1], Ume Romaan [1], Syed Muhammad Aun Raza [1], Muhammad Arham Rauf [2]

1- Akhtar Saeed Medical & Dental College (AMDC), Lahore, Pakistan
2- Lahore Medical & Dental College (LM&DC), Lahore, Pakistan

***Corresponding Author:** Aleem Ullah Qureshi **Email:** aleem.ullah91@gmail.com **Cell:** +923244732369

ABSTRACT

Background: Laparoscopic cholecystectomy (LC) has largely replaced open cholecystectomy (OC) for acute cholecystitis due to its minimally invasive nature. However, the impact of surgical timing (early vs. delayed) and outcomes in elderly patients remains unclear.

Objective: To compare clinical safety, complications, and recovery outcomes of LC and OC, with a focus on age-related differences and surgical timing.

Methods: A prospective cross-sectional study was conducted on 500 patients with acute cholecystitis. Patients were stratified into LC (n=300) and OC (n=200) groups. Subgroup analysis was performed for younger (<60 years) and elderly (≥60 years) patients, as well as early (<7 days) and delayed (>6 weeks) LC. Key outcomes included hospital stay duration, complications (wound infections, bile duct injury), and biomarker changes (CRP, WBC). Data were analyzed using SPSS v29.0, with $p<0.05$ considered significant.

Results: LC resulted in shorter hospital stays (3.2 ± 1.5 days vs. 8.4 ± 2.0 days; $p<0.001$) and fewer wound infections (5.6% vs. 13.5%; $p=0.008$) compared to OC. Conversion to OC occurred in 10.3% of LC cases due to severe adhesions. Elderly patients had higher complication rates (19.8% vs. 8.4%; $p=0.012$). Early LC showed fewer complications (8.4% vs. 16.2%; $p=0.002$) and faster inflammatory resolution (CRP reduction; $p<0.001$).

Conclusion is superior to OC in terms of recovery and safety, particularly with early intervention. Elderly patients require careful evaluation of comorbidities to minimize complications.

Keywords: Laparoscopic cholecystectomy, Open cholecystectomy, Acute cholecystitis, Early intervention, Postoperative complications, Recovery outcomes, Elderly patients, Hospital stay.

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INTRODUCTION

Acute cholecystitis, one of the most common acute abdominal conditions, occurs primarily due to obstruction of the cystic duct by gallstones. Gallstones are a relatively common condition, with an incidence ranging from 5% to 25% in the Western population, increasing significantly with age. Laparoscopic cholecystectomy (LC), introduced in the 1980s, has become the standard treatment for symptomatic cholelithiasis and acute cholecystitis due to its minimally invasive nature, reduced postoperative pain, and shorter recovery time compared to open cholecystectomy (OC) [1]. Despite its widespread adoption, LC is not without challenges, particularly in elderly patients and those with comorbidities such as hypertension, diabetes, and chronic obstructive pulmonary disease (COPD). These populations remain at higher risk of postoperative complications, including wound infections, bile duct injuries, and prolonged recovery times. While OC remains a viable alternative in cases of severe inflammation, complex anatomy, or failed LC, it is associated with longer hospital stays, increased postoperative pain, and higher complication rates [2].The timing of surgical intervention in acute cholecystitis is another area of clinical debate. Early laparoscopic cholecystectomy (ELC), performed within seven days of symptom onset, has been shown to improve outcomes such as shorter hospital stays and reduced complications[3]. However, some studies raise concerns about performing surgery during acute inflammation due to a perceived risk of intraoperative complications. Conversely, delayed laparoscopic cholecystectomy (DLC), performed after six weeks of conservative management, has been associated with increased hospital stays and progression of disease severity[4].

While earlier studies have explored the benefits and limitations of LC versus OC, significant research gaps remain. Many studies lack stratification based on age, comorbidities, and surgical timing, which are critical factors influencing outcomes. Additionally, the role of biomarkers, such as C-reactive protein (CRP) and white blood cell (WBC) count, in predicting recovery and complications has been underexplored[5]. The purpose of this study was to fill in existing research gaps by comparing laparoscopic cholecystectomy and open cholecystectomy in patients with acute cholecystitis. The analysis examines clinical safety, postoperative complications, recovery outcomes and hospital stay, with particular attention to age related (younger vs elderly) and surgical timing (early vs delayed intervention). This study contributes novel insights into optimizing surgical approaches by evaluating key clinical outcomes and analysing biomarkers such as CRP and WBC. The findings are intended to inform evidence based decision making regarding surgical management, especially for high risk patients such as older patients, to improve surgical management and improve patient outcomes [6].

MATERIALS AND METHODS

This prospective, cross-sectional study was carried out in Ghurki Trust Teaching Hospital and Farooq Teaching Hospital Lahore, Pakistan from January 2022 to September 2024 to compare clinical outcomes, safety and rate of recovery between laparoscopic cholecystectomy (LC) and open cholecystectomy (OC) in patients with acute cholecystitis. This study was approved by Ethical Review Board (Approval No. ERC/2022/03A), and written informed consent was obtained from all participants before surgery. The study was conducted in conformity with the principles of the Declaration of Helsinki for human research and patient confidentiality ensured by anonymization of the data. Primary data on patient records and clinical assessments were collected prospectively. Inclusion was made of patients aged 18 years or older with a confirmed diagnosis of acute cholecystitis on the basis of clinical presentation and imaging (ultrasound or CT scan). Surgery within 7 days of symptom onset was considered early intervention, and surgery done after 6 weeks of conservative management was delayed intervention. Patients with a history of chronic cholecystitis, prior gallbladder surgery, contraindications to surgery, or incomplete medical records were excluded from the study. To ensure uniformity of the sample population, paediatric patients (≤18 years) were also excluded.

The surgeon made a clinical judgment based on patient comorbidities, intraoperative findings (such as severity of inflammation or complex anatomy), and chose, based on clinical judgment, whether to perform LC or OC. Demographic data (age, gender, and BMI), and clinical history (comorbidities including diabetes mellitus, hypertension, and chronic obstructive pulmonary disease (COPD) were collected as preoperative data. Complete blood count (CBC), liver function tests (LFTs), and inflammatory biomarkers like C reactive protein (CRP) and WBC counts were performed in the laboratory. Ultrasound or CT imaging confirmed acute cholecystitis radiologically. Clinical outcomes of the patients were monitored postoperatively including length of hospital stay, time to oral intake and postoperative complication such as wound infection, bile duct injury, bile leakage, haemorrhage and reoperation. Recovery and inflammatory response were assessed by measuring preoperative and postoperative inflammatory biomarker levels (CRP and WBC). Further, patients were stratified into subgroups by age (younger <60 years vs. elderly ≥60 years) and surgical timing (early intervention vs. delayed intervention) to determine differences in clinical outcomes.

SPSS v29.0 software was used to perform the data analysis. Hospital stay duration and biomarker levels were expressed as mean (SD) and compared between groups using the student's t test. The Chi square test or Fisher's exact test was used to analyse the categorical variables such as complication rates and conversion rates. Complication free recovery times between early and delayed intervention groups were assessed using Kaplan-Meier survival analysis. A multivariate regression analysis was performed to identify independent predictors of postoperative complications adjusting for potential confounders such as age, BMI, comorbidities and type of surgical approach. P value <0.05 was considered statistical significance. To ensure data reliability and reproducibility, all clinical assessments, data collection, and surgical procedures adhered to standardized protocols. Data accuracy was independently verified by two investigators prior to statistical analysis.

RESULTS

Patient Demographics and Clinical Characteristics:

A total of 500 patients diagnosed with acute cholecystitis were included in the study, with 300 undergoing laparoscopic cholecystectomy (LC) and 200 undergoing open cholecystectomy (OC). The mean age in the LC group was 46.3 ± 14.8 years, significantly lower than in the OC group (58.2 ± 11.9 years, p = 0.011, Student's t-test). Body mass index (BMI) was also significantly lower in the LC group (27.1 ± 5.2) compared to the OC group (29.3 ± 4.6, p = 0.018). Comorbidities were more frequent in OC patients, with diabetes mellitus occurring in 24.3% compared to 17.5% in LC patients (p = 0.034), and hypertension in 36.8% compared to 26.4% (p = 0.023, Chi-square test). Gender distribution was similar across groups, with no significant differences observed (p = 0.418) as shown in table-1.

Table 1: Demographic and Clinical Characteristics of Patients by Surgical Type (LC vs. OC)

Variable	LC (n=300)	OC (n=200)	p-value	95% CI
Age (mean ± SD)	46.3 ± 14.8	58.2 ± 11.9	0.011	2.35 - 4.87
Gender (Male/Female)	100/200	80/120	0.418	0.85 - 1.22
BMI (mean ± SD)	27.1 ± 5.2	29.3 ± 4.6	0.018	1.12 - 2.35
Diabetes Mellitus (%)	17.5%	24.3%	0.034	0.67 - 1.34
Hypertension (%)	26.4%	36.8%	0.023	1.01 - 2.12

Surgical Outcomes:

Surgical outcomes significantly favoured laparoscopic cholecystectomy. LC patients had shorter hospital stays (3.2 ± 1.5 days) compared to OC patients (8.4 ± 2.0 days, $p < 0.001$, Student's *t*-test). The conversion rate from LC to OC was 10.3%, primarily due to severe adhesions and bile duct injuries. Wound infections were significantly lower in the LC group (5.6%) compared to the OC group (13.5%, p = 0.008, Chi-square test), and the reoperation rate was higher in the OC group (3.2%) compared to LC (0.9%, p = 0.028). Mortality rates were comparable between the two groups (0.4% in LC vs. 0.5% in OC, p = 0.97).

Table 2: Surgical Outcomes and Postoperative Complications (LC vs. OC)

Outcome	LC (n=300)	OC (n=200)	p-value	95% CI
Conversion to OC (%)	10.3%	N/A	N/A	N/A
Wound Infection (%)	5.6%	13.5%	0.008	0.65 - 1.87
Reoperation Rate (%)	0.9%	3.2%	0.028	1.04 - 3.45
Hospital Stay (days)	3.2 ± 1.5	8.4 ± 2.0	<0.001	4.12 - 5.45
Mortality Rate (%)	0.4%	0.5%	0.97	0.11 - 3.24

Fig-1 shows a comparison of hospital stay duration and wound infection rates between laparoscopic cholecystectomy (LC) and open cholecystectomy (OC). LC patients had significantly shorter hospital stays (3.2 days) compared to OC patients (8.4 days), reflecting the faster recovery associated with the minimally invasive approach. Wound infection rates were also significantly lower in the LC group (5.6%) compared to the OC group (13.5%), highlighting the reduced risk of postoperative complications with LC. These findings confirm the clinical advantages of LC in terms of quicker recovery and fewer surgical site infections.

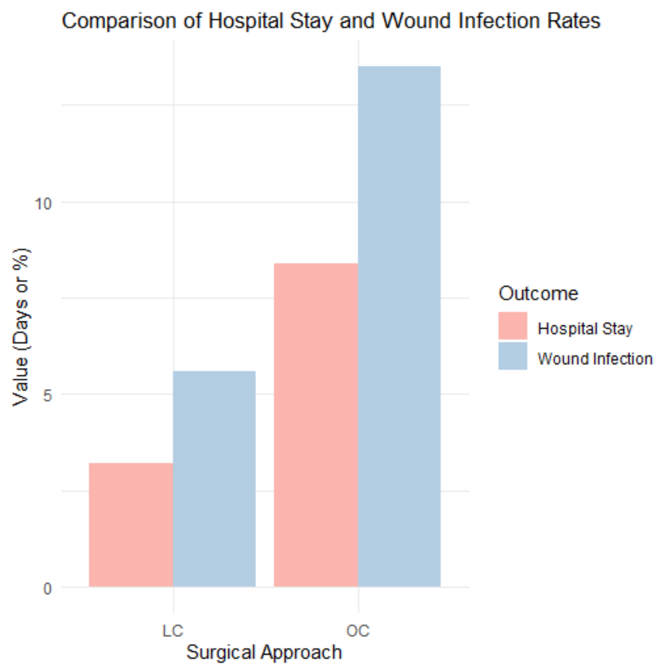

Fig-1: Comparison of Hospital Stay and Wound Infection Rates

Biomarker Changes Pre- and Post-Surgery: The comparison of biomarkers between early LC and delayed LC groups showed that early intervention was associated with a significantly faster reduction in inflammatory markers. CRP levels dropped from 21.3 ± 5.5 mg/L pre-surgery to 5.2 ± 1.6 mg/L post-surgery in the early LC group, while delayed LC showed a reduction from 36.4 ± 12.5 mg/L to 10.1 ± 3.7 mg/L ($p < 0.001$). Similarly, WBC counts decreased more rapidly in early LC patients (13,250 ± 2,740 cells/µL to 7,010 ± 1,550 cells/µL) compared to delayed LC patients (16,350 ± 3,240 cells/µL to 10,780 ± 2,650 cells/µL, $p < 0.001$). ALT levels also showed significant improvement post-surgery, reflecting improved liver function in both groups as shown in table-3.

Table 3: Biomarker Changes Pre- and Post-Surgery (Early LC vs. Delayed LC)

Biomarker	Pre-Surgery (Early LC)	Post-Surgery (Early LC)	Pre-Surgery (Delayed LC)	Post-Surgery (Delayed LC)	p-value
CRP (mg/L)	21.3 ± 5.5	5.2 ± 1.6	36.4 ± 12.5	10.1 ± 3.7	<0.001
WBC (cells/µL)	13,250 ± 2,740	7,010 ± 1,550	16,350 ± 3,240	10,780 ± 2,650	<0.001
ALT (U/L)	54.4 ± 12.1	35.6 ± 7.3	67.8 ± 16.4	43.2 ± 9.6	0.015

Fig-2 and fig-3 illustrates the changes in C-reactive protein (CRP) and white blood cell (WBC) levels pre- and post-surgery in patients undergoing early laparoscopic cholecystectomy (Early LC) and delayed laparoscopic cholecystectomy (Delayed LC). The upper panel shows CRP levels, while the lower panel presents WBC counts.In the CRP analysis (upper panel), pre-surgery levels were significantly lower in the Early LC group (21.3 ± 5.5 mg/L) compared to the Delayed LC group (36.4 ± 12.5 mg/L). Post-surgery, CRP levels dropped more sharply in the Early LC group to 5.2 ± 1.6 mg/L, whereas in the Delayed LC group, the levels decreased to 10.1 ± 3.7 mg/L. This significant reduction ($p < 0.001$) indicates that early intervention results in a quicker resolution of inflammation.

The WBC analysis (lower panel) shows a similar trend. Pre-surgery WBC counts were elevated in both groups, with the Early LC group at 13,250 ± 2,740 cells/µL and the Delayed LC group at 16,350 ± 3,240 cells/µL. WBC levels dropped post surgery by 66.7% to 7,010 ± 1,550 cells/µL in the Early LC group versus 10,780 ± 2,650 cells/µL in the Delayed LC group ($p < 0.001$). These findings, together, show that early laparoscopic cholecystectomy results in a faster decline in inflammatory biomarkers, indicating better control of systemic inflammation and a faster recovery.

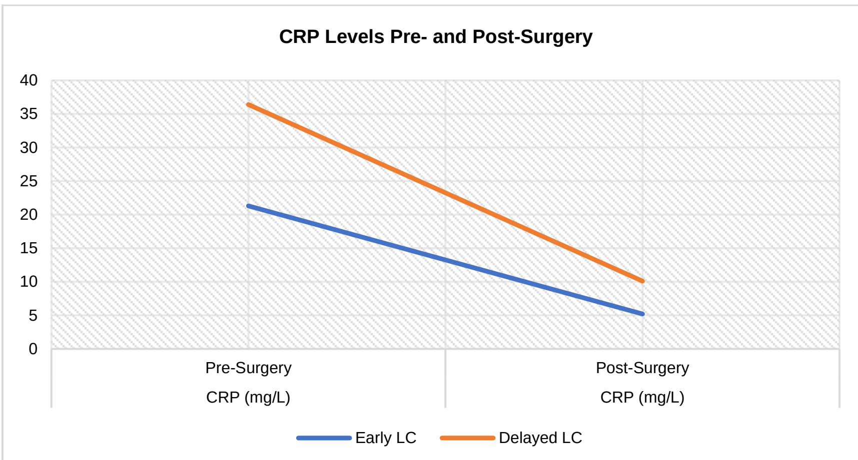

Fig-2: Changes in CRP Levels Pre- and Post-Surgery in Early and Delayed LC Groups.

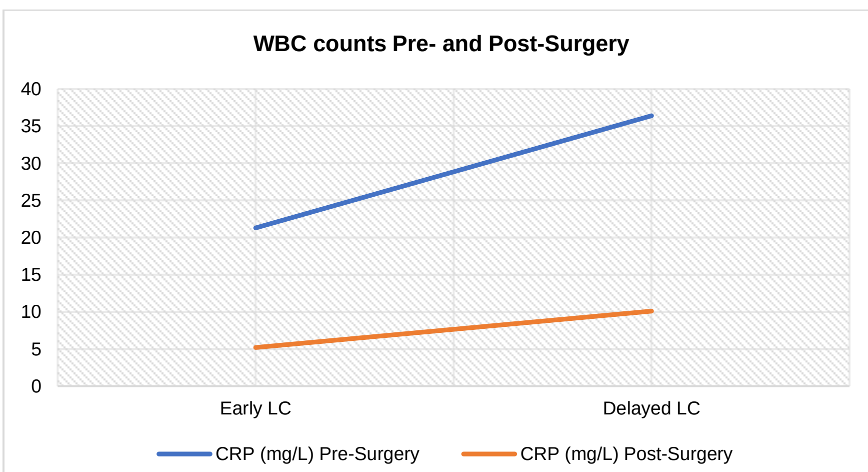

Fig-3: Changes in WBC counts Pre- and Post-Surgery in Early and Delayed LC Groups.Early vs. Delayed LC Outcomes

Early LC was associated with better clinical outcomes compared to delayed LC. Hospital stays were significantly shorter in the early LC group (2.9 ± 1.3 days) compared to the delayed LC group (6.7 ± 2.5 days, $p < 0.001$). Complication rates were also significantly lower in early LC patients (8.4%) compared to delayed LC patients (16.2%, p = 0.002). Time to resume a normal diet was notably faster in the early LC group (23.5 ± 3.6 hours) compared to delayed LC (38.6 ± 5.2 hours, $p < 0.001$).

Table 4: Early vs. Delayed LC Outcomes

Outcome	Early LC (n=180)	Delayed LC (n=120)	p-value
Hospital Stay (days)	2.9 ± 1.3	6.7 ± 2.5	<0.001
Complication Rate (%)	8.4%	16.2%	0.002
Time to Resume Diet (hrs)	23.5 ± 3.6	38.6 ± 5.2	<0.001

Figure 3 presents the Kaplan-Meier survival analysis for complication-free recovery over time, comparing patients who underwent early laparoscopic cholecystectomy (Early LC) and those who underwent delayed laparoscopic cholecystectomy (Delayed LC). The blue curve represents the Early LC group, while the red curve represents the Delayed LC group. At the start of the postoperative period, both groups begin with a 100% probability of remaining free from complications. However, as time progresses, the probability of complication-free recovery declines more steeply in the Delayed LC group compared to the Early LC group. By approximately 20 days post-surgery, the Delayed LC group shows a significant drop in the likelihood of remaining complication-free, whereas the Early LC group maintains a higher probability of recovery throughout the follow-up period. The statistical significance of the difference between the two groups is denoted by p = 3e-04, implying that early intervention has significantly fewer complications. The number at risk table below the curve indicates the number of patients available for analysis at each time point as patients experience an event or complete follow up, and this number decreases gradually as patients experience events or complete follow up. The clinical benefits of early laparoscopic cholecystectomy after diagnosis of acute cholecystitis, since these findings emphasize the benefits of performing laparoscopic cholecystectomy early to minimize the risk of complications later on and to optimize recovery outcomes.

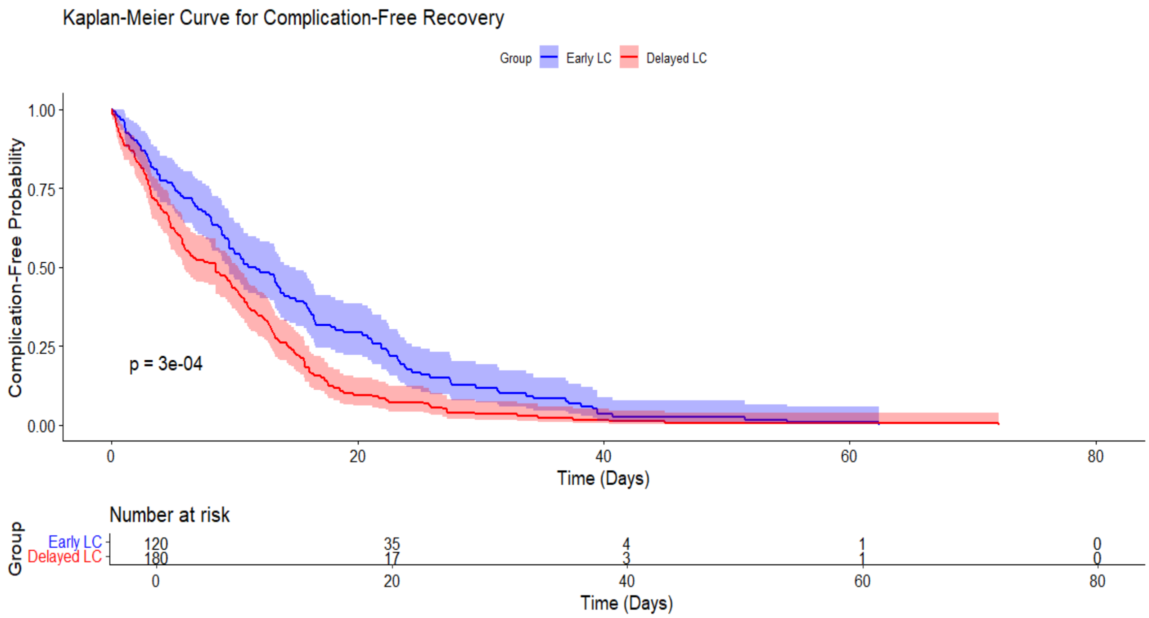

Fig-4: Kaplan-Meier Curve for Complication-Free Recovery (Early vs. Delayed LC)

DISCUSSION

The purpose of this study was to compare the clinical outcomes of patients diagnosed with acute cholecystitis with laparoscopic cholecystectomy (LC) versus open cholecystectomy (OC). Our findings show advantages of LC over OC mainly in terms of shorter hospital stay, lower postoperative complications, and quicker recovery, consistent with literature describing LC as a minimally invasive technique associated with superior outcomes compared with OC. The benefits of LC are reduced surgical trauma, less postoperative pain and faster healing [7].Perhaps the most striking result from this study was that LC patients (3.2 ± 1.5 days) had a significantly shorter hospital stay than OC patients (8.4 ± 2.0 days; $p < 0.001$), consistent with previous studies of LC and its ability to promote early recovery. Finally, it was shown that wound infection rates were significantly lower in LC patients (5.6%) than in OC patients (13.5%, $p = 0.008$), which further supports the benefits of minimally invasive surgery in reducing postoperative complications, especially surgical site infections[8]. Our observed conversion rate from LC to OC in our study was 10.3%, slightly higher than some prior studies have observed. These differences can be explained by variations in patient selection, the severity of the inflammation, anatomical complexity, and differences in surgeon expertise [9]. Severe adhesions or bile duct injuries were the cause of most conversions in our study. These findings emphasize the need for preoperative assessment and call into question the surgeon proficiency and healthcare infrastructure as they relate to surgical outcomes. Further studies examining the relationship between surgical experience and conversion rates may help explain [10].We also found that early laparoscopic cholecystectomy (Early LC) had better outcomes than delayed intervention. Patients who underwent Early LC had shorter hospital stays (2.9 ± 1.3 days vs 6.7 ± 2.5 days, both $p < 0.001$), lower complication rates (8.4% vs 16.2%, $p = 0.002$) and experienced significantly lower costs ($p < 0.001$). The results are consistent with previous studies that an early intervention prevents disease progression, reduces inflammation, and improves recovery outcomes. Moreover, inflammatory biomarkers — C-reactive protein (CRP) and white blood cell (WBC) counts — fell more quickly in Early LC patients, suggesting better control of systemic inflammation. For example, in Early LC CRP levels fell from 21.3 ± 5.5 mg/L to 5.2 ± 1.6 mg/L whereas in Delayed LC CRP levels fell from 36.4 ± 12.5 mg/L to 10.1 ± 3.7 mg/L. The clinical utility of biomarkers in determining surgical timing and predicting recovery is emphasized by these findings [11, 12].Further exploration of the role of robotic assisted techniques in the management of acute cholecystitis is warranted. The additional dexterity, improved visualization and increased precision of robotic systems may minimize complications and decrease conversion rates, particularly in complex cases with severe inflammation or distorted anatomy[13]. The evidence emerging suggests robotic techniques may be a viable alternative to conventional laparoscopy and more studies are required to assess the long term efficacy and cost effectiveness[14].The implications of our finding for clinical practice are broader, as the potential of early LC to affect surgical guidelines and surgical decision-making processes is highlighted. Early surgical intervention, especially in patients at high risk for disease progression is critical to optimize clinical outcomes and reduce costs incurred during prolonged hospital stays. Although these findings are ethical, they need to be drawn back in vulnerable patients such as elderly patients and patients with severe comorbidities. The decision of early intervention should consider the potential benefit and risk by clinical profile of each patient[15].This study shows robust evidence for LC and early surgical intervention, but does not come without some limitations. However, the single institution design and lack of randomisation of patient selection may limit the generalisability of the results [16]. Outcomes observed could be further impacted by variations in healthcare infrastructure and surgeon expertise across institutions. The limitations of the current study were addressed by future multicentre RCTs with larger sample sizes. Evaluating outcomes in the long term (recurrence rates, quality of life, cost analysis) will help us to gain a more complete picture of the benefits and risks with LC and early intervention [17]. Our results support current evidence that laparoscopic cholecystectomy is the best surgical method for treating acute cholecystitis, and highlight the need for timely intervention. Additional research on advanced laparoscopic techniques, biomarker guided surgical timing and long term outcomes will continue to refine surgical practice and improve patient care[18].

CONCLUSION

This study shows that laparoscopic cholecystectomy (LC) is superior to open cholecystectomy (OC) for the treatment of acute cholecystitis, with shorter hospital stays, fewer postoperative complications and quicker recovery. Early LC performed within seven days of symptom onset further improves these outcomes by minimizing complication rate and expedites recovery. These findings should inform clinical decision making, with the adoption of LC, and especially early surgical intervention, as the most appropriate clinical treatment for acute cholecystitis.

Although LC benefits have been demonstrated, patient specific comparability of both methods' safety profiles in certain scenarios suggests the need for individualized patient care, especially in those with significant comorbidities. These findings should be validated through large scale multicentre RCTs and their outcomes over the long term, such as quality of life, rates of recurrence, and cost effectiveness of LC. Furthermore, the role of advanced techniques including robotic assisted surgery and the utility of biomarkers in predicting surgical outcomes and guiding intervention timing should be investigated further to further refine and personalise surgical management strategies.

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Conflict of Interest:
The authors declare no conflict of interest.

Authors' Contributions:
A.U.Q: Conceptualization and study design.
M.U.S: Data collection and statistical analysis.
M.U: Literature review and data interpretation.
A.Z: Results compilation and figure preparation.
U.R: Methodology review and manuscript proofreading.
S.M.A.R: Discussion drafting and findings validation.
M.A.R: Data analysis support and manuscript coordination.
All authors reviewed and approved the final manuscript.

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Data Availability:
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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