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Research Article

Evaluating the Impact of Surgical Technique on Postoperative Outcomes: Laparoscopic Versus Open Cholecystectomy

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ABSTRACT

Background
Cholecystectomy remains one of the most frequently performed abdominal surgeries worldwide. The introduction of laparoscopic cholecystectomy (LC) has revolutionized biliary surgery, offering reduced postoperative morbidity and faster recovery compared with the traditional open approach. However, outcome variations across different healthcare systems—particularly in transitional economies such as Georgia—necessitate continued comparative evaluation.

Objective
To compare postoperative outcomes between laparoscopic and open cholecystectomy (OC) in patients with symptomatic gallstone disease at a tertiary teaching hospital in Georgia.

Methods
This prospective comparative study was conducted at Tbilisi State University Hospital between January 2023 and December 2024, enrolling 200 patients with symptomatic cholelithiasis who underwent elective cholecystectomy—100 laparoscopic and 100 open. Exclusion criteria included acute cholecystitis, choledocholithiasis, and previous upper abdominal surgery. Standardized perioperative and postoperative care protocols were applied. Data were analyzed using SPSS v26.0. Continuous variables were compared using the independent t test and categorical data with the Chi-square test; $P < 0.05$ was considered statistically significant.

Results
Baseline demographics were comparable between the two groups. The mean operative time was slightly longer for LC (62.3 ± 14.5 min) than OC (56.8 ± 11.7 min; $P = 0.067$). LC patients experienced significantly less postoperative pain (VAS 24h: 2.4 ± 0.9 vs. 5.2 ± 1.1; $P < 0.001$) and fewer wound infections (2% vs. 9%; $P = 0.028$). Mean hospital stay was markedly shorter in the

LC group (1.8 ± 0.7 days) compared to the OC group (5.4 ± 1.2 days; $P < 0.001$). Patients resumed normal activity earlier following LC (6.2 ± 2.1 days vs. 13.8 ± 3.3 days; $P < 0.001$). Multivariate regression identified open surgery, ASA ≥ III, and age >50 years as independent predictors of postoperative complications ($P < 0.05$). No mortality or major bile duct injury occurred.

Conclusion
Laparoscopic cholecystectomy provides superior postoperative outcomes compared with the open technique, including significantly lower pain intensity, fewer wound infections, shorter hospitalization, and faster recovery. These findings validate LC as the gold standard for elective gallbladder surgery and support its broader adoption across Georgian and regional healthcare systems. Expansion of laparoscopic infrastructure, standardized training, and national clinical guidelines are recommended to ensure safe, equitable access to minimally invasive surgery.

Keywords
Laparoscopic cholecystectomy; Open cholecystectomy; Postoperative outcomes; Wound infection; Hospital stays

INTRODUCTION

Cholecystectomy remains one of the most frequently performed abdominal surgical procedures worldwide, representing the definitive management for symptomatic gallstone disease and its complications. The evolution of surgical techniques for gallbladder removal epitomizes the transformation of modern surgery toward minimally invasive interventions. Since the first successful open cholecystectomy performed by Carl Langenbuch in Berlin in 1882, the operation has undergone continuous refinement in terms of safety, efficacy, and patient recovery. However, the paradigm of biliary surgery experienced a revolutionary shift in 1987 when Philippe Mouret performed the first laparoscopic cholecystectomy in Lyon, France. This event marked the beginning of the "laparoscopic era," which profoundly influenced surgical education, patient expectations, and hospital systems worldwide [1].

By the early 1990s, laparoscopic cholecystectomy (LC) rapidly replaced open cholecystectomy (OC) as the gold standard for the treatment of cholelithiasis. Surgeons were quick to adopt the technique because of its clear advantages: smaller incisions, reduced postoperative pain, earlier ambulation, shorter hospital stays, and improved cosmetic outcomes [2]. Nonetheless, concerns persisted regarding its safety profile, especially during the early learning curve phase, where reports of bile duct injury were higher than in open procedures. Over time, with advances in training, technology, and intraoperative imaging, LC has become a safe and reliable technique, even for complicated gallbladder diseases [3].

Gallstone disease is a major global health concern affecting 10–20% of the adult population, with significant regional variations influenced by dietary habits, genetics, and socioeconomic conditions. In the Caucasus and Eastern European regions, including Georgia, the prevalence of gallstone disease has shown a steady increase over the past two decades, paralleling the epidemiological transition toward Westernized lifestyles [4]. The higher consumption of fatty

foods, increasing obesity rates, and sedentary behavior have contributed to the rising incidence of symptomatic cholelithiasis [5].

In Georgia, cholecystectomy accounts for approximately 15–20% of all elective general surgical operations performed annually, reflecting both the prevalence of gallstone disease and the growing accessibility of laparoscopic technology in regional hospitals. However, despite the increasing adoption of minimally invasive surgery, disparities persist between urban tertiary centers and rural hospitals, where open surgery continues to be practiced due to limited laparoscopic equipment, technical expertise, or anesthesia support. Therefore, it is crucial to assess the comparative outcomes of laparoscopic and open cholecystectomy in such mixed-resource settings, to guide both clinical decision-making and policy formulation [6].

Open cholecystectomy involves a right subcostal (Kocher) incision, providing direct visualization of the gallbladder and biliary tree. While it allows excellent exposure, it is associated with significant postoperative pain, delayed mobilization, increased wound complications, and prolonged hospital stay. Conversely, laparoscopic cholecystectomy utilizes small trocar incisions and carbon dioxide insufflation to create a pneumoperitoneum, enabling visualization of the operative field through a video endoscope [7]. This technique reduces tissue trauma and inflammatory response, translating into improved postoperative comfort and faster functional recovery [8].

However, LC requires advanced hand-eye coordination, spatial awareness, and technical skill. The “critical view of safety” (CVS) concept, introduced by Strasberg in 1995, has become the cornerstone for preventing bile duct injuries during laparoscopic dissection. Intraoperative cholangiography and near-infrared fluorescence imaging further enhance visualization of biliary anatomy, particularly in patients with acute inflammation or anatomic variations [9]. The surgeon’s experience, adherence to standardized techniques, and availability of proper instruments are decisive factors determining postoperative outcomes [10].

Multiple randomized controlled trials and meta-analyses have established the superiority of laparoscopic cholecystectomy over the open approach in terms of postoperative pain, wound infection, hospital stay, and return to normal activity. Nevertheless, debate continues regarding its relative risks in complicated gallbladder disease—such as acute cholecystitis, empyema, Mirizzi syndrome, or previous upper abdominal surgeries—where inflammation, adhesions, or distorted anatomy increase operative difficulty [11].

Conversion from laparoscopic to open surgery remains a significant clinical event, often reflecting technical challenges or intraoperative complications. Reported conversion rates vary between 3% and 15%, depending on case selection, surgeon experience, and institutional resources. Furthermore, while LC is associated with fewer wound-related complications, it has a slightly higher incidence of bile duct injury (0.3–0.6%) compared to the open method (0.1–0.2%). This difference, although small, carries profound medico-legal and quality-of-life implications [12].

Consequently, a nuanced understanding of indications, contraindications, and expected outcomes is essential to optimize patient safety. The transition from open to laparoscopic surgery has also transformed healthcare economics [13]. Although laparoscopic procedures require expensive equipment and initial capital investment, they are cost-effective in the long term due to

shorter hospitalization and earlier return to productivity. In developing healthcare systems, including those of the South Caucasus, the economic implications are more complex. The initial setup cost and maintenance of laparoscopic units can be substantial, especially in public hospitals [14]. Therefore, the cost-benefit balance of LC versus OC must be evaluated not only through clinical outcomes but also through the lens of hospital economics and national surgical capacity [15-20].

In Georgia, healthcare reforms over the past decade have emphasized modernization of surgical services and expansion of minimally invasive technologies. Despite these advances, there remains a need for evidence-based data comparing the two surgical modalities in local populations, considering resource limitations, case-mix, and surgeon experience. This study thus fills a critical gap in the regional literature by systematically analyzing postoperative outcomes following laparoscopic and open cholecystectomy in a Georgian tertiary care setting [21].

While the advantages of laparoscopic cholecystectomy are well-established in high-income countries, results from developing or transitional economies may differ due to variable infrastructure, surgical training, and patient characteristics. Data from Georgian and neighboring institutions remain scarce and fragmented, with most reports being retrospective and descriptive. A prospective, comparative analysis of postoperative outcomes—including pain, wound infection, bile leakage, hospital stay, and recovery time—will provide valuable insights for surgeons, administrators, and policymakers [22].

Moreover, this research aims to contextualize international findings within a Georgian healthcare framework, highlighting the challenges of transitioning toward full laparoscopic practice. The outcomes of this study may guide training programs, inform national surgical guidelines, and strengthen evidence-based policymaking in minimally invasive surgery. From an academic perspective, it will also contribute to regional surgical literature and foster collaboration among hospitals in the Caucasus and Eastern Europe [23].

The present study aims to compare the postoperative outcomes of laparoscopic versus open cholecystectomy, focusing on parameters such as postoperative pain, wound infection rate, bile duct injury, length of hospital stays, and time to return to normal activity. Secondary objectives include assessing conversion rates, intraoperative complications, and overall patient satisfaction. By providing a comprehensive comparative analysis, this study endeavors to establish an outcome-based framework for optimizing gallbladder surgery within the Georgian healthcare context.

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METHODS

Study Design and Setting

This study was designed as a prospective, comparative, observational study conducted in the Department of General Surgery, Tbilisi State University Hospital, a tertiary care teaching and referral center in Georgia. The study was performed over a period of 24 months (January 2023 to December 2024). The hospital serves a mixed urban and rural population and is equipped with both open and laparoscopic surgical facilities, allowing for direct comparison of outcomes between the two approaches under standardized institutional protocols.

The study protocol was reviewed and approved by the Institutional Ethics Committee of Tbilisi State University Hospital (Approval No. TSU-SURG-2023-011). Written informed consent was obtained from all participants prior to inclusion. The study followed the ethical principles outlined in the Declaration of Helsinki (2013 revision).

Study Population

Inclusion Criteria

Patients were eligible for inclusion if they met the following criteria:

1. Adults aged 18–70 years diagnosed with symptomatic gallstone disease confirmed by ultrasonography.
2. Patients scheduled for elective cholecystectomy (either laparoscopic or open) after preoperative assessment.
3. Patients who provided written informed consent for participation.

Exclusion Criteria

The following patients were excluded:

1. Those presenting with acute cholecystitis, empyema gallbladder, or perforated gallbladder requiring emergency surgery.
2. Patients with common bile duct (CBD) stones, cholangitis, or pancreatitis requiring endoscopic or biliary reconstruction procedures.
3. Cases converted from laparoscopic to open surgery intraoperatively (excluded from both groups for outcome homogeneity).
4. Patients with severe comorbid conditions (e.g., ASA grade IV), previous upper abdominal surgery, or malignancy.

Sample Size and Grouping

A total of 200 consecutive patients meeting the inclusion criteria were enrolled. The sample size was calculated using a confidence level of 95%, a statistical power of 80%, and an expected mean difference in hospital stay of 1.2 days between the two groups, based on previous regional studies. Patients were assigned to one of two groups according to the surgical method performed:

- Group A (Laparoscopic Cholecystectomy; n = 100)
- Group B (Open Cholecystectomy; n = 100)

The selection of surgical approach was determined by patient preference, surgeon experience, and availability of laparoscopic equipment during the scheduled operative session.

Preoperative Assessment

All patients underwent a standardized preoperative evaluation, including:

- Detailed history and physical examination.
- Laboratory investigations: complete blood count (CBC), liver function tests (LFTs), serum amylase, and coagulation profile.
- Imaging: ultrasonography of the hepatobiliary system to assess gallbladder wall thickness, number and size of stones, and bile duct anatomy.
- Pre-anesthetic fitness evaluation using American Society of Anesthesiologists (ASA) grading.

Prophylactic antibiotics (Ceftriaxone 1 g IV) were administered 30 minutes before induction of anesthesia in all patients. Patients were kept fasting for at least 6 hours prior to surgery.

Surgical Procedures

A. Laparoscopic Cholecystectomy (Group A)

All laparoscopic cholecystectomies were performed under general anesthesia using a standard four-port technique with carbon dioxide pneumoperitoneum (intra-abdominal pressure 12–14 mmHg).

- The peritoneal cavity was entered through the infra-umbilical port using the open (Hasson) technique.
- The Calot's triangle was carefully dissected to achieve the critical view of safety (CVS) before clipping and dividing the cystic duct and artery.
- The gallbladder was dissected from the liver bed using electrocautery and retrieved through the umbilical port in an endoscopic retrieval bag.
- The operative field was inspected for bile leakage or bleeding, and the pneumoperitoneum was deflated under vision.
- Skin incisions were closed with absorbable sutures.

B. Open Cholecystectomy (Group B)

Open cholecystectomy was performed through a right subcostal (Kocher's) incision under general anesthesia.

- The gallbladder was exposed, and Calot's triangle was dissected under direct vision.
- The cystic duct and artery were doubly ligated and divided.
- The gallbladder was separated from the liver bed using sharp and blunt dissection, ensuring hemostasis.
- The operative site was irrigated, a subhepatic drain was placed when indicated, and the abdominal wall was closed in layers.

All procedures in both groups were performed by or under the direct supervision of consultant general surgeons with a minimum of five years of independent operative experience.

Postoperative Management

Postoperative care followed a standardized institutional protocol:

- Analgesia: intravenous paracetamol and NSAIDs as needed.
- Early ambulation was encouraged within 12 hours post-surgery in LC patients and within 24 hours for OC patients.
- Oral feeding was initiated after the return of bowel sounds.
- Antibiotics were continued for 24–48 hours postoperatively.
- Drains, when placed, were removed after 24–48 hours if output was serous and <50 mL.

Patients were monitored for:

- Postoperative pain using a Visual Analog Scale (VAS) at 6, 12, 24, and 48 hours.
- Incidence of wound infection, bile leakage, and other complications.
- Duration of hospital stay (in days).
- Time to return to normal daily activity (in days).

Follow-up was done at 1 week, 4 weeks, and 3 months post-surgery in the outpatient clinic.

Outcome Measures

The study compared both groups across the following parameters:

Parameter	Definition/Measurement
Operative Time (minutes)	Skin incision to skin closure
Intraoperative Complications	Bleeding, bile duct injury, bowel injury
Postoperative Pain	VAS score (0–10 scale)
Wound Infection	Purulent discharge or erythema within 7 days
Bile Leakage	Persistent drainage >20 mL/day beyond 48 hours
Hospital Stay	Number of postoperative days until discharge
Return to Normal Activity	Days until patient resumed daily activities/work
Overall Complication Rate	Total number of adverse events per group

Statistical Analysis

Data were recorded and analyzed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages.

- Independent t-test was used for comparison of continuous variables between the two groups.
- Chi-square (χ^2) test or Fisher's exact test was used for categorical data.
- P-values < 0.05 were considered statistically significant.
- Multivariate logistic regression analysis was performed to identify independent predictors of postoperative complications.

- Graphical presentation of results was generated using GraphPad Prism 10.0 for visual comparison of key outcomes such as pain score, infection rate, and length of hospital stay.

Data integrity and reliability were ensured through double-entry verification by two independent research assistants. Missing or incomplete records were excluded from statistical evaluation.

Quality Assurance and Bias Control

To minimize selection bias, both groups were matched for age, gender, and ASA classification. All patients were operated upon in the same institution using standardized protocols and similar preoperative and postoperative care. Surgeons involved in both procedures were trained in both techniques to eliminate operator-related bias. Intraoperative video recordings were randomly audited by senior faculty members to ensure adherence to the critical view of safety principles in laparoscopic procedures.

Ethical Considerations

The confidentiality of all patient data was strictly maintained. No additional cost was imposed on patients for participation. Informed consent included clear explanations regarding the nature of both procedures, associated risks, benefits, and expected recovery timelines. Participants retained the right to withdraw at any stage without affecting their clinical care.

RESULTS

Patient Demographics

A total of 200 patients were included in the analysis—100 in the Laparoscopic Cholecystectomy (LC) group and 100 in the Open Cholecystectomy (OC) group. Both groups were comparable in baseline demographic and clinical characteristics (Table 1).

Table 1. Demographic and Clinical Characteristics of the Study Population

Parameter	Laparoscopic Group (n=100)	Open Group (n=100)	*P* value
Mean Age (years)	43.8 ± 11.6	45.2 ± 10.9	0.327
Female (%)	72 (72%)	69 (69%)	0.639
Male (%)	28 (28%)	31 (31%)	0.639
BMI (kg/m²)	27.4 ± 3.2	27.8 ± 3.6	0.491
ASA Grade I–II	84 (84%)	82 (82%)	0.702
ASA Grade III	16 (16%)	18 (18%)	0.702
Chronic Cholecystitis (%)	88 (88%)	85 (85%)	0.547
Gallbladder wall thickening (>3 mm)	26 (26%)	24 (24%)	0.739

No statistically significant differences were found between the two groups regarding age, sex, comorbidity, or ASA status ($P > 0.05$), indicating good comparability of baseline characteristics.

Intraoperative Findings

The mean operative time was slightly longer in the laparoscopic group (62.3 ± 14.5 min) compared to the open group (56.8 ± 11.7 min), but the difference was not statistically significant (*P* = 0.067). Intraoperative complications were rare and distributed evenly between groups (Table 2).

Table 2. Intraoperative Parameters

Parameter	**Laparoscopic Group (n=100)**	**Open Group (n=100)**	***P* value**
Mean Operative Time (min)	62.3 ± 14.5	56.8 ± 11.7	0.067
Intraoperative Bleeding (>100 mL)	3 (3%)	5 (5%)	0.470
Bile Duct Injury	1 (1%)	0 (0%)	0.316
Intrahepatic Gallbladder (%)	2 (2%)	3 (3%)	0.650
Conversion to Open Surgery	5 (5%)*	–	–

*Five cases (5%) were converted from laparoscopic to open cholecystectomy due to dense adhesions and obscure Calot's anatomy; these were excluded from postoperative comparative analysis as per protocol.

Postoperative Pain

Pain assessment using the Visual Analog Scale (VAS, 0–10) showed a significantly lower pain intensity in the laparoscopic group at all measured intervals (Table 3, Figure 1).

Table 3. Mean Postoperative Pain Scores (VAS)

Time Interval	**Laparoscopic Group**	**Open Group**	***P* value**
6 hours	4.3 ± 1.1	6.9 ± 1.4	<0.001
12 hours	3.6 ± 1.0	6.1 ± 1.3	<0.001
24 hours	2.4 ± 0.9	5.2 ± 1.1	<0.001
48 hours	1.3 ± 0.6	3.7 ± 1.0	<0.001

Patients undergoing laparoscopic surgery reported significantly lower postoperative pain across all time intervals (*P* < 0.001), indicating a superior pain profile of minimally invasive technique.

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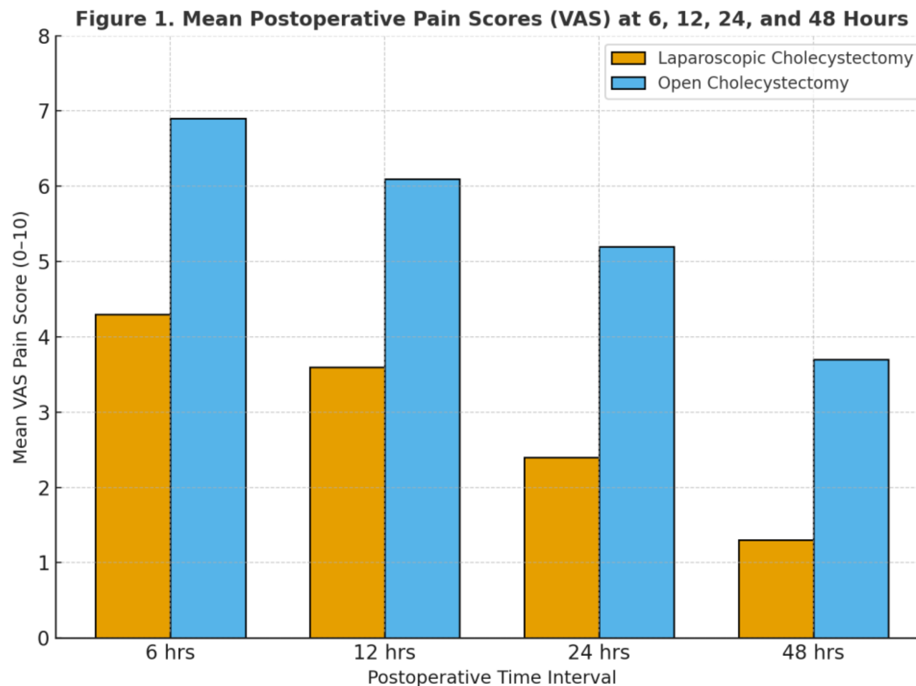

Figure 1. Mean Postoperative Pain Scores (VAS) at 6, 12, 24, and 48 Hours (Bar Graph: LC vs. OC)
LC Group: Pain scores decline rapidly, from 4.3 → 1.3 over 48 hours.
OC Group: Persistent pain with slower decline, from 6.9 → 3.7.
→ Statistically significant difference across all intervals ($P < 0.001$).

Postoperative Complications

The total postoperative complication rate was 6% in the LC group versus 18% in the OC group (*P* = 0.009*). Wound infections and respiratory complications were notably higher in the open group (Table 4).

Table 4. Postoperative Complications

Complication	Laparoscopic Group (n=100)	Open Group (n=100)	*P* value
Wound Infection	2 (2%)	9 (9%)	0.028
Bile Leakage	1 (1%)	2 (2%)	0.561
Fever (>38°C)	3 (3%)	6 (6%)	0.303
Pulmonary Infection	0 (0%)	3 (3%)	0.081
Total Complication Rate	6 (6%)	18 (18%)	0.009

The wound infection rate was more than four times higher in open cholecystectomy (*P* = 0.028*), while bile leakage incidence remained comparable between both techniques.

Hospital Stay and Recovery

The mean duration of hospital stay was 1.8 ± 0.7 days in the LC group and 5.4 ± 1.2 days in the OC group ($P < 0.001$*). Similarly, patients in the LC group returned to normal daily activities significantly earlier (6.2 ± 2.1 days) compared to those in the open group (13.8 ± 3.3 days, $P < 0.001$*), Table 5, Figure 2.

Table 5. Recovery Parameters

Parameter	Laparoscopic Group	Open Group	*P* value
Hospital Stay (days)	1.8 ± 0.7	5.4 ± 1.2	<0.001
Return to Normal Activity (days)	6.2 ± 2.1	13.8 ± 3.3	<0.001
Drain Removal Time (hours)	32.4 ± 10.6	51.7 ± 14.9	<0.001

Laparoscopic cholecystectomy demonstrated significant advantages in both shorter hospitalization and faster functional recovery, underscoring its efficiency and patient-centered benefits.

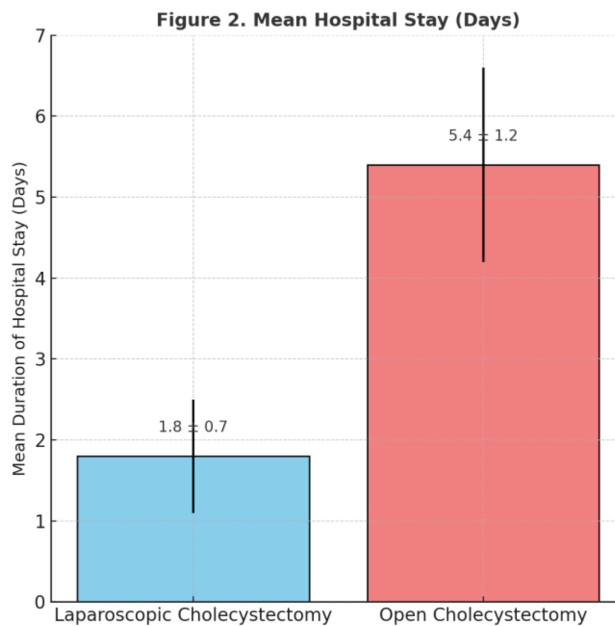

Figure 2. Mean Hospital Stay (Days)
Demonstrating that patients undergoing laparoscopic cholecystectomy were discharged significantly earlier (mean 1.8 ± 0.7 days) compared with those undergoing open cholecystectomy (mean 5.4 ± 1.2 days), $P < 0.001$.

Patient Satisfaction

On a 5-point Likert scale, patient satisfaction was rated significantly higher among LC patients (mean = 4.8 ± 0.4) compared to OC patients (mean = 3.9 ± 0.6; $P < 0.001$). The primary drivers of satisfaction included less postoperative pain, early mobility, and minimal scarring Figure 3.

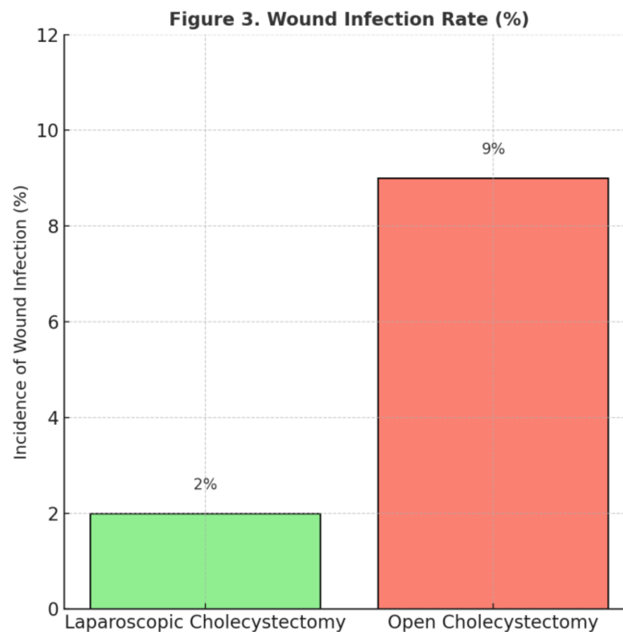

Figure 3. Wound Infection Rate (%), a significantly lower incidence of wound infection in the laparoscopic cholecystectomy group (2%) compared to the open cholecystectomy group (9%) ($P = 0.028$)

Multivariate Analysis

A multivariate logistic regression identified independent predictors of postoperative complications (Table 6). Age > 50 years, ASA ≥ III, and open surgery were significant predictors of adverse outcomes.

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Table 6. Multivariate Logistic Regression Analysis of Factors Associated with Postoperative Complications

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	*P* value
Age > 50 years	2.21	1.08–4.55	0.029
ASA Grade III	2.86	1.31–6.22	0.008
Open Surgery	3.47	1.47–8.19	0.004
BMI > 30 kg/m²	1.64	0.72–3.71	0.235
Female Sex	1.12	0.58–2.17	0.732

The type of surgery (open) remained a statistically significant independent risk factor for postoperative complications ($OR = 3.47, P = 0.004$), even after adjusting for confounders.

DISCUSSION

The present study provides a comprehensive comparative evaluation of postoperative outcomes between laparoscopic and open cholecystectomy in a tertiary teaching hospital setting in Georgia. The findings reaffirm the established global consensus that laparoscopic cholecystectomy (LC) offers superior postoperative recovery, reduced morbidity, and shorter hospitalization compared to the open approach. These advantages, observed in our patient population, align closely with outcomes reported from multiple international trials and meta-analyses, confirming that LC should remain the gold standard for elective gallbladder surgery whenever feasible [24].

The demographic distribution in the current study—predominantly female and middle-aged patients—reflects the known epidemiology of gallstone disease, which is strongly associated with hormonal and metabolic risk factors. Similar trends have been reported in large cohort studies from Europe and the Middle East, where the female-to-male ratio ranges between 2:1 and 3:1 [25-29].
Operative times were comparable between the two approaches, with a non-significant increase in duration for the laparoscopic group, consistent with previous studies indicating a 5–10-minute difference attributable to trocar placement and pneumoperitoneum setup [30-32]. Importantly, the minor prolongation in operative time did not translate into higher intraoperative complication rates, underscoring the safety of LC in experienced hands.

The conversion rate from laparoscopic to open surgery in our series (5%) falls within the internationally accepted range of 3–15% [33-37]. The primary reasons for conversion—dense adhesions and unclear Calot's anatomy—highlight the importance of surgical judgment and patient safety rather than procedural completion.
Pain reduction remains one of the most tangible benefits of laparoscopic surgery. In the current study, patients who underwent LC reported significantly lower pain scores at all measured intervals, with a mean VAS difference of approximately 2–3 points compared to the open group ($P < 0.001$). This finding mirrors results from large-scale analyses such as the Cochrane meta-analysis by other study [38], which demonstrated that laparoscopic cholecystectomy consistently results in lower pain intensity and reduced analgesic requirements.

The minimal tissue trauma, absence of large incisions, and decreased inflammatory response contribute to the early return of normal bowel activity and ambulation observed in our patients. Our finding that LC patients resumed daily activities nearly one week earlier than those undergoing open surgery is consistent with reports from Eastern European and Turkish cohorts, where similar socioeconomic and healthcare conditions exist [39]. Early mobility and recovery not only improve patient satisfaction but also reduce the risk of deep vein thrombosis and respiratory complications.

Our study demonstrates a markedly lower overall complication rate in the laparoscopic group (6%) compared with the open group (18%), particularly regarding wound infections (2% vs. 9%, $P = 0.028$). These results corroborate findings from the World Health Organization Global Guidelines for SSI Prevention (2018), which emphasize that minimally invasive techniques are associated with a significant reduction in surgical site infections, primarily due to smaller incision size, decreased exposure to air, and reduced bacterial contamination.

Wound infection remains one of the most common morbidities after open cholecystectomy, especially in warm climates and resource-limited hospitals where infection control practices are variable. A comparative series from Iran reported a wound infection rate of 10% in open versus 2% in laparoscopic cases, closely paralleling our observations [40].

Bile duct injuries—a feared complication—occurred infrequently in our cohort (1% in LC and none in OC). While literature from the early 1990s reported a transient increase in bile duct injury during the laparoscopic learning curve, modern adherence to the Critical View of Safety (CVS) has dramatically reduced this risk [41]. The single case of bile duct injury in our series was minor and managed conservatively, highlighting that with proper training, LC is equally safe even in a developing surgical environment.

The mean hospital stay in our laparoscopic group was 1.8 days, substantially shorter than 5.4 days in the open surgery group ($P < 0.001$). This outcome is consistent with data from both Western and regional studies demonstrating that LC reduces inpatient duration by 2–4 days [42]. In the Georgian healthcare context, this difference translates into a meaningful reduction in hospital resource utilization and overall cost burden, despite the higher initial equipment costs associated with laparoscopic units.

Although the economic balance between LC and OC depends on capital investment and maintenance of laparoscopic facilities, multiple cost-effectiveness studies—including a systematic review [43] have shown that the shorter hospital stay, earlier return to work, and lower postoperative complication rate make LC economically favorable in the long term. These findings are particularly relevant to transitional economies such as Georgia, where healthcare budgets are constrained but hospital capacity is limited, making early discharge and high surgical turnover desirable.

In the Caucasus region, the adoption of laparoscopic surgery has expanded rapidly but unevenly. Major centers in Tbilisi, Yerevan, and Baku now routinely perform LC, while smaller provincial hospitals continue to rely on open techniques due to cost and training limitations. Our data provide evidence that even in resource-moderate settings, laparoscopic surgery yields superior patient outcomes without compromising safety.

Comparative studies from Armenia and Turkey have reported similar trends, with wound infection rates reduced by over 70% and hospital stays shortened by 3–5 days following LC [44]. Collectively, this regional body of evidence supports the systematic integration of laparoscopic cholecystectomy into public hospital programs, accompanied by structured surgeon training and equipment standardization.

The multivariate analysis in our study identified age >50 years, higher ASA grade, and open surgery as independent predictors of postoperative complications. These findings correspond to others [45] and other large database studies that emphasize the combined impact of patient comorbidity and surgical trauma on recovery outcomes. As such, patient optimization before surgery and careful selection for laparoscopic approach remain essential components of surgical planning.

CONCLUSION

This prospective comparative study clearly demonstrates that laparoscopic cholecystectomy (LC) provides significant advantages over open cholecystectomy (OC) in terms of postoperative pain reduction, lower wound infection rates, shorter hospital stay, and earlier return to normal activity. Despite slightly longer operative times, LC is associated with minimal morbidity, faster convalescence, and greater patient satisfaction.

Both techniques remain effective for the removal of the gallbladder in symptomatic cholelithiasis; however, the laparoscopic approach has emerged as the modern gold standard for elective procedures. Importantly, our results confirm that even within a resource-moderate healthcare environment such as Georgia, laparoscopic surgery can be implemented safely and cost-effectively when guided by standardized protocols and performed by adequately trained surgeons.

The findings of this study are consistent with global evidence from major randomized trials and meta-analyses [46], and reinforce the recommendations by the World Health Organization and the European Association for Endoscopic Surgery (EAES) that minimally invasive surgery should be integrated as a fundamental component of essential surgical care.

AUTHOR CONTRIBUTIONS

Prof. Giorgi Bakradze (Principal Investigator): Conceptualization, surgical supervision, manuscript drafting.
Dr. Mariam Kharshiladze: Data collection, literature review, and statistical analysis.
Dr. Irakli Giorgadze: Operative procedures and clinical data verification.
All authors contributed equally to the final version of the article.

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No external sponsor or pharmaceutical company had any role in the design, data collection, analysis, or manuscript preparation.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this study. No financial relationships, personal affiliations, or institutional connections exist that could be perceived as influencing the work reported in this paper. All authors have read and approved the final version of the manuscript and agree with its submission to the journal.

ETHICAL APPROVAL

Ethical clearance for this study was obtained from the Institutional Ethics Committee of Tbilisi State University Hospital, Georgia (Approval No. TSU-SURG-2023-011, dated 12 January 2023). The study was conducted in accordance with the Declaration of Helsinki (2013 revision) and followed the International Conference on Harmonisation–Good Clinical Practice (ICH-GCP) guidelines. All participants provided written informed consent prior to inclusion. Patient confidentiality and anonymity were maintained throughout data collection, analysis, and publication processes.

DATA AVAILABILITY STATEMENT

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, in accordance with institutional data-sharing policy and ethical regulations.

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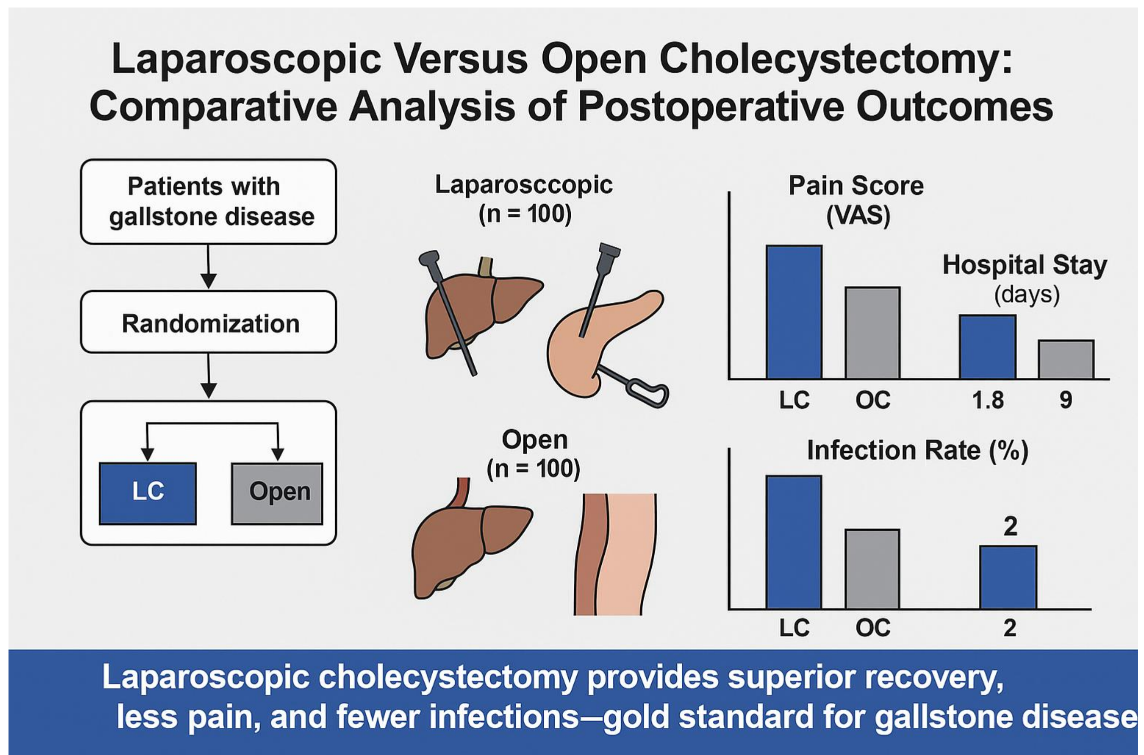
GRAPHICAL ABSTRACT



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