Section: General Surgery

Original Research Article

CLINICAL OUTCOMES OF DIFFICULT LAPAROSCOPIC CHOLECYSTECTOMY

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Received *: 10/05/2026*
Received in revised form *: 20/06/2026*
Accepted *: 03/07/2026*

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DOI: 10.70034/ijmedph.2026.3.456

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 2897-2904

ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is established globally as the definitive therapeutic modality for benign gallbladder disease. However, intraoperative dense fibrosis, architectural distortion, and severe inflammatory adhesions define 'Difficult Laparoscopic Cholecystectomy' (DLC), exposing patients to high conversion rates and hazardous injuries. This study prospectively analyzes clinical outcomes of difficult cholecystectomy stratified by the Randhawa clinico-radiological scoring index.

Materials and Methods: A prospective longitudinal clinical investigation was conducted over 18 months at a tertiary healthcare center in Northern India, monitoring 40 patients preoperatively classified with high technical risk. Clinico-demographic indices, radiological markers, intraoperative anatomical hurdles, bailout utilization rates, and 30-day post-surgical complications were meticulously logged and analyzed utilizing multivariable logistic regression and standard parametric/non-parametric testing.

Results: The study population had a mean age of 47.8 ±12.6 years and a female preeminence (62.5%). Severe operative difficulty was significantly linked with advanced age (53.4 ±11.2 years, p=0.018) and a higher BMI (p=0.029). Preoperative Randhawa scores achieved strong predictive accuracy, highly correlating with operating times (r=0.62, p<0.001). Independent multivariable risk factors for extreme technical complexity were gallbladder wall thickness >4 mm (Adjusted Odds Ratio [AOR] = 3.4, 95% CI: 1.1–10.5, p=0.03) and stone impaction at the neck (AOR = 2.9, 95% CI: 1.0–8.6, p=0.04). Seven cases (17.5%) required proactive bailout maneuvers—subtotal cholecystectomy (12.5%) or fundus-first dissection (5.0%)—which completely eliminated major bile duct injuries (0%). While early postoperative minor complications occurred in 30% of cases, 70% maintained entirely favorable profiles at 30 days.

Conclusion: Difficult laparoscopic cholecystectomy exhibits a predictable spectrum of technical complexity. Preoperative risk stratification utilizing the Randhawa scoring system effectively guides surgical planning, prompt execution of bailout techniques, and optimal resource allocation, successfully containing major morbidity.

Keywords: Difficult Laparoscopic, Cholecystectomy.

INTRODUCTION

Surgical excision of the gallbladder for gallstone disease has undergone a monumental paradigm shift over the past century, representing one of the greatest technological leaps in gastrointestinal surgery. Introduced in the late nineteenth century, open cholecystectomy became the foundational treatment for symptomatic cholelithiasis and its acute complications, such as cholecystitis, empyema, perforation, and gallstone pancreatitis.

Regardless of advances in anesthesia and perioperative care, open laparotomy carried inherent morbidity. Patients routinely suffered severe post-surgical incisional pain, compromised pulmonary mechanics leading to atelectasis or hypostatic pneumonia, wound infections, incisional hernias, and prolonged hospital stays often stretching over a week.

The revolutionary breakthrough occurred in 1987 with the successful introduction of laparoscopic cholecystectomy (LC). By integrating controlled pneumoperitoneum with fiberoptic optics, micro-cameras, and specialized long-shafted instrumentation, surgeons could visualize and resect the gallbladder through minute trocar incisions under high magnification. The advantages over open laparotomy were immediately clear: vastly minimized postoperative pain, reduced respiratory compromise, low wound morbidity, abbreviated hospital stays, and expedited return to regular work schedules. Within a decade, laparoscopic cholecystectomy eclipsed open cholecystectomy to become the unquestioned global gold standard for treating benign gallbladder conditions.

Despite these advances, everyday surgical experience demonstrates that a notable subset of cases presents significant technical challenges. Long-standing chronic inflammation, dense fibrotic scar tissue, architectural distortion, anatomical variants, and impacted gallstones often obscure tissue planes, predisposing the patient to vascular tears and dangerous bile duct injuries (BDI). Consequently, 'Difficult Laparoscopic Cholecystectomy' (DLC) has emerged as a distinct clinical and technical challenge that requires objective risk stratification and proactive management.

Gallstone disease represents a substantial healthcare burden worldwide. Prevalence varies by geographic region and genetic background, affecting 10% to 20% of adult populations in Western countries due to high-fat diets, sedentary lifestyles, and obesity. While historically lower across parts of Asia, urbanization and rapid nutritional transitions have led to a steady increase in biliary stone disease. Women are disproportionately affected, with an estimated lifetime risk of symptomatic cholelithiasis between 10% and 15%. Risk factors include obesity, multiparity, rapid weight loss, and insulin resistance. Although a high percentage remains asymptomatic, symptomatic disease often manifests as biliary colic or acute cholecystitis, empyema, or gallstone ileus. These inflammatory states increase intraoperative technical difficulties, extending operative duration and resource use.

To systematically anticipate and prepare for these technical challenges, multiple preoperative scoring algorithms have been introduced. The Randhawa difficulty scoring system integrates clinical parameters (history of previous attacks, localized tenderness, palpable masses) with objective radiological markers (gallbladder wall thickening, impacted neck stones, pericholecystic fluid). Accurate preoperative scoring allows the surgical team to anticipate potential difficulties, optimize theater scheduling, ensure the availability of experienced senior operating staff, and discuss the threshold for safe conversion or bailout approaches with patients.

MATERIALS AND METHODS

This prospective longitudinal observational study was conducted over an 18-month period in the Department of General Surgery at Teerthanker Mahaveer Medical College and Research Centre (TMMC & RC), Moradabad, Uttar Pradesh, India. The clinical investigation tracked patients preoperatively identified with risk factors for difficult laparoscopic cholecystectomy from initial presentation through surgery up to a 30-day postoperative endpoint. No experimental interventions or deviations from standardized institutional care paths were implemented.

Inclusion Criteria

- Adult individuals aged ≥18 years willing to provide written informed consent.
- Scheduled for elective or urgent laparoscopic cholecystectomy.
- Preoperatively classified with features indicating a difficult procedure based on the Randhawa difficulty index.

Exclusion Criteria

- Confirmed or strongly suspected gallbladder malignancy.
- Concomitant common bile duct (CBD) stones or Mirizzi syndrome requiring open common bile duct exploration or advanced endoscopic retrograde cholangiopancreatography (ERCP).
- Severe, uncompensated systemic comorbidities (e.g., severe COPD, unstable coronary artery disease, or decompensated liver cirrhosis) rendering the patient unfit for general anesthesia or pneumoperitoneum.

All included patients underwent a comprehensive clinical workup, including a detailed history, general physical check, assessment of body mass index (BMI), and laboratory investigations (complete blood count, liver function tests, serum electrolytes, and renal profile). High-resolution transabdominal ultrasound (USG) was performed to document key

anatomical features: gallbladder wall thickness, the presence of pericholecystic fluid collections, gallbladder contraction, and the position of large impacted gallstones. Preoperative risk was categorized using the validated Randhawa scoring system, which assigns weighted points to variables such as age, male sex, history of recurrent acute cholecystitis hospitalizations, BMI, palpable gallbladder, previous upper abdominal incisions, gallbladder wall thickness (>4 mm), pericholecystic fluid, and stone impaction at the neck.

The parameters tracked intraoperatively included total operating time (minutes), estimated intraoperative blood loss (ml), gallbladder perforation, or stones/bile spillage. Postoperatively, patients were monitored across three predefined phases: immediate early complications (0–48 hours) including pain visual analog scale (VAS) scores, nausea, vomiting, or surgical site infections; intermediate complications (48 hours to 7 days) monitoring drain output and early readmissions; and late complications (7 to 30 days) assessing port-site or intra-abdominal fluid collections via ultrasound follow-up at outpatient department appointments on postoperative days 2, 7, and 30.

The minimum necessary sample size was determined using the standardized estimation formula for descriptive and observational cohorts: $n = [Z^2 \times P \times (100 - P)] / E^2$. Using a 95% confidence interval ($Z = 1.96$), an estimated regional prevalence of high-difficulty cholecystectomy cases ($P = 11.6\%$), and an absolute margin of error ($E = 10\%$), the calculation yielded a minimum requirement of 40 patients, who were successfully recruited and followed.

Gathered clinical information was compiled into Microsoft Excel and analyzed using SPSS Version 21.0 (IBM Corp.). Continuous parametric values were reported as mean ± standard deviation (SD), and non-parametric indices or categorical metrics were expressed as percentages and absolute frequencies. Intergroup comparisons between mild/moderate and severe difficulty subsets were evaluated using the independent Student's t-test, Mann-Whitney U test, Chi-square (χ^2) analysis, or Fisher's exact test where appropriate. Correlation mapping between scoring indices and operative parameters was evaluated via Spearman's rank correlation coefficient (r). Independent preoperative predictors of high difficulty were identified using multivariable logistic regression analysis. All tests were two-tailed, with a p-value of <0.05 considered statistically significant.

RESULTS

The prospective study population of 40 patients undergoing difficult laparoscopic cholecystectomy had a mean age of 47.8 ± 12.6 years (range: 19–72 years). The cohort showed a female preeminence, with 25 females (62.5%) and 15 males (37.5%). Stratification based on intraoperative technical difficulty demonstrated that patients within the severe difficulty category were significantly older (mean: 53.4 ± 11.2 years) compared to the mild/moderate category (mean: 43.1 ± 12.1 years; independent t-test t=2.46, p=0.018), confirming that advanced age is associated with more challenging dissection. Body mass index (BMI) also proved to be a significant predictor of surgical difficulty: an obese status (BMI ≥30 kg/m²) was significantly more common in the severe difficulty group (χ^2=4.74, p=0.029). No statistically significant correlation was observed regarding sex distribution or residential background.

Table 1: Baseline demographic indices stratified by operative difficulty category

Parameter / Metric	Overall Cohort (n=40)	Mild/Moderate (n=22)	Severe Difficulty (n=18)	Test Statistic	p-value
Age, mean ± SD (years)	47.8 ± 12.6	43.1 ± 12.1	53.4 ± 11.2	t = 2.46	0.018*
Female Sex, n (%)	25 (62.5%)	12 (54.5%)	13 (72.2%)	χ^2 = 1.82	0.176
BMI, mean ± SD (kg/m²)	27.4 ± 3.1	26.6 ± 2.8	28.4 ± 3.2	χ^2 (cat) = 4.74	0.029*

The mean preoperative Randhawa score for the entire cohort was 7.1 ± 1.8 (range: 4–11). Based on predefined cutoffs, 22 patients (55.0%) were categorized with lower risk scores (4–7), while 18 patients (45.0%) presented with high risk scores (≥8). A highly significant difference in mean preoperative scoring was observed between the two intraoperative difficulty groups: patients with mild/moderate intraoperative difficulty had a mean score of 6.2 ± 1.3, whereas those in the severe difficulty group had a mean score of 8.2 ± 1.4 (t=5.02, p<0.001). Preoperative Randhawa categories correlated strongly with the actual intraoperative difficulty encountered (χ^2=12.46, p=0.002), and Spearman's rank correlation demonstrated a strong positive relationship (r=0.68, p<0.001).

Table 2: Randhawa difficulty score distribution and correlation metrics

Randhawa Scoring Parameter	Patient Count / Value	Statistical Test Value	p-value
Overall Mean Score (± SD)	7.1 ± 1.8	—	—
Score Category 4–7 (Difficult Risk)	22 (55.0%)	χ^2 = 12.46	0.002*

Score Category ≥8 (Very Difficult Risk)	18 (45.0%)	t = 5.02 (Means)	<0.001*
Spearman Correlation Coefficient (r)	0.68	Randhawa vs Difficulty	<0.001*

Transabdominal ultrasound identified specific radiological risk factors that correlated with technical difficulty. The mean gallbladder wall thickness for the entire cohort was 4.3 ± 0.9 mm. A thick gallbladder wall (>4 mm) was significantly associated with severe intraoperative difficulty (χ^2=6.21, p=0.045). Similarly, the presence of an impacted stone at the gallbladder neck or cystic duct (identified in 27.5% of cases) was significantly more common in the severe group (p=0.040). Pericholecystic fluid collections were noted in 22.5% of cases but did not reach statistical significance (p=0.12).

Table 3: Preoperative transabdominal ultrasound parameters and correlations

Ultrasonographic Finding	Incidence n (%) or Mean ± SD	Statistical Test Method	p-value
Gallbladder Wall Thickness (mm)	4.3 ± 0.9 mm	Spearman r = 0.38	0.014*
Wall Thickness >4 mm	18 (45.0%)	Chi-Square Test	0.045*
Impacted Neck/Duct Stones	11 (27.5%)	Fisher's Exact Test	0.040*
Pericholecystic Fluid Collection	9 (22.5%)	Chi-Square Test	0.120

The most frequent intraoperative technical challenge encountered was the presence of dense, thick adhesions, documented in 23 patients (57.5%). Adhesions were highly indicative of extreme surgical difficulty (χ^2, p=0.006) and correlated with an extended operative duration (r=0.42, p=0.008) and increased intraoperative blood loss. Distended gallbladders were noted in 47.5% of cases, and extensive omental wrapping was observed in 40.0%. Crucially, an inability to clearly visualize the anatomical boundaries of Calot's triangle occurred in 9 cases (22.5%) and was highly correlated with severe technical difficulty (p=0.002). Mean intraoperative blood loss for the entire cohort was 82.6 ± 31.4 ml, and blood loss was significantly higher in patients with dense adhesions (Mann-Whitney U, p=0.030).

Table 4. Intraoperative anatomical and pathological parameters

Intraoperative Anatomical Finding	Frequency n (%)	Statistical Test Measure	p-value
Dense / Thick Adhesions	23 (57.5%)	χ^2 Adhesions vs Difficulty	0.006*
Distended Gallbladder Body	19 (47.5%)	Chi-Square Test	0.040*
Extensive Omental Wrapping	16 (40.0%)	Chi-Square Test	0.030*
Calot's Triangle Non-Visualization	9 (22.5%)	Fisher's Exact Test	0.002*
Mean Estimated Blood Loss (ml)	82.6 ± 31.4 ml	Mann-Whitney U Test	0.030*

The mean operating time for the entire study population was 76.4 ± 18.7 minutes. When stratified by the final difficulty category, operative duration showed a significant, stepwise increase: mild cases averaged 58.7 ± 12.1 minutes, moderate cases averaged 72.8 ± 15.3 minutes, and severe cases required 91.1 ± 17.9 minutes. One-way ANOVA confirmed a highly significant difference between groups (p<0.001), and post-hoc analysis confirmed that severe cases took significantly longer than mild or moderate procedures (p<0.01). Preoperative Randhawa scores correlated strongly with total operating time (r=0.62, p<0.001).

Table 5: Operative duration metrics across difficulty tiers

Operative Difficulty Category	Mean Duration ± SD (minutes)	Statistical Test Used	p-value
Mild Risk Category	58.7 ± 12.1 min	One-Way ANOVA (F)	<0.001*
Moderate Risk Category	72.8 ± 15.3 min	Post-Hoc Tukey HSD	<0.010*
Severe Risk Category	91.1 ± 17.9 min	Spearman r (vs Randhawa)	<0.001*

In 7 cases (17.5%), safe anatomical landmark visualization could not be established, requiring a transition to alternative surgical strategies. Subtotal cholecystectomy was utilized in 5 cases (12.5%), while a fundus-first (top-down) approach was performed in 2 cases (5.0%). Decisions to execute a bailout procedure were significantly more frequent in the severe group, with 5 out of the 7 bailouts occurring in patients with Randhawa scores ≥8 (χ^2=10.2, p=0.001). The mean preoperative Randhawa score for patients requiring a bailout was 9.0 ± 0.9, significantly higher than those managed with standard cholecystectomy (mean: 6.7 ± 1.6; p<0.001). Operating times were also significantly

longer in the bailout group (104.8 ± 16.3 min vs. 71.2 ± 16.5 min; p<0.001). No procedures required conversion to open laparotomy.

Table 6: Summary of active bailout strategies deployed

Surgical Strategy / Technique	Incidence n (%)	Statistical Test Basis	p-value
Subtotal Cholecystectomy (Bailout)	5 (12.5%)	χ^2 Bailout vs Severity = 10.2	0.001*
Fundus-First Dissection (Bailout)	2 (5.0%)	t-Test (Randhawa Means)	<0.001*
Total Active Bailout Rate	7 (17.5%)	Operative Time Discrepancy	<0.001*

Most intraoperative and postoperative complications encountered were low-grade and manageable. The most frequent intraoperative event was accidental gallbladder perforation with bile spillage, noted in 12 patients (30.0%), and was significantly more common in severe cases (p=0.020). Gallstone spillage occurred in 12.5% of cases, minor mucosal tears in 10.0%, and controlled bleeding from the cystic artery bed in 5.0%. Crucially, no major injuries to the common bile duct or main hepatic structures occurred (0%). In the immediate postoperative phase (0–48 hours), transient nausea and vomiting affected 30.0% of patients, and post-surgical fever occurred in 10.0%. Early superficial surgical site infection (SSI) was noted in 3 cases (7.5%) and was significantly associated with intraoperative bile spillage (χ^2, p<0.05). The mean pain score on the Visual Analog Scale (VAS) was 4.9 ± 1.1, showing a positive correlation with estimated intraoperative blood loss (r=0.32, p=0.040). During the 48-hour to 7-day phase, 2 patients (5.0%) had persistent superficial wound infections, and 3 (7.5%) required drainage for serous output exceeding 7 days. Late complications (7–30 days) were rare, with 1 case (2.5%) of delayed port-site infection and 1 case (2.5%) of a small subhepatic collection managed conservatively. No cases of retained common bile duct stones or delayed biliary strictures occurred.

Table 7: Distribution of surgical complications and adverse events

Postoperative Phase & Complication	Overall Cohort n (%)	Statistical Comparative Basis	p-value
Bile Spillage (Intraoperative)	12 (30.0%)	χ^2 Spillage vs Severity	0.020*
Nausea & Vomiting (0–48 hours)	12 (30.0%)	Conservative Ward Management	—
Early Superficial SSI (0–48 hours)	3 (7.5%)	χ^2 SSI vs Intraoperative Spillage	<0.050*
Persistent Serous Drain Output >7d	3 (7.5%)	Gradual Outpatient Removal	0.070
Late Subhepatic Fluid Collection	1 (2.5%)	Ultrasonic Tracking / Resolution	0.280

The mean postoperative length of hospital stay (LOS) for the entire cohort was 3.4 ± 1.2 days. Patients in the severe difficulty category required a significantly longer hospitalization (mean: 4.6 ± 1.3 days) compared to the mild/moderate category (mean: 2.9 ± 0.9 days; t=4.12, p=0.001). A total of 10 patients (25.0%) required hospital stays exceeding 4 days, which was associated with long operative durations (t=3.01, p=0.004) and increased intraoperative blood loss (p=0.030). The 30-day readmission rate was 5.0% (2 patients), and 1 patient (2.5%) required radiologic drainage for a localized subhepatic collection. No patient required surgical reoperation.

Table 8: Summary of healthcare resource indicators

Resource Utilization Parameter	Value Summarized	Statistical Evaluation Value	p-value
Mean Postoperative Length of Stay (LOS)	3.4 ± 1.2 days	t = 4.12 (Severe vs Mild Group)	<0.001*
Extended Hospitalization Stay >4 Days	10 (25.0%)	Associated with Long Surgery Time	0.004*
Unplanned 30-Day Hospital Readmission	2 (5.0%)	Subhepatic Focus / Wound Care	0.170
Invasive Secondary Reintervention Rate	1 (2.5%)	Percutaneous Ultrasound Drainage	—

A multivariable logistic regression model was constructed to determine independent preoperative predictors of high technical difficulty (defined as a Randhawa score ≥8). The model demonstrated that independent predictors of high surgical complexity were a gallbladder wall thickness >4 mm (Adjusted Odds Ratio [AOR] = 3.4, 95% CI: 1.1–10.5, p=0.030) and the presence of an impacted stone at the gallbladder neck or cystic duct junction (AOR = 2.9, 95% CI: 1.0–8.6, p=0.040). Advanced age (≥50

years) and a high body mass index (BMI ≥30 kg/m²) showed elevated odds ratios but did not achieve statistical significance after adjustment, confirming that radiological findings are stronger predictors of technical challenge than demographic factors in this cohort. The final model achieved a classification accuracy of 78% and a good calibration check (Hosmer-Lemeshow test p>0.1).

Table 9: Multivariable logistic regression analysis for high surgical difficulty

Preoperative Predictive Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-value
Gallbladder Wall Thickness >4 mm	3.4	1.1 – 10.5	0.030*
Impacted Neck / Cystic Duct Stone	2.9	1.0 – 8.6	0.040*
Advanced Age Profile ≥50 Years	1.8	0.8 – 4.2	0.120
Obese Status (BMI ≥30 kg/m²)	1.9	0.9 – 4.4	0.100

Overall clinical outcomes at the 30-day endpoint were integrated across intraoperative findings, hospital course, and complication metrics. Recovery was categorized as 'Favorable' in 28 patients (70.0%), characterized by an uneventful post-surgical course without major early or late complications. The remaining 12 patients (30.0%) had a 'Complicated' outcome due to low-grade morbidity, such as minor superficial wound infections, transient bile leaks, localized fluid collections, or prolonged serous drainage. No mortalities occurred.

Table 10: Integration of overall 30-day clinical profiles

Final Clinical Outcome Category	Patient Count (n)	Percentage Share (%)
Favorable Clinical Outcome Status	28	70.0%
Complicated Clinical Outcome Status	12	30.0%
Total Analytical Cohort	40	100.0%

DISCUSSION

This prospective clinical investigation provides a comprehensive evaluation of clinical outcomes in difficult laparoscopic cholecystectomy by systematically correlating preoperative risk assessments with objective intraoperative metrics, healthcare resource utilization, and multi-phase postoperative recovery tracking. While previous studies have primarily evaluated preoperative predictors or intraoperative conversion rates independently, this study links preoperative risk categories with specific, quantifiable postoperative outcomes across a 30-day period, providing an integrated analysis of surgical safety in difficult cases.

A major finding in this study was the clear, step-wise increase in operative duration corresponding to higher risk categories, with severe cases requiring a mean operating time of 91.1 ± 17.9 minutes. This finding is consistent with the results reported by Khalid et al., who noted that difficult laparoscopic cholecystectomies require significantly longer operative times due to the need for meticulous adhesiolysis and cautious anatomical dissection. This study expands on that observation by demonstrating that operative duration is a key surrogate marker for post-surgical recovery, as prolonged procedures correlated with an increase in minor postoperative symptoms, including persistent nausea, longer drain requirements, and an extended hospital stay.

Intraoperative complications encountered in this cohort were predominantly low-grade and manageable, with gallbladder perforation and bile spillage being the most common events (30.0%). These events occurred significantly more frequently in the severe difficulty group (p=0.020), which is consistent with findings by Brian et al., who attributed higher rates of spillage and minor tissue injury to friable gallbladder walls and extensive inflammation. Crucially, despite these technical challenges, no major injuries to the common bile duct or main hepatic structures occurred (0%).

The utilization of bailout strategies as protective maneuvers was an important modifier of clinical outcomes in this study. Active bailout techniques were deployed in 17.5% of cases, primarily subtotal cholecystectomy, and were highly concentrated among patients presenting with severe intraoperative difficulty and high preoperative Randhawa scores (p=0.001).

Early postoperative complications were largely mild and self-limiting, with nausea and vomiting affecting 30.0% of patients and early superficial wound infections occurring in 7.5%. The significant association observed between intraoperative bile spillage and subsequent superficial surgical site infection (p<0.05) highlights the direct link between intraoperative events and immediate post-surgical wound morbidity, underscoring the importance of meticulous irrigation and the use of specimen extraction bags. Furthermore, the correlation between intraoperative blood loss and early pain scores on the Visual Analog Scale (VAS) (p=0.040) emphasizes the impact of surgical tissue trauma on immediate patient-reported recovery metrics.

Intermediate (48 hours to 7 days) and late (7 to 30 days) complications remained low, with isolated cases of persistent wound infections or localized subhepatic fluid collections that were successfully managed conservatively. The statistically significant association between a high preoperative Randhawa score and unplanned readmission (p=0.042) demonstrates that preoperative risk assessment tools have predictive value that extends beyond the operating room into the post-discharge recovery phase. This aligns with observations by Gupta et al., who noted that structured scoring systems can help anticipate hospital resource needs and post-operative recovery courses.

The final clinical outcome summary provides an integrated measure of surgical success: 70.0% of patients achieved an entirely favorable, uneventful recovery, while 30.0% experienced minor, easily manageable complications. Major adverse events were rare, confirming that difficult laparoscopic cholecystectomy can be safely performed without compromising overall patient safety. These findings support the safety-first approach to cholecystectomy, which prioritizes strict adherence to anatomical safety margins and the timely use of alternative strategies over procedural completion at all costs.

CONCLUSION

This prospective institutional study demonstrates that difficult laparoscopic cholecystectomy represents a predictable spectrum of technical complexity that is associated with an increased operative duration and minor postoperative morbidity but not with an increase in major complications. Preoperative risk stratification utilizing the Randhawa scoring system demonstrates high predictive accuracy, correlating with total operating time and post-surgical recovery patterns. Gallbladder wall thickness >4 mm and stone impaction at the neck are strong independent radiological predictors of severe technical difficulty. Based on these findings, we recommend the routine clinical implementation of standardized preoperative scoring models to improve surgical planning and optimization. When severe inflammation or dense fibrosis prevents clear visualization of Calot's triangle, surgeons should have a low threshold for executing safe bailout strategies, such as subtotal cholecystectomy or a fundus-first approach. These techniques should be integrated into surgical training curricula as proactive, safety-driven choices that protect the biliary tract and optimize patient outcomes in challenging cases.

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