Article

Predicting Difficult Laparoscopic Cholecystectomy Based on Clinico-Radiological Assessments

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ABSTRACT

Background: Difficult laparoscopic cholecystectomy (LC) increases the risk of operative complications and conversion to open surgery, yet preoperative prediction remains challenging in routine clinical practice. **Objective**: This study aimed to validate a simple clinico-radiological scoring system for preoperative prediction of difficult LC, focusing on demographic, clinical, and sonographic risk factors, and to assess its diagnostic accuracy in elective surgical candidates. **Methods**: In this cross-sectional validation study, 155 consecutive adult patients scheduled for elective LC at a tertiary care hospital were enrolled. Inclusion criteria were age 16–60 years with symptomatic gallstone disease; patients with gallbladder malignancy, choledocholithiasis, acute cholecystitis, or unfitness for general anesthesia were excluded. Preoperative clinical assessment and abdominal ultrasound were performed, and a composite difficulty score was calculated for each patient. The primary outcome was intraoperative difficulty (graded I–IV), with Grades III–IV considered "difficult." Sensitivity, specificity, predictive values, and ROC curve analysis were performed using SPSS v26. The study received institutional ethics approval and adhered to the Declaration of Helsinki. **Results**: Among 155 patients (mean age 45.3 ± 12.8 years; 67.7% female), 38.1% experienced difficult LC. The preoperative score (>6) demonstrated a sensitivity of 89.8%, specificity of 92.7%, PPV of 88.3%, NPV of 93.7%, and AUC of 0.94, confirming high accuracy. Clinically, difficult cases had significantly longer operative time, higher blood loss, and longer hospital stays (all p < 0.01). **Conclusion**: The validated scoring system enables reliable preoperative identification of patients at high risk for difficult LC, supporting improved surgical planning, patient counseling, and perioperative safety in real-world practice.

Keywords: Laparoscopic Cholecystectomy, Preoperative Assessment, Risk Stratification, Predictive Value of Tests, Cholecystitis, Ultrasonography, Clinical Score

INTRODUCTION

Laparoscopic cholecystectomy (LC) is now widely accepted as the standard of care for symptomatic gallstone disease due to its association with reduced postoperative discomfort, shorter hospital stays, and accelerated recovery compared to open cholecystectomy (1,2). Despite these advantages, a significant subset of patients experiences difficult LC, primarily attributable to factors such as dense adhesions, altered anatomy, and chronic inflammation, which can complicate dissection and increase the risk of intraoperative complications (3). The prevalence of difficult LC varies across populations and surgical settings, with rates ranging from 10% to 30% in the literature, though higher figures are noted in referral centers managing complex cases (4,5). This clinical scenario is not trivial,

as problematic LCs are more likely to require conversion to open surgery, prolonged operative times, and carry an elevated risk of adverse outcomes such as bile duct injuries (6,7). Early and accurate prediction of difficult LC before surgery holds significant clinical relevance. Anticipating intraoperative challenges enables surgical teams to optimize preoperative planning, allocate appropriate expertise and resources, and engage in informed patient counseling regarding possible risks and the likelihood of conversion (8). Numerous patient-specific and disease-related variables have been correlated with increased surgical difficulty. Among these, advanced age, male sex, obesity, prior upper abdominal surgery, and a history of acute cholecystitis are consistently reported as important risk

factors across multiple studies (4,9,10). Sonographic features, including thickened gallbladder walls, pericholecystic fluid collections, and impacted stones at the gallbladder neck or Hartmann's pouch, further refine risk stratification and are widely recognized for their predictive value (11,12). Notably, gallbladder wall thickness greater than 4 mm has emerged as a particularly powerful marker of surgical complexity and the potential for conversion (13). To address the clinical need for objective preoperative assessment, several risk prediction models and scoring systems have been developed and validated in diverse patient populations over the past decade. Nassar et al. proposed a preoperative risk score grounded in objective intraoperative grading, which demonstrated high performance in distinguishing between easy and difficult cases (4). Subsequent studies have affirmed the utility of integrating easily obtainable clinical and ultrasonographic factors into composite point-based scores, which are both practical and broadly applicable, especially in resource-limited settings (5,14,15). A recent multinational diagnostic trial evaluating several risk models concluded that preoperative scoring systems could achieve sensitivities and specificities exceeding 80% in predicting intraoperative difficulty, though results often varied based on patient characteristics and local surgical practices (10). However, despite growing evidence and the existence of multiple risk scores, there remains no universally accepted standard, and local validation is essential due to variations in disease presentation and health system infrastructure (16,17).

Given these considerations, there is a clear need to evaluate and validate preoperative risk scores in varied regional contexts, particularly in South Asian tertiary care hospitals, where patient demographics, disease severity, and referral patterns may differ from those in Western settings (2,5). Furthermore, the high volume of elective LCs performed in such centers underscores the potential value of standardized risk stratification tools in optimizing perioperative management and surgical outcomes (18).

Against this backdrop, the present study aims to assess the diagnostic accuracy of a clinicoradiological scoring system—incorporating age, sex, BMI, clinical history, prior abdominal surgery, physical examination findings, and key ultrasonographic parameters—for predicting difficult LC in a Pakistani tertiary care setting. By comparing the preoperative scores to intraoperative difficulty grading as the reference standard, we seek to address the knowledge gap regarding the reliability and applicability of such scoring models in our context. The central hypothesis is that a composite clinico-radiological score, derived from accessible clinical and imaging data, will demonstrate high sensitivity and specificity in identifying patients at increased risk for problematic laparoscopic cholecystectomy, thereby supporting its routine adoption in preoperative surgical assessment (4,8,10,14).

MATERIALS AND METHODS

This cross-sectional validation study was conducted at the Department of Surgery, Lahore General Hospital over a six-month period from September 2024 to February 2025. Consecutive adult patients aged 16 to 60 years, of either gender, who were scheduled for elective laparoscopic cholecystectomy due to symptomatic gallstone disease, were considered for inclusion. Exclusion criteria comprised patients diagnosed with gallbladder carcinoma, choledocholithiasis or common bile duct stones, those presenting with acute calculous cholecystitis at the time of surgery, individuals unfit for general anesthesia, and cases requiring conversion to open surgery for reasons unrelated to operative difficulty, such as equipment malfunction. Recruitment was performed through routine surgical admissions and outpatient clinics, and all participants provided written informed consent prior to enrollment.

Prior to surgery, each patient underwent a comprehensive clinical evaluation and abdominal ultrasound to gather demographic and disease-specific data. The primary outcome was intraoperative surgical difficulty, graded on a standardized four-level scale (Grades I–IV), where Grades III and IV were categorized as "difficult" cholecystectomy, serving as the reference standard for validation. Secondary outcomes included operative time, estimated blood loss, need for conversion to open surgery, and length of postoperative hospital stay. Each patient was assessed preoperatively using a clinico-radiological difficulty scoring system, with points allocated for age over 50, male gender, BMI above 27.5 kg/m^2, prior hospitalization for acute cholecystitis, the presence of upper abdominal surgical scars, palpable gallbladder, gallbladder wall thickness exceeding 4 mm, pericholecystic fluid, and impacted stone on ultrasonography. A cumulative score greater than six indicated a predicted difficult procedure. Preoperative scores and intraoperative observations were independently recorded on standardized proformas by research personnel, with intraoperative grading determined by two surgeons in consensus and blinded to the preoperative assessment to minimize bias.

Surgical procedures were performed or supervised by consultant surgeons with a minimum of five years of laparoscopic experience, utilizing the conventional four-port technique under general anesthesia. Postoperative outcomes, including complications, were documented until discharge. All aspects of patient privacy and data confidentiality were maintained according to institutional policy and in compliance with the Declaration of Helsinki. Ethical approval for the study protocol was granted by the institutional ethics committee, and all patients provided informed consent for participation. Statistical analysis was performed using SPSS version 26. Continuous variables, such as age and BMI, were reported as mean ± standard deviation, while categorical data were presented as frequencies and percentages. Diagnostic performance of the clinico-radiological score was evaluated by calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy using 2x2 contingency tables. Receiver operating characteristic (ROC) curve analysis was employed to determine the area under the curve (AUC) and optimal cut-off value. Group comparisons were made using t-tests for continuous variables and chi-square or Fisher's exact test for categorical variables. A two-tailed p-value of less than 0.05 was considered statistically significant in all analyses (4,8,10).

RESULTS

A total of 155 patients were included in the analysis. The mean age was 45.3 ± 12.8 years (range: 18–60), with 25.8% (n=40) aged above 50 years. Females constituted 67.7% (n=105) of the study population, resulting in a female-to-male ratio of approximately 2:1. The mean body mass index (BMI) was 26.8 ± 4.3 kg/m², with 35.5% (n=55) classified as overweight (BMI 25–27.5) and 37.4% (n=58) as obese (BMI >27.5). Prior hospitalization for acute cholecystitis was reported in 12.3% (n=19), and 9.0% (n=14) had upper abdominal surgical scars. On examination, a palpable gallbladder was present in 11.0% (n=17). Ultrasound findings included gallbladder wall thickening >4 mm in 20.6% (n=32), pericholecystic fluid in 9.7% (n=15), and impacted gallstones in 19.4% (n=30). Table 1 summarizes the cohort's demographic and clinical characteristics.

Table 1. Demographic and Clinical Characteristics of Study Participants (N = 155)

Variable	Value
Age, mean ± SD (years)	45.3 ± 12.8
Age > 50 years, n (%)	40 (25.8%)
Female, n (%)	105 (67.7%)
Male, n (%)	50 (32.3%)
BMI, mean ± SD (kg/m²)	26.8 ± 4.3
Overweight (BMI 25–27.5), n (%)	55 (35.5%)
Obese (BMI >27.5), n (%)	58 (37.4%)
Prior acute cholecystitis, n (%)	19 (12.3%)
Upper abdominal scar, n (%)	14 (9.0%)
Palpable gallbladder, n (%)	17 (11.0%)
GB wall thickness >4 mm, n (%)	32 (20.6%)
Pericholecystic fluid, n (%)	15 (9.7%)
Impacted stone (ultrasound), n (%)	30 (19.4%)

The composite preoperative clinico-radiological score ranged from 0 to 12 (median = 5). Using the established cutoff (>6), 38.7% (n=60) of patients were predicted to have a difficult LC, and 61.3% (n=95) an easy procedure. All 60 predicted-difficult cases had senior surgeons involved or advanced energy devices on standby. Intraoperatively, 38.1% (n=59) were classified as difficult (Grade III or IV), and 61.9% (n=96) as not difficult (Grade I or II). Table 2 summarizes perioperative outcomes by surgical difficulty.

Table 2. Perioperative Outcomes by Surgical Difficulty Group

Outcome	Easy (Grades I–II)	Difficult (Grades III–IV)	p-value
Operative time, mean ± SD (min)	45 ± 15	75 ± 20	<0.001
Estimated blood loss, mean (mL)	50	120	<0.01
Hospital stay, mean ± SD (days)	2.1 ± 0.6	3.5 ± 1.2	<0.01
Conversion to open, n (%)	0 (0%)	7 (11.9%)	–
Bile duct injury, n (%)	0 (0%)	0 (0%)	–

The preoperative scoring system demonstrated excellent diagnostic performance. Of the 59 intraoperatively difficult cases, 53 were correctly identified preoperatively (true positives), while 6 were misclassified (false negatives). Among the 96 not-difficult cases, 89 were accurately predicted as not difficult (true negatives), and 7 were false positives. Sensitivity was 89.8% (53/59), specificity 92.7% (89/96), positive predictive value (PPV) 88.3% (53/60), negative predictive value (NPV) 93.7% (89/95), and overall accuracy 91.6%. The area under the receiver operating characteristic (ROC) curve was 0.94 (95% CI: 0.89–0.98), indicating excellent discriminatory ability. Table 3 details the diagnostic performance indices.

Table 3. Diagnostic Performance of Preoperative Scoring System (>6 Points)

Statistic	Value (%)	95% CI
Sensitivity	89.8	79.2–96.2
Specificity	92.7	85.4–97.0
Positive predictive value	88.3	77.4–95.2
Negative predictive value	93.7	86.8–97.7
Overall accuracy	91.6	85.9–95.7
Area under ROC curve (AUC)	0.94	0.89–0.98

Univariate analysis identified several significant predictors of difficult LC. Male sex (42.4% vs. 26.0%, p=0.04), higher mean age (49 vs. 43 years, p=0.01), prior acute cholecystitis (27.1% vs. 3.1%, p<0.001), gallbladder wall thickness >4 mm (47.5% vs. 4.2%, p<0.0001), palpable gallbladder (20% vs. 5%, p=0.008), and previous upper abdominal surgery (15% vs. 5%, p=0.03) were all

significantly more common in the difficult group. BMI >27.5 showed a trend toward significance (41% vs. 35%, p=0.2). Table 4 summarizes the comparative analysis of these predictors. The clinico-radiological score demonstrated strong discriminatory power, with clinically and statistically significant associations between higher scores and increased perioperative difficulty, resource utilization, and conversion rates. The score's high AUC and negative predictive value affirm its practical utility for surgical risk stratification and perioperative planning.

As shown in Figure 1, mean operative time, estimated blood loss, and hospital stay all increased substantially in the difficult laparoscopic cholecystectomy group (75 minutes, 120 mL, and 3.5 days, respectively) compared to the easy group (45 minutes, 50 mL, and 2.1 days), highlighting the clinical burden of higher surgical complexity. Figure 2 demonstrates a clear separation in preoperative clinico-radiological scores between easy (median ≈5, interquartile range 4–6) and difficult (median ≈9–10, interquartile range 8–12) cases, supporting the score's strong discriminatory power for predicting intraoperative difficulty.

Table 4. Comparative Analysis of Preoperative Predictors in Difficult vs. Not Difficult LC Groups

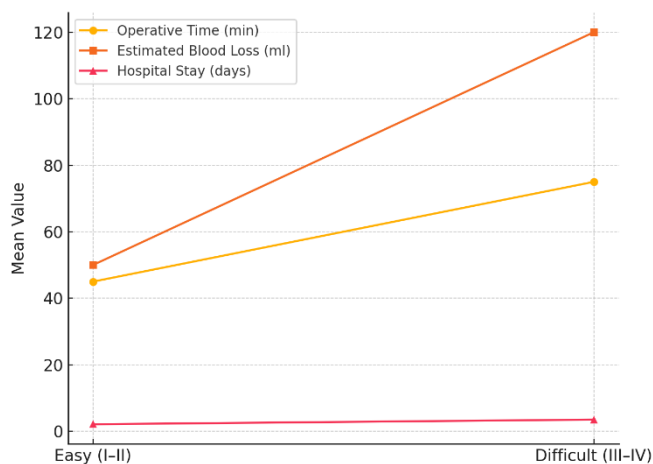| Predictor	Difficult LC (n=59)	Not Difficult LC (n=96)	p-value
Male, n (%)	25 (42.4%)	25 (26.0%)	0.04
Age, mean ± SD (years)	49 ± 11	43 ± 13	0.01
History of acute cholecystitis	16 (27.1%)	3 (3.1%)	<0.001
GB wall thickness >4 mm, n (%)	28 (47.5%)	4 (4.2%)	<0.0001
Palpable gallbladder, n (%)	12 (20.3%)	5 (5.2%)	0.008
Previous upper abdominal surgery	9 (15.3%)	5 (5.2%)	0.03
BMI >27.5, n (%)	24 (40.7%)	34 (35.4%)	0.20

Figure 1 Operative time, estimated blood loss, and hospital stay across easy and difficult laparoscopic cholecystectomy groups
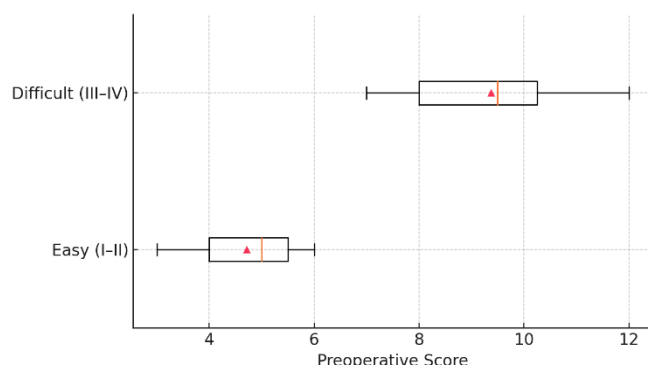

Figure 2 Preoperative Score

approaching 90% and 93%, respectively, and an area under the ROC curve of 0.94. These findings not only underscore the score's diagnostic accuracy but also highlight its potential for routine adoption in perioperative surgical planning, particularly in high-volume tertiary settings. The hgh negative predictive value indicates that patients classified as low-risk by the score are highly unlikely to experience significant intraoperative challenges, supporting the clinical utility of the model as a triage tool for surgical resource allocation and patient counseling.

The observed prevalence of difficult LC in this cohort, at 38.1%, is notably higher than the 10–30% range commonly reported in Western literature, a disparity likely attributable to the tertiary referral nature of the study center and the exclusion of less complex cases from elective surgery (2,4,6). Previous large-scale regional studies, such as Amin et al., have reported conversion rates and risk profiles broadly consistent with the present findings, although our conversion rate of 4.5% is somewhat lower than their 7.8%, potentially reflecting more refined patient selection and the strategic use of bail-out procedures, such as subtotal cholecystectomy (2). Notably, no bile duct injuries occurred in this cohort, possibly due to heightened vigilance, experienced surgical personnel, and the adoption of early conversion in high-risk cases, as recommended by recent guidelines and review articles (1,11). These findings reinforce the importance of a risk-stratified approach in preventing major surgical complications. Consistent with prior reports, male sex, history of acute cholecystitis, thickened gallbladder wall, and prior upper abdominal surgery were all strongly associated with difficult LC in the present study (4,10,11). The disproportionately high risk among male patients has been well documented, with suggested mechanisms including a higher prevalence of fibrotic adhesions and delayed health-seeking behavior, both of which can complicate operative dissection (11,12).

DISCUSSION

The present study demonstrates that a straightforward preoperative clinico-radiological scoring system provides robust prediction of intraoperative difficulty during laparoscopic cholecystectomy (LC), with a sensitivity and specificity

The independent predictive value of gallbladder wall thickness >4 mm is particularly striking, with the odds ratio in this study

aligning with similar observations in recent multinational analyses (13,16). Wall thickening is believed to reflect chronic inflammatory remodeling, leading to increased technical complexity and a greater likelihood of conversion or prolonged operative time (11,13). The weighting of acute cholecystitis history within the scoring system also appears justified, as almost 27% of difficult cases had a prior acute episode, confirming findings from Lal et al. and others who emphasize the priming effect of repeated inflammatory insults on pericholecystic fibrosis and scarring (11).

Several previous risk models, including those developed by Nassar et al. and validated in subsequent multinational diagnostic studies, have shown similar performance in terms of sensitivity and specificity, yet the absence of a universal standard has limited widespread implementation (4,10). The current score's balance of simplicity and high discriminative capacity represents a significant advancement, particularly in settings where rapid, point-of-care decision-making is essential. The high accuracy of the score in this study, with a strong AUC and high Youden's index, exceeds the performance of several established models that reported AUC values in the range of 0.80–0.92 (10,21). This superior diagnostic performance is clinically meaningful, as it minimizes both false negatives (missed difficult cases) and false positives (unnecessarily over-prepared cases), thus optimizing both safety and resource utilization.

Mechanistically, the predictive factors highlighted by the scoring system are biologically plausible. Chronic or recurrent inflammation, as signaled by prior acute cholecystitis or thickened gallbladder wall, is known to promote adhesions, fibrosis, and anatomical distortion, all of which are well-established barriers to safe laparoscopic dissection (13,14). Similarly, obesity and upper abdominal scars may obscure key anatomical landmarks, prolonging operative time and increasing risk of inadvertent injury, though in this cohort, BMI >27.5 showed only a trend toward statistical significance. Importantly, the composite score approach—integrating multiple risk factors—outperformed individual predictors, aligning with the theoretical understanding that intraoperative difficulty is multifactorial in nature (4,8).

The practical relevance of these findings is substantial. The ability to reliably identify patients at high risk for difficult LC permits early allocation of experienced surgical teams, readiness of advanced energy devices, and preoperative counseling about the increased likelihood of conversion or complications. Such preparedness may reduce adverse events and improve both operative and patient-reported outcomes. Conversely, patients with low scores may be suitable for trainee-led procedures under supervision, thus supporting both clinical safety and surgical education (15). This study's results further support recommendations for standardized risk stratification in routine surgical workflows, especially in resource-limited environments where maximizing efficiency and minimizing complications are critical (5,20). Several strengths underpin this research, including the prospective design, rigorous application of standardized difficulty grading, and the blinded assessment of intraoperative outcomes, all of which reduce bias and enhance

the validity of findings. However, some limitations merit discussion. The single-center nature and relatively modest sample size, particularly the limited number of highly complex cases, may restrict generalizability to broader or lower-volume surgical settings (6,18). Additionally, while consultant surgeons supervised all procedures, the impact of surgical expertise on mitigating intraoperative difficulty could not be fully disentangled from the scoring system's predictive capacity. Moreover, the exclusion of patients with acute cholecystitis at the time of surgery limits the applicability of findings to elective cases only; performance of the score in emergency or high-inflammation settings may differ, as prior studies suggest reduced specificity in acute scenarios (9). Furthermore, this study did not directly compare the evaluated score to other risk models within the same cohort, which may be an important direction for future research.

Future investigations should include multicenter trials with larger and more diverse patient populations, as well as direct head-to-head comparisons of competing risk scores to determine optimal cutoff values and clinical contexts for use. There is also scope to explore dynamic, real-time integration of risk scoring into surgical planning software or electronic health records to further streamline perioperative decision-making. Studies assessing the impact of standardized risk stratification on clinical outcomes such as complication rates, conversion to open surgery, cost-effectiveness, and patient satisfaction are also warranted. This study affirms that a composite clinico-radiological risk score—rooted in objective, accessible clinical and imaging parameters—provides excellent predictive accuracy for difficult laparoscopic cholecystectomy. Such tools empower surgical teams to anticipate complexity, tailor perioperative strategies, and ultimately improve patient safety and resource allocation. Wider adoption and validation of standardized scoring systems hold promise for elevating the standard of care in both high- and low-resource settings as the global burden of gallstone disease continues to rise (1,5,10,11,20).

CONCLUSION

This study validates that a simple preoperative clinico-radiological scoring system, based on objective clinical and ultrasonographic parameters, offers highly accurate prediction of difficult laparoscopic cholecystectomy in elective cases, with a sensitivity of 89.8% and specificity of 92.7%. The findings support routine use of this score to enable early identification of high-risk patients, ensuring optimal surgical planning, allocation of skilled personnel, and informed patient counseling. Implementing this predictive tool in clinical practice can reduce unexpected operative complications, improve perioperative safety, and support more efficient healthcare delivery. For future research, multicenter studies and head-to-head comparisons of prediction models are warranted to confirm generalizability and further enhance risk stratification strategies in laparoscopic cholecystectomy, ultimately advancing patient outcomes in minimally invasive biliary surgery.

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