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Pre-operative Prediction of Difficult Laparoscopic Cholecystectomy

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is the standard care for gallbladder stone disease. It promotes quicker recovery compared to other open surgical processes. But different stages become difficult to maintain results for surgical intervention. For an efficient plan of surgical procedures, some necessary predictors enable accurate prediction, including patient factors, imaging technique features, and laboratory markers. These are also used in risk management and optimization of perioperative outcomes.

Methods: This prospective study, conducted at SUM Hospital Campus-II, Bhubaneswar, India, involved 110 patients undergoing elective laparoscopic cholecystectomy (LC) over one year. The study focused on predicting difficult LC based on preoperative scores, which considered factors like age, sex, BMI, hospitalization status, surgical history, and sonographic findings. A scoring system was developed, with scores ranging from 0 to 15, indicating the complexity of the surgery. Data analysis was performed using SPSS, with multivariate logistic regression used to assess risk factors for predicting difficult surgeries.

Results: This research involving 110 patients who underwent laparoscopic cholecystectomy revealed that a preoperative risk score was quite effective in analysing the difficulty level of the surgery. Most cases (70%) fell into the intermediate risk category, with scores ranging from 6 to 10. Through multivariate analysis, it was found that prior hospitalisation, a palpable gallbladder (OR 4.25, p=0.01), and sonographic wall thickening (OR 9.23, p=0.032) were significant independent predictors of a challenging surgery. Additionally, a ROC curve helped to indicate the cut-off score that demonstrated high sensitivity (0.77) and specificity (0.74) for forecasting surgical complexity.

Conclusion: The strongest predictors of poor perioperative outcomes are a history of past hospitalizations, thickened gallbladder wall, palpable gallbladder, and a BMI over 27.5 kg/m².

Key-words: Laparoscopic cholecystectomy, Preoperative prediction, Scoring system, Difficult surgery, Risk factors

INTRODUCTION

Laparoscopic cholecystectomy is the standard of care for symptomatic cholelithiasis and most presentations of acute cholecystitis, offering shorter hospital stay, reduced postoperative pain, and quicker return to activity compared with open surgery. Despite its routine nature, a non-trivial proportion of LCs are “difficult.” These cases are characterized by prolonged operative time, dense adhesions, or severe inflammation that obscures Calot’s triangle.

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They carry a higher risk of bile duct injury and may require subtotal cholecystectomy or conversion to open surgery. Anticipating these challenges preoperatively is clinically valuable, as it informs consent, theatre scheduling, surgeon allocation, the need for senior supervision, readiness for bail-out strategies, and perioperative resource planning [1].

Multiple preoperative clinical and imaging variables have been linked to difficult LC or conversion. Consistently reported patient factors include older age, male sex, obesity, diabetes, prior upper abdominal surgery, recurrent biliary colic or prior acute cholecystitis, and longer symptom duration before surgery. On ultrasound and cross-sectional imaging, a contracted or distended tense gallbladder, impacted cystic duct/neck stone, increased gallbladder wall thickness, pericholecystic fluid, and a dilated common bile duct are associated with

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operative complexity. Elevated inflammatory markers, particularly high C-reactive protein and leukocytosis, also correlate with technical difficulty and an increased risk of conversion. Systematic reviews and contemporary cohort analyses reaffirm many of these associations and quantify their effect sizes with pooled estimates [1,2].

To translate such risk factors into practical tools, several preoperative scoring systems have been proposed. The influential score by Randhawa and Pujahari integrates elements such as body mass index, prior admissions, palpable gallbladder, and ultrasound features (e.g., wall thickening, impacted stone) to stratify patients into easy, difficult, and very difficult categories, achieving useful predictive performance in its original cohort and subsequent adaptations. More recent single- and multicentre validations from diverse settings continue to report good discrimination (e.g., area under the ROC ≈0.90 in some series) for composite preoperative scores. However, external validation has been heterogeneous and often limited by sample size and spectrum bias [3,4].

Disease-severity frameworks for acute cholecystitis, particularly the Tokyo Guidelines, are also relevant to prediction. TG18 classifies severity (Grades I–III) and recommends early LC in selected patients, while acknowledging that Grade III disease may necessitate triage to advanced centres or delayed methods, depending on physiology and local expertise. TG-based severity correlates with intraoperative difficulty and postoperative results; emerging analyses leveraging TG18 "difficulty scores" search for to bridge preoperative assessment with the expected surgical task [4,5].

Despite progress, key gaps remain. First, many scores are built from single-centre data with limited generalizability, and their components differ extensively (clinical vs laboratory vs imaging features). Second, the beginnings (e.g., wall thickness cut-offs, CRP levels, timing from symptom onset) differ across studies, which confounds adoption. Third, models often treat "difficulty" as a composite outcome, combining prolonged operative time, conversion, and bail-out procedures. While pragmatic, this approach can obscure which preoperative signals specifically predict which intraoperative problem (e.g., dense adhesions versus a hostile Calot's triangle). Finally, few tools incorporate modern data-driven methods or harmonise with intraoperative scales such as PGS to create end-to-end predictive pathways from clinic to operating room [6,7].

Accordingly, current studies continue to evaluate and refine preoperative predictors, often combining demographics, comorbidities, laboratory markers, and detailed ultrasound features to stratify the risk of difficult LC and conversion. Making parallel these predictors with standardised intraoperative grading and established severity frameworks may enable more reproducible benchmarking, better case selection for early versus delayed surgery, and more nuanced counselling [8].

MATERIALS AND METHODS

Research design- This prospective study was conducted to investigate the predictive analysis before the operation of difficult LC. The study was conducted at South East Hospital, within the Institute of Medical Science, and at SUM Hospital, Campus II, Phulnakhra. The study was conducted with a total of 110 patients, who were included after meeting specific inclusion and exclusion criteria. The study was conducted for a period of 1 year.

Inclusion criteria

- ✓ The patients who are undergoing elective laparoscopic cholecystectomy (LC) from the said hospital only were included in the study.
- ✓ Patients handled by a single laparoscopic surgeon are included in the study.

Exclusion criteria

- ✓ If, due to a lack of equipment, LCs that are changed into open cholecystectomies are excluded from the study.
- ✓ Patients who undergo emergency cholecystectomy are excluded from the study.

Procedure- The study procedure was carried out by a single, skilled laparoscopic surgeon to minimise inter-operator variability. Patients who had to transit from LC to open cholecystectomy due to equipment issues, along with those needing emergency cholecystectomy, were not included in the study. After a routine evaluation in the outpatient department (OPD), eligible patients were admitted a day before their surgery. Preoperative scoring was performed based on the patients' clinical history, physical examination results, and sonographic assessments. For the difficult score, 6-10 scores are identified as difficult scores.

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The definitions for difficulty level were standardised before the surgery. All surgeries were conducted under CO_2 pneumoperitoneum at a pressure of 10 mmHg, utilizing a standard four-port technique (two 5 mm ports and two 10 mm ports). The operative time was observed from the first incision at the port site to the final closure of the last port. Detailed documentation of intraoperative findings and events was maintained. All patients received consistent postoperative care and were followed up according to the institutional protocol.

Table 1 presents the scoring system based on the risk profile of patients undergoing surgical or medical treatment for gallbladder disease. Various preoperative factors are included, mainly age, sex, hospitalization status, BMI, surgical history, and sonography findings, and scores have been assigned to many clinical presentations. The maximum score that can be obtained is 15, which indicates high complexity and increased risks.

Table 1: Representation of pre-operative score regarding various clinical history of patients

History	Criteria		Maximum score
Age	<50 yrs (0)	>50 yrs (1)	1
Sex	Female (1)	Male (1)	1
Hospitalization	N (0)	Y (4)	4
BMI kg/hg m^2	<25 (0)	25–27.5(1) > 27.5 (2)	2
Abdominal scar	N (0)	Infra-umbilical (1) supra-umbilical (2)	2
Palpable gallbladder	N (0)	Y (1)	1
Sonography			
Wall thickness	Thin (0)	Thick > 4 mm (1)	1
Pericholecystic collection	N (0)	Y (1)	1
Impacted stone	N (0)	Y (1)	1

Table 2 defines the criteria for the difficult level in laparoscopic cholecystectomy. It specifies that a complicated case is characterized by a longer duration of about 60–120 minutes, bile spillage, bile duct injury, and surgery performed without conversion.

Table 2: Criteria for intraoperative process for the difficult level of Laparoscopic Cholecystectomy

Level	criteria
Difficult	Duration is 60-120 mins
	spilage is in bile
	duct injury
	no conversion

Statistical Analysis- Data analysis was carried out using SPSS version 15.0 using SPSS 27. For creating tables, graphs, and other visual aids, Microsoft Excel was used. To evaluate the relationship between preoperative scores and intraoperative outcomes, the Chi-square test was employed. Multivariate logistic regression analysis was used to determine the independent predictive value of these risk factors in assessing the chances of having an easy versus a difficult intraoperative experience. The study considered $p<0.05$ as statistically significant.

RESULTS

In Table 3, the data analysis revealed the relationship between preoperative risk scores and the occurrence of difficult surgeries. The patient group was divided based on their pre-operative risk scores. Most patients (70%, n=77) were in the intermediate risk (scores 6-10), while a smaller group (30%, n=33) fell into the lowest risk

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category (scores 0-5). Notably, there's no data for the highest risk category (scores 11-15), which either means that there were no patients in that group or that the data were not collected.

Table 3: The difficult levels of preoperative score in Laparoscopic Cholecystectomy are shown along with the percentages

Pre-op score	Difficult
0-5	33(30%)
6-10	77(70%)
11-15	-
Total	110(100%)

Fig. 1 illustrates the ROC analysis for predicting operative outcome based on pre-operative evaluation. A sensitivity of 0.48 (48%) means less than half of the difficult cases are being recognized correctly. Specificity is at 0.0 (0%), indicating that none of the easier cases are being accurately classified. At a sensitivity of 0.76 (76%) and a specificity of 0.26 (26%), the model effectively identifies most of the challenging cases. A sensitivity of 0.75 (75%) and a specificity of 0.52 (52%) indicate a balance between correctly identifying difficult cases and minimising false positives. At a sensitivity of 0.77 (77%) and a specificity of 0.74 (74%), the classification becomes much more dependable. The highest cut-off achieves perfect classification, with both sensitivity and specificity hitting 1 (100%), meaning every difficult case is identified without mistakenly classifying any easy cases.

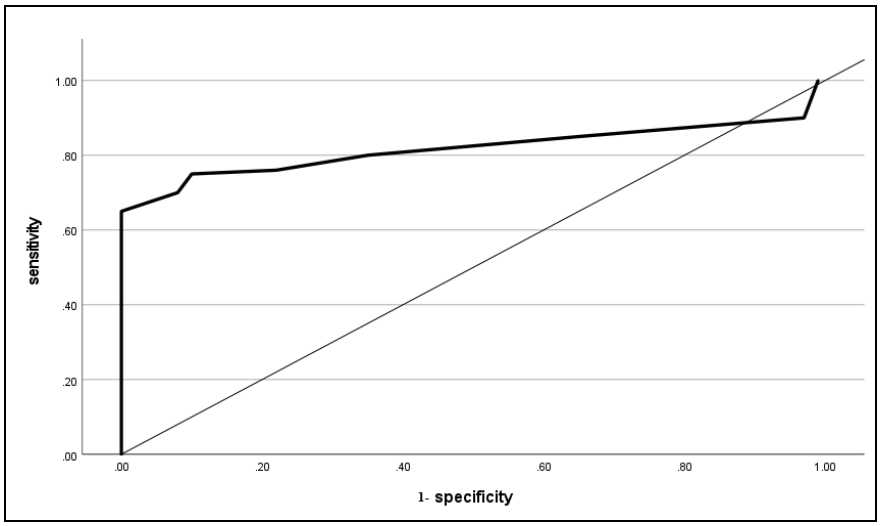

Fig. 1: ROC analysis for prediction of operative outcome from the pre-operative evaluation

Table 4 shows that the multivariate logistic regression analysis has identified several risk factors associated with poor outcomes during the perioperative period. The highest predictor is a history of past hospitalisations, which significantly increases the odds of a negative outcome (OR 11.71, 95% CI not provided, $p < 0.001$). Additionally, certain sonographic findings have proven to be independent risk factors for both the thickened wall of the gallbladder (OR 9.23, p=0.03) and a palpable gallbladder (OR 4.25, p=0.01). Moreover, having a BMI over 27.5 kg/m² is another potential predictor (OR 1.26, p=0.01), highlighting obesity as a major risk factor.

On the other side, factors like age (OR 1.08, p=0.92), sex (OR 1.87, p=0.72), low BMI (OR 1.16, p=0.23), past surgical record (OR 1.51, p=0.86), and the presence of an impacted stone (OR 1.29, p=0.18) showed elevated odds ratios but in case of the multivariate model, statistically significant. Pericholecystic collection was not considered for the model because it was not observed in all cases. Thus, the independent predictors of perioperative outcomes include the record of hospitalisation, clinical outcomes related to palpable gallbladder, and the USG results indicating a thick gallbladder wall.

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Table 4: Multivariate analysis of perioperative outcome with respect to various Risk Factors

Risk factors	Level	Peroperative outcome	p-value	Multivariate (OR)
Age	≤50 years	77(70%)	0.92	1.08
	>50 years	33(30%)		
Sex	Female	66(60%)	0.72	1.87
	Male	44(40%)		
BMI	≤25.0 (kg/m^2)	33(30%)	0.23	1.16
	25.1–27.5 (kg/m^2)	22(20%)		
	>27.5 (kg/m^2)	55(50%)	0.01	1.26
Previous surgery	Nil	88(80%)	0.86	1.51
	Yes	22(20%)		
Hospitalisation	Nil	55(50%)	<0.001	11.71
	Yes	55(50%)		
Gallbladder palpable	NP	77(70%)	0.01	4.25
	Yes	33(30%)		
US-Wall thick	Normal	88(80%)	0.03	9.23
	Thickened	22(20%)		
Impacted stone	Nil	99(90%)	0.18	1.29
	Yes	11(10%)		
Pericholecystic collection	Nil	110(100%)	0.98	-
	Yes	-		
Total		110		

DISCUSSION

Our findings are even with the prevailing literature that preoperative clinical, laboratory, and ultrasonographic variables, considered jointly, can meaningfully stratify the risk of a difficult LC. Systematic reviews and meta-analyses demonstrate that older age, male sex, obesity, diabetes mellitus, prior upper abdominal surgery, and prior episodes of cholecystitis increase technical difficulty and conversion risk; our results echo these tendencies, with particularly strong signals for prior attacks and elevated inflammatory markers. For example, CRP above moderate thresholds and symptom duration beyond 72 hours have been linked with increased odds of conversion, findings mirrored in contemporary cohorts [9].

Imaging features in our series, wall thickening, impacted neck/cystic duct stone, contracted gallbladder, and pericholecystic fluid, were independently associated with difficulty. This mirrors the variables emphasized in the Randhawa–Pujahari preoperative score and its derivatives, which assigns meaningful weight to ultra-sonographic markers. Notably, the discriminative ability reported in external evaluations (AUC often >0.80 and up to ≈approximately 0.93) is comparable to our model's performance, supporting the premise that careful synthesis of preoperative data can anticipate difficult anatomy or severe inflammation. Differences between studies likely reflect case mix, local imaging protocols, and operator variability in ultrasound capabilities [10].

When benchmarked against intraoperative reference standards, difficulty grades in our cohort correlated with Parkland Grading Scale categories reported elsewhere; higher predicted difficulty was associated with higher PGS grades, longer operative times, and a greater use of bail-out strategies, such as subtotal cholecystectomy. Prior work has demonstrated strong correlations between PGS and adverse outcomes, validating its reproducibility across various settings, including resource-limited environments. While PGS itself is an intraoperative measure, the concordance between preoperative risk strata and PGS in our data strengthens its face validity [11].

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The severity of acute cholecystitis, as per the Tokyo Guidelines, also paralleled the predicted difficulty in our experience. TG18 supports early LC for most patients, with nuanced triage for Grade III disease based on organ dysfunction and institutional expertise. Observational studies have shown that higher TG grades are associated with increased operative complexity and complications. Our analysis found similar gradients, suggesting that integrating TG-based severity with preoperative difficulty scoring may yield additive predictive value, particularly for timing decisions and the need for senior surgeon involvement. Recent TG18-anchored difficulty score investigations further highlight the feasibility of identifying likely high-difficulty cases preoperatively [12,13].

Comparisons with other contemporary cohorts reveal both consensus and nuance. Chin and social group identified age, male sex, prior cholecystitis, symptom duration >72 h, diabetes, obesity, and CRP >76 mg/L as key conversion predictors; our data set corroborates most of these, though the effect size for obesity was attenuated, plausibly due to ergonomic advances and experience effects. Likewise, San Lio *et al.* meta-analysis emphasised patient-related predictors (age, sex, and prior surgery), which is consistent with our multivariable results. Where discrepancies exist, e.g. the contribution of CBD diameter or gallbladder distension, they may stem from differences in imaging criteria and measurement standardization [2].

Importantly, not all “difficulties” are equal. Some predictors pointed towards an aggressive Calot’s triangle (e.g., impacted neck stone, dense oedema), whereas others predict adhesion or bleeding risk (e.g., prior upper abdominal surgery, coagulopathy). Studies using composite endpoints (conversion, subtotal cholecystectomy, operative time) can mask these distinctions. The Parkland framework helps unpack mechanisms by grading anatomic/inflammatory severity; in our view, future models should explicitly map preoperative variables to distinct intra-operative phenotypes (fibrotic/contracted infundibulum vs empyema vs dense adhesions), potentially enabling personalised methods (fundus-first dissection, liberal use of subtotal fenestration cholecystectomy, or early call for senior assistance) [14].

Clinical implications follow. First, a simple preoperative score using routinely available data (demographics, history, CRP/WBC, ultrasound) can flag high-difficulty cases for senior-led operating lists and comprehensive bail-out planning. Second, making a straight preoperative risk assessment with TG18 severity supports rational timing. Patients predicted to have high difficulty improving their physiology might benefit from optimisation or referral to a higher-volume centre, whereas low-risk patients should proceed to early LC to avoid readmissions. Third, documentation of both preoperative risk and intraoperative grade standardises communication, facilitates audit/quality improvement, and supports patient-centred consent in discussing the realistic risks of conversion or subtotal cholecystectomy [15].

Limitations common to this field remain salient: single-centre designs, modest sample sizes, inter-observer variability in ultrasound, and heterogeneity in defining “difficulty.” Our results, along with those of others, underscore the need for multi-centre prospective validation with uniform definitions, calibration across populations, and decision-analytic evaluation (e.g., how risk stratification affects staffing, scheduling, and outcomes). Incorporating standardised imaging measurements and leveraging routinely collected electronic health record data may enhance generalizability. Finally, harmonising preoperative prediction with intraoperative grading and established severity background proposals provides a coherent, end-to-end method to anticipate and manage difficult LCs [16].

SUMMARY

In summary, while certain clinical and sonographic factors are identified as strong individual predictors, the overall scoring model requires further validation and refinement. Future research should aim to prospectively validate an updated risk stratification tool that incorporates these predictors, enabling better anticipation of surgical challenges and enhancing preoperative planning.

CONCLUSIONS

The study concluded that a history of past hospitalizations is the strongest predictor of poor outcomes, with other significant risk factors including a thickened gallbladder wall, palpable gallbladder, and BMI over 27.5 kg/m². Factors such as age, sex, and previous surgeries were not statistically significant predictors in

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this model. Based on the study's findings, a preoperative scoring system was developed. Many patients were not classified, and the highest-risk group (those scoring between 11 and 15) was notably absent. The multivariate analysis identified a history of hospitalisation (OR 11.71, $p < 0.001$), a thickened gallbladder wall as seen on ultrasound (OR 9.23, $p = 0.03$), and a palpable gallbladder (OR 4.25, $p = 0.01$) as the key independent predictors of negative perioperative outcomes.

CONTRIBUTION OF AUTHORS

Research concept- Ashoka Tiadi, Nihar Ranjan Pradhan
Research design- Ashoka Tiadi, Nihar Ranjan Pradhan
Supervision- Juicy Mahanta
Materials- Ashoka Tiadi, Nihar Ranjan Pradhan
Data collection- Ashoka Tiadi, Nihar Ranjan Pradhan
Data analysis and interpretation- Ashoka Tiadi, Nihar Ranjan Pradhan
Literature search- Ashoka Tiadi, Nihar Ranjan Pradhan
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Final approval- Juicy Mahanta

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