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Research Article

Clinical Predictors of Difficult Laparoscopic Cholecystectomy in Patients with Symptomatic Cholelithiasis: A Prospective Observational Study

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Abstract

Background: Laparoscopic cholecystectomy (LC) is the standard treatment for symptomatic cholelithiasis, but a proportion of cases prove technically difficult, leading to prolonged operative time, higher complication rates and occasional conversion to open surgery. Reliable preoperative identification of these cases enables informed consent, optimal case scheduling and appropriate surgeon selection.

Aim: To identify clinical, biochemical and sonographic predictors of difficult laparoscopic cholecystectomy in patients undergoing elective LC for symptomatic cholelithiasis.

Methods: A prospective observational study was conducted at the Department of General Surgery, FAME Hospital and Research Institute, Mysore, Karnataka, India, over three months (22 February 2026 to 22 May 2026). Forty-eight consecutive adult patients undergoing elective LC were enrolled after informed consent. Preoperative variables (age, sex, body mass index, prior attacks of cholecystitis, prior upper abdominal surgery, diabetes mellitus, and ultrasonographic findings including gallbladder wall thickness, pericholecystic fluid, impacted stone at the neck, and a contracted gallbladder) were recorded. Intraoperative difficulty was graded by Nassar's scale, and cases were dichotomised into 'easy' (Grade I–II) and 'difficult' (Grade III–IV). Univariate analysis (chi-square/Fisher's exact test) and multivariable binary logistic regression were used to identify independent predictors. The Randhawa preoperative scoring system was applied and its discriminative ability assessed by receiver-operating-characteristic (ROC) analysis.

Results: Seventeen of forty-eight patients (35.4%) had a difficult LC. On univariate analysis, male sex, age >50 years, prior attacks of cholecystitis, prior upper abdominal surgery,

gallbladder wall thickness >4 mm, pericholecystic fluid, impacted stone at the neck and a contracted gallbladder were significantly associated with difficulty ($p < 0.05$). On multivariable analysis, gallbladder wall thickness >4 mm (adjusted odds ratio [aOR] 18.9, 95% CI 3.2–112.0; $p = 0.001$), prior attacks of cholecystitis (aOR 7.6, 95% CI 1.4–41.3; $p = 0.019$) and impacted stone at the neck (aOR 6.1, 95% CI 1.1–33.6; $p = 0.038$) emerged as independent predictors. Mean operative time was 54.2 ± 8.2 minutes in easy cases and 107.9 ± 22.1 minutes in difficult cases ($p < 0.001$). Two patients (4.2%) required conversion to open surgery. The Randhawa preoperative scoring system had an area under the ROC curve of 0.88 (95% CI 0.78–0.98); at the standard cut-off of ≥6, sensitivity was 88.2% and specificity 67.7%.

Conclusion: A gallbladder wall thickness of more than 4 mm on preoperative ultrasound, a history of previous attacks of cholecystitis and an impacted stone at the gallbladder neck are the strongest independent predictors of a difficult laparoscopic cholecystectomy. Applying the Randhawa preoperative score in the outpatient setting stratifies operative risk with acceptable discrimination and can meaningfully guide preoperative planning.

Keywords: Laparoscopic cholecystectomy; cholelithiasis; predictors; difficult surgery; ultrasonography; scoring system.

1. Introduction

Since its introduction in the late 1980s, laparoscopic cholecystectomy (LC) has become the treatment of choice for symptomatic gallstone disease. It offers established advantages over the open approach in terms of postoperative pain, cosmesis, length of hospital stay and return to daily activity, and is now the reference standard for elective gallbladder removal in most centres [1,2]. Even so, a proportion of laparoscopic procedures prove technically challenging owing to distorted anatomy, dense adhesions, an inflamed or contracted gallbladder or an impacted stone at Hartmann's pouch. These cases are associated with a prolonged operative time, greater blood loss, higher rates of bile duct injury, higher rates of conversion to open cholecystectomy and longer hospitalisation [3,4]. The reported incidence of a 'difficult' LC varies widely (15–35%) depending on the population studied and the criteria used, while the conversion rate ranges between 2% and 15% [5,6]. Predicting difficulty before the patient reaches the operating theatre allows the surgeon to counsel the patient realistically, allocate an appropriately experienced operator, schedule adequate theatre time and prepare the necessary instrumentation. It also permits early consideration of a fundus-first approach, a subtotal cholecystectomy or planned conversion, all of which reduce the risk of iatrogenic injury.

Several authors have proposed clinical, biochemical and ultrasonographic parameters that correlate with intraoperative difficulty. Randhawa and Pujahari [7] devised a fifteen-point preoperative score incorporating age, sex, history, body mass index, presence of an abdominal scar, palpability of the gallbladder and four sonographic features. Others have highlighted the value of individual variables such as male sex, previous attacks of acute cholecystitis, obesity, gallbladder wall thickness of more than 4 mm and an impacted stone at the neck [8,9,10]. However, results from Indian centres are heterogeneous, sample sizes are modest, and no single parameter demonstrates uniformly high sensitivity and specificity.

Against this background, the present prospective observational study was undertaken at a tertiary teaching hospital in Mysore with the following

objectives: (i) to describe the distribution of intraoperative difficulty in patients undergoing elective LC for symptomatic cholelithiasis; (ii) to identify preoperative clinical and sonographic predictors of a difficult LC; and (iii) to evaluate the discriminative performance of the Randhawa preoperative scoring system in this cohort.

2. Materials and Methods

2.1 Study design and setting

This was a hospital-based, prospective observational study conducted in the Department of General Surgery, FAME Hospital and Research Institute, Mysore, Karnataka, India. Recruitment took place over a three-month period from 22 February 2026 to 22 May 2026. All eligible patients admitted for elective laparoscopic cholecystectomy during this interval were considered for inclusion.

2.2 Ethical approval and consent

The study conformed to the ethical principles set out in the Declaration of Helsinki (2013 revision) and to Good Clinical Practice guidelines.

2.3 Study population

Inclusion criteria: adult patients aged 18 years or older with symptomatic cholelithiasis confirmed by transabdominal ultrasonography, scheduled for elective LC, and who provided written informed consent.

Exclusion criteria: acute cholecystitis requiring emergency intervention; suspected gallbladder malignancy on imaging; concomitant choledocholithiasis or obstructive jaundice; uncorrected coagulopathy (international normalised ratio > 1.5 or platelet count < 100,000/μL); pregnancy; decompensated liver disease with portal hypertension; American Society of Anesthesiologists (ASA) physical status of IV or above; and any patient in whom a laparoscopic approach was contraindicated on medical grounds.

2.4 Sample size

Assuming a prior estimate of difficult LC of approximately 30% based on published literature from Indian centres [7,11], and using the formula $n = Z^2pq/d^2$ with $Z = 1.96$, $p = 0.30$, $q = 0.70$ and an absolute precision $d = 0.13$, the calculated minimum sample size was 47. Forty-eight consecutive patients meeting the eligibility criteria were therefore enrolled.

2.5 Preoperative evaluation

A structured proforma was used to record demographic details, symptom duration, number of prior episodes of biliary colic or acute cholecystitis requiring admission, comorbidities (diabetes mellitus, hypertension), previous upper abdominal surgery, and clinical findings (body mass index [BMI], presence of a palpable gallbladder or right upper-quadrant tenderness). Routine biochemistry (complete blood count, liver function tests, renal function tests and coagulation profile), electrocardiography and chest radiography were performed.

All patients underwent a preoperative transabdominal ultrasonogram performed by a consultant radiologist using a 3.5-MHz curvilinear probe. The following sonographic parameters were documented: gallbladder wall thickness (measured on a fasting scan in the anterior wall, categorised as ≤4 mm or >4 mm), presence of pericholecystic fluid, size and number of calculi, presence of an impacted stone at the neck or in Hartmann's pouch, and a contracted gallbladder (defined as a longitudinal length < 5 cm).

The Randhawa preoperative scoring system was calculated for each patient using the parameters and weights described in the original publication [7]. Total scores were classified as easy (0–5), difficult (6–10) or very difficult (11–15).

2.6 Operative procedure

All operations were performed by consultant surgeons or by senior residents under direct consultant supervision, using a standard four-port technique under general anaesthesia. Pneumoperitoneum was created by the closed (Veress) or open (Hasson) technique at the surgeon's discretion. Dissection of Calot's triangle followed the 'critical view of safety' principle before division of the cystic duct and cystic artery [12]. The decision to convert to open cholecystectomy was left to the operating surgeon and was based on inability to safely identify the biliary anatomy, uncontrolled haemorrhage or suspected biliary injury.

2.7 Assessment of operative difficulty

Intraoperative difficulty was graded prospectively by the operating surgeon using Nassar's scale [13]: Grade I – floppy, non-adherent gallbladder with clear anatomy; Grade II – mucocoele, thin adhesions to the gallbladder body or Hartmann's pouch, or packed stones; Grade III – deeply buried gallbladder, dense fibrous adhesions distorting the anatomy, contracted or thick-walled gallbladder; Grade IV – empyema, gangrene, Mirizzi syndrome or extensive adhesions preventing safe identification of the biliary tree. For analysis, Grades I and II were combined as 'easy LC' and Grades III and IV as 'difficult LC'.

2.8 Outcome variables

The primary outcome was the classification of the procedure as difficult (Nassar Grade III–IV) or easy (Grade I–II). Secondary outcomes were operative time (skin-to-skin, in minutes), conversion to open surgery, intraoperative complications (major bleeding, bile spillage, bile duct injury), postoperative complications and length of postoperative hospital stay.

2.9 Statistical analysis

Data were entered in Microsoft Excel 2019 and analysed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY). Continuous variables are reported as mean ± standard deviation (SD) or median with interquartile range as appropriate, and categorical variables as frequencies and percentages. Between-group comparisons of continuous variables used the independent-samples Student's t-test (Welch's correction where appropriate); categorical variables were compared using the chi-square test or Fisher's exact test where any expected cell frequency was less than five. Variables significant on univariate analysis ($p < 0.05$) were entered into a binary logistic regression model to identify independent predictors of difficult LC; odds ratios with 95% confidence intervals are reported. The discriminative performance of the Randhawa preoperative score was evaluated by receiver-operating-characteristic (ROC) analysis with computation of the area under the curve (AUC). A two-sided p-value of less than 0.05 was considered statistically significant throughout.

3. Results

3.1 Baseline characteristics

During the study period, 48 patients underwent elective laparoscopic cholecystectomy and were included in the final analysis. The mean age was 46.3 ± 12.4 years (range 22–72). Thirty-one patients (64.6%) were women and 17 (35.4%) were men, giving a female-to-male ratio of 1.8:1. The mean BMI was 26.4 ± 3.1 kg/m², and 18 patients (37.5%) were overweight or obese (BMI > 27.5 kg/m²). Right upper-quadrant pain was the presenting symptom in all patients; 15 (31.3%) had a history of one or more previous admissions for acute cholecystitis, 8 (16.7%) had a previous upper-abdominal operation, and 10 (20.8%) had type 2 diabetes mellitus. Baseline characteristics are summarised in Table 1.

Table 1. Baseline demographic and clinical characteristics of the study cohort (n = 48).

Variable	Value	Range / %
Age (years), mean ± SD	46.3 ± 12.4	22–72
≤ 50 years, n (%)	26	54.2%
> 50 years, n (%)	22	45.8%
Sex, n (%)		
Female	31	64.6%
Male	17	35.4%
Body mass index (kg/m²), mean ± SD	26.4 ± 3.1	20.1–34.6
> 27.5 kg/m², n (%)	18	37.5%
Previous attacks of cholecystitis, n (%)	15	31.3%
Previous upper abdominal surgery, n (%)	8	16.7%
Diabetes mellitus, n (%)	10	20.8%
Hypertension, n (%)	12	25.0%
Palpable gallbladder on examination, n (%)	4	8.3%
ASA physical status, n (%)		
I	22	45.8%
II	21	43.8%
III	5	10.4%
Sonographic gallbladder wall thickness > 4 mm, n (%)	14	29.2%
Pericholecystic fluid on ultrasound, n (%)	6	12.5%
Impacted stone at gallbladder neck, n (%)	12	25.0%
Contracted gallbladder on ultrasound, n (%)	8	16.7%

Abbreviations: SD, standard deviation; ASA, American Society of Anesthesiologists.

3.2 Distribution of intraoperative difficulty

Using Nassar's intraoperative grading system, 19 patients (39.6%) were classified as Grade I (easy), 12 (25.0%) as Grade II (moderate), 11 (22.9%) as Grade III (difficult) and 6 (12.5%) as Grade IV (very difficult). When dichotomised, 31 procedures (64.6%) were classified as easy and 17 (35.4%) as difficult (Figure 1).

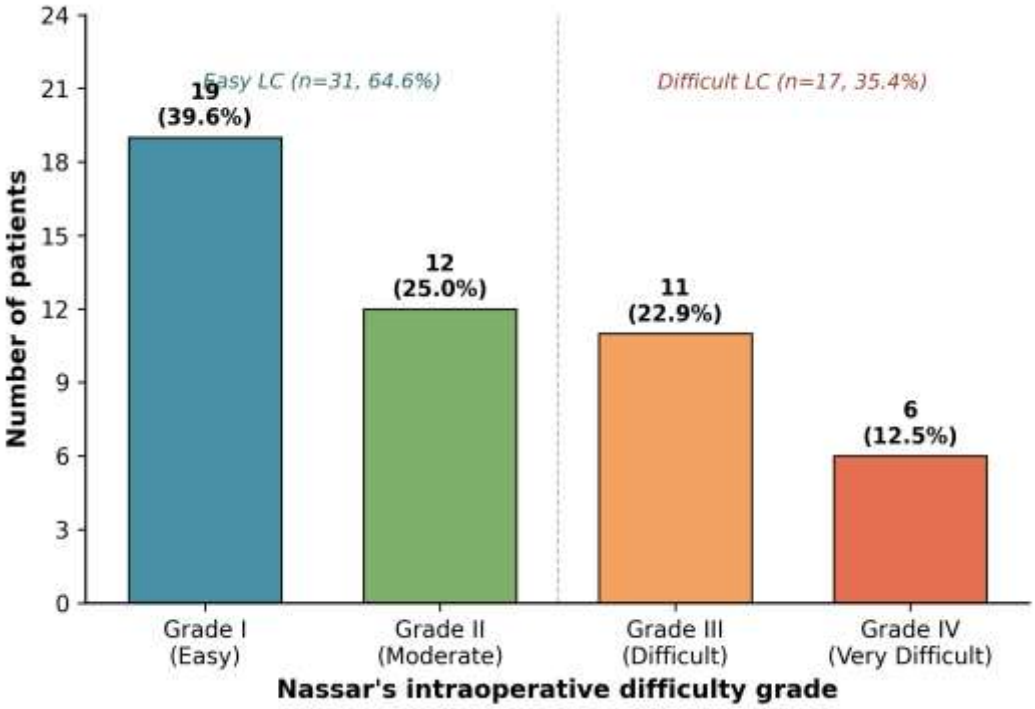

Figure 1. Distribution of intraoperative difficulty grades using Nassar's classification in the study cohort (n = 48). Cases were dichotomised as easy LC (Grade I–II) and difficult LC (Grade III–IV) for further analysis.

3.3 Univariate analysis of predictors

Table 2 presents a comparison of preoperative variables between the easy and difficult LC groups. Male sex, age older than 50 years, previous attacks of cholecystitis, previous upper abdominal surgery, sonographic gallbladder wall thickness of more than 4 mm, pericholecystic fluid, an impacted stone at the neck and a contracted gallbladder were all significantly associated with a difficult LC ($p < 0.05$). Body mass index above 27.5 kg/m² and diabetes mellitus showed a trend towards association without reaching statistical significance. Figure 2 depicts the univariate odds ratios with 95% confidence intervals.

Table 2. Univariate comparison of preoperative variables between easy and difficult laparoscopic cholecystectomy.

Variable	Easy LC (n = 31)	Difficult LC (n = 17)	χ^2 / t	p-value
Age > 50 years, n (%)	10 (32.3)	12 (70.6)	6.50	0.011*
Male sex, n (%)	7 (22.6)	10 (58.8)	6.30	0.012*
BMI > 27.5 kg/m², n (%)	9 (29.0)	9 (52.9)	2.66	0.099
Previous attacks of cholecystitis, n (%)	4 (12.9)	11 (64.7)	13.73	< 0.001*
Previous upper abdominal surgery, n (%)	2 (6.5)	6 (35.3)	6.59	0.010*
Diabetes mellitus, n (%)	4 (12.9)	6 (35.3)	3.34	0.068
Palpable gallbladder, n (%)	1 (3.2)	3 (17.6)	2.88	0.089

Variable	Easy LC (n = 31)	Difficult LC (n = 17)	χ^2 / t	p-value
GB wall thickness > 4 mm, n (%)	2 (6.5)	12 (70.6)	21.85	< 0.001*
Pericholecystic fluid, n (%)	1 (3.2)	5 (29.4)	6.86	0.009*
Impacted stone at neck, n (%)	3 (9.7)	9 (52.9)	10.96	< 0.001*
Contracted gallbladder, n (%)	1 (3.2)	7 (41.2)	11.40	< 0.001*

** Statistically significant ($p < 0.05$). Chi-square (χ^2) test with 1 degree of freedom; Fisher's exact test was used where any expected cell frequency was < 5. Abbreviations: BMI, body mass index; GB, gallbladder.*

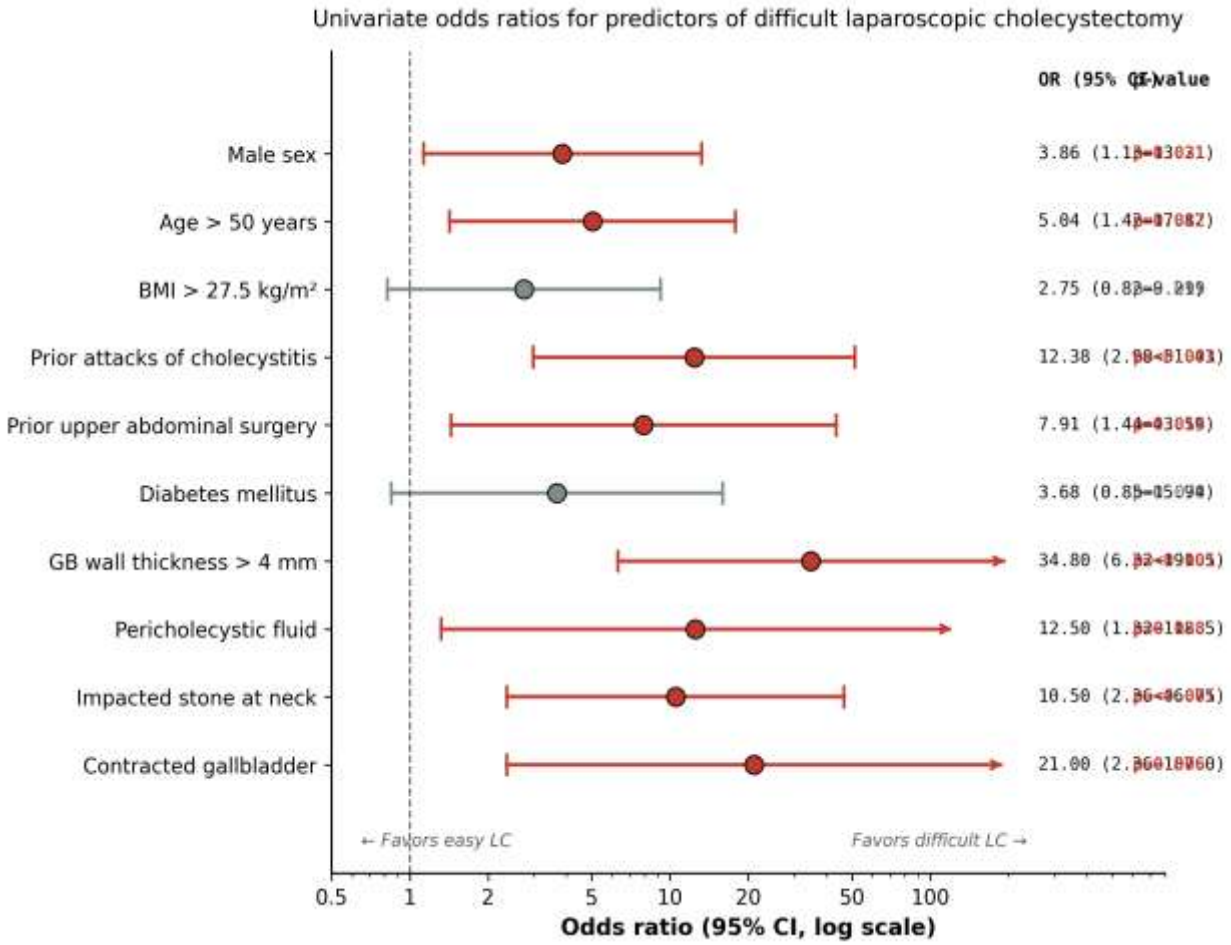

Figure 2. Univariate odds ratios (95% CI) for preoperative predictors of difficult laparoscopic cholecystectomy. Statistically significant predictors are highlighted in red. The vertical dashed line represents an odds ratio of 1 (null value); the log scale is used to accommodate wide confidence intervals for rare exposures.

3.4 Multivariable logistic regression

The eight variables significant on univariate analysis were considered for multivariable analysis. Because the number of events (n = 17) restricts model complexity to approximately three variables (rule of ten events per predictor), a parsimonious model was constructed retaining the three variables with the strongest univariate association and the greatest clinical relevance: gallbladder wall thickness of more than 4 mm, previous attacks of cholecystitis and impacted stone at the neck. On multivariable analysis, all three

variables emerged as independent predictors of difficult LC (Table 3). Gallbladder wall thickness of more than 4 mm demonstrated the strongest independent association (aOR 18.9, 95% CI 3.2–112.0; p = 0.001).

Table 3. Multivariable binary logistic regression analysis of independent predictors of difficult laparoscopic cholecystectomy.

Predictor	Adjusted OR	95% CI	p-value
Gallbladder wall thickness > 4 mm	18.9	3.2 – 112.0	0.001*
Previous attacks of cholecystitis	7.6	1.4 – 41.3	0.019*
Impacted stone at gallbladder neck	6.1	1.1 – 33.6	0.038*

** Statistically significant (p < 0.05). Model Hosmer–Lemeshow goodness-of-fit test: $\chi^2 = 2.14$, df = 6, p = 0.906; Nagelkerke $R^2 = 0.62$; overall model classification accuracy = 87.5%. Abbreviations: OR, odds ratio; CI, confidence interval.*

3.5 Operative outcomes

The mean operative time for the whole cohort was 73.2 ± 29.7 minutes. Operative time was significantly longer for difficult cases (107.9 ± 22.1 minutes) than for easy cases (54.2 ± 8.2 minutes; p < 0.001) (Figure 3). Two patients (4.2%) required conversion to open cholecystectomy; both were classified as Nassar Grade IV, both had a gallbladder wall thickness of more than 4 mm and an impacted stone at the neck, and in both the reason for conversion was inability to safely delineate Calot's triangle. Intraoperative bile spillage occurred in 7 patients (14.6%) and was significantly more common in the difficult group (5 vs 2 patients; p = 0.036). Minor bleeding requiring cauterisation or a haemostatic agent occurred in 3 patients (6.3%), all in the difficult group. There were no cases of major bile duct injury.

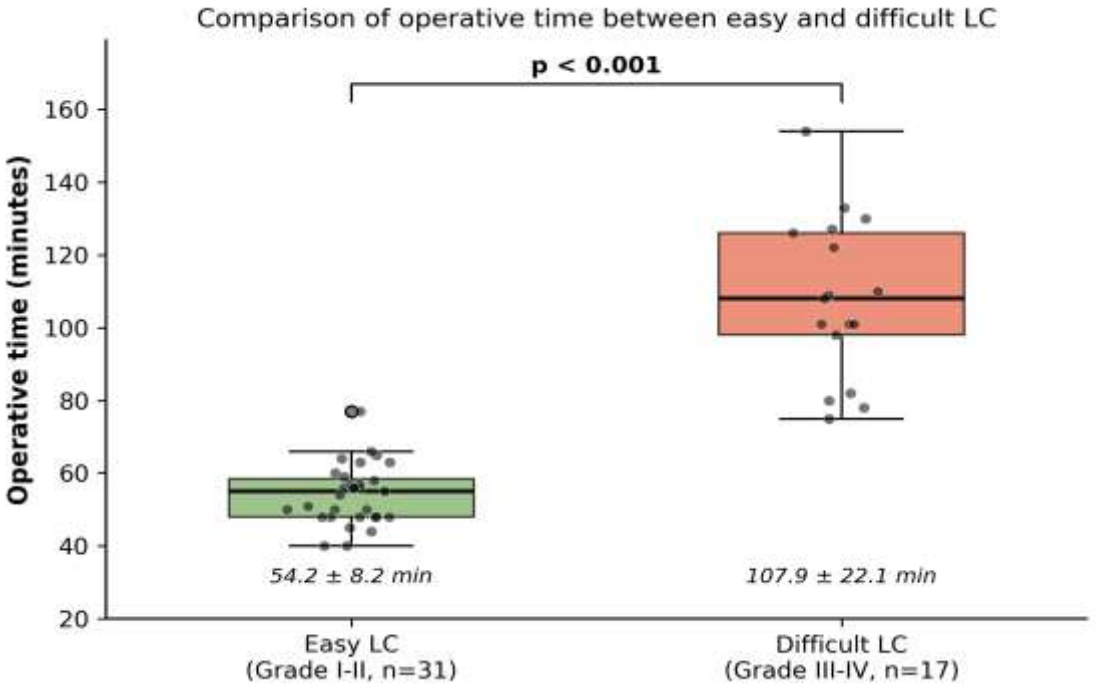

Figure 3. Box plot comparison of operative time between easy and difficult laparoscopic cholecystectomy. Boxes represent interquartile range with the median shown as a horizontal line; whiskers extend to 1.5 × IQR. Individual data points are overlaid.

Postoperative complications were infrequent and are summarised in Table 4. The overall complication rate was 16.7% (8/48). One patient developed a low-output bile leak from the gallbladder bed that resolved with conservative management. Two patients (4.2%) had a port-site infection managed with dressings and oral antibiotics. There were no perioperative deaths. The mean postoperative hospital stay was 2.3 ± 0.5 days for easy cases and 4.1 ± 1.2 days for difficult cases ($p < 0.001$).

Table 4. Intraoperative and postoperative outcomes stratified by operative difficulty.

Outcome	Easy LC (n = 31)	Difficult LC (n = 17)	p-value
Operative time (min), mean ± SD	54.2 ± 8.2	107.9 ± 22.1	< 0.001*
Conversion to open surgery, n (%)	0 (0)	2 (11.8)	0.121
Intraoperative bile spillage, n (%)	2 (6.5)	5 (29.4)	0.036*
Bleeding requiring intervention, n (%)	0 (0)	3 (17.6)	0.036*
Postoperative bile leak, n (%)	0 (0)	1 (5.9)	0.354
Port-site infection, n (%)	1 (3.2)	1 (5.9)	1.000
Bile duct injury, n (%)	0 (0)	0 (0)	–
Postoperative stay (days), mean ± SD	2.3 ± 0.5	4.1 ± 1.2	< 0.001*

** Statistically significant ($p < 0.05$). Fisher's exact test used for categorical variables with expected cell frequency < 5; independent-samples Student's t-test for continuous variables. SD, standard deviation.*

3.6 Diagnostic performance of individual predictors

The sensitivity, specificity, positive and negative predictive values and overall accuracy of each significant preoperative variable for predicting difficult LC are shown in Table 5. A gallbladder wall thickness of more than 4 mm on preoperative ultrasound had the highest overall accuracy (85.4%) with a specificity of 93.5% and a positive predictive value of 85.7%. A contracted gallbladder had the highest specificity (96.8%) but the lowest sensitivity (41.2%).

Table 5. Diagnostic performance of individual preoperative predictors for a difficult laparoscopic cholecystectomy.

Predictor	Sens (%)	Spec (%)	PPV (%)	NPV (%)	Accuracy (%)
GB wall thickness > 4 mm	70.6	93.5	85.7	85.3	85.4
Impacted stone at neck	52.9	90.3	75.0	77.8	77.1
Contracted gallbladder	41.2	96.8	87.5	75.0	77.1
Pericholecystic fluid	29.4	96.8	83.3	71.4	72.9
Previous cholecystitis attacks	64.7	87.1	73.3	81.8	79.2
Previous upper abd. surgery	35.3	93.5	75.0	72.5	72.9
Male sex	58.8	77.4	58.8	77.4	70.8
Age > 50 years	70.6	67.7	54.5	80.8	68.8

Sens, sensitivity; Spec, specificity; PPV, positive predictive value; NPV, negative predictive value; GB, gallbladder.

3.7 Performance of the Randhawa preoperative scoring system

The Randhawa preoperative score was applied to all 48 patients. Score distributions differed markedly between groups: patients undergoing an easy LC had a mean score of 4.5 ± 2.3, whereas those with a difficult LC had a mean score of 9.2 ± 2.8 ($p < 0.001$). At the standard cut-off of ≥ 6, the score classified 25 patients as anticipated 'difficult'; of these, 15 were confirmed intraoperatively as difficult (positive predictive value 60.0%), while of the 23 patients with a score < 6, 21 were confirmed as easy (negative predictive value 91.3%). Corresponding sensitivity, specificity and overall accuracy were 88.2%, 67.7% and 75.0% respectively (Table 6). ROC analysis of the continuous score yielded an area under the curve of 0.88 (95% CI 0.78–0.98; $p < 0.001$), indicating good discriminative ability (Figure 4).

Table 6. Classification of patients by the Randhawa preoperative scoring system against intraoperative Nassar grading.

Randhawa category (score)	Easy LC (n = 31)	Difficult LC (n = 17)	Total
Easy (0 – 5)	21	2	23
Difficult (6 – 10)	9	11	20
Very difficult (11 – 15)	1	4	5
Total	**31**	**17**	**48**

At a binary cut-off of ≥ 6, the score identifies difficult LC with sensitivity 88.2%, specificity 67.7%, PPV 60.0%, NPV 91.3% and overall accuracy 75.0%.

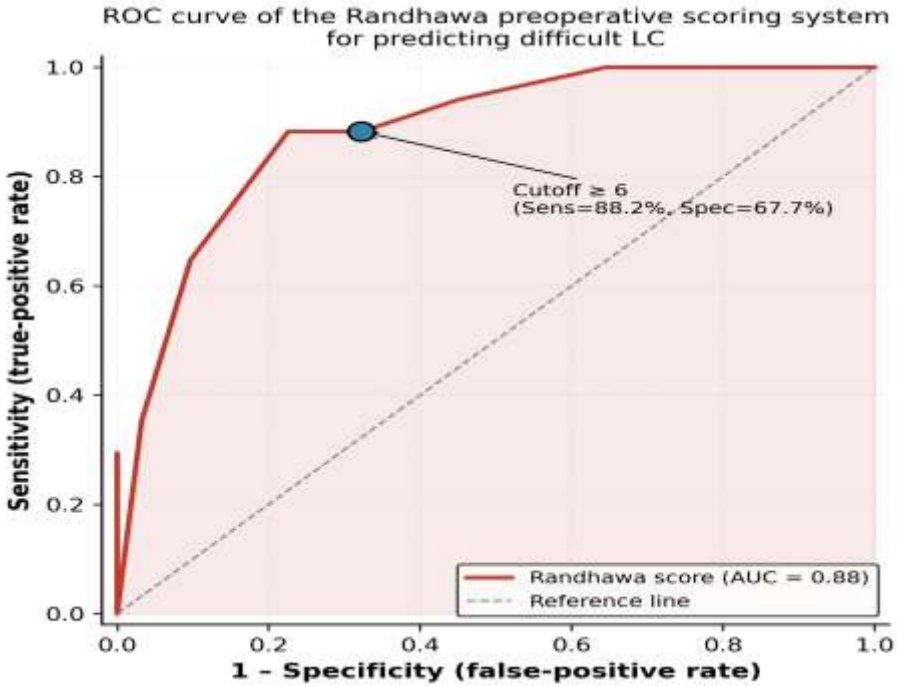

Figure 4. Receiver-operating-characteristic curve of the Randhawa preoperative scoring system for the prediction of a difficult laparoscopic cholecystectomy (area under the curve = 0.88, 95% CI 0.78–0.98). Performance at the standard binary cut-off of ≥ 6 is marked.

4. Discussion

In this prospective observational study of 48 consecutive patients undergoing elective laparoscopic cholecystectomy at a tertiary teaching hospital in Mysore, approximately one-third of procedures were technically difficult, and three preoperative variables — a sonographic gallbladder wall thickness of more than 4 mm, a history of previous attacks of cholecystitis and an impacted stone at the gallbladder neck — emerged as independent predictors of difficulty. The Randhawa preoperative scoring system stratified operative risk with an area under the ROC curve of 0.88, comparable to previously published Indian series.

The proportion of difficult cases in the present series (35.4%) accords well with published figures. Randhawa and Pujahari [7] reported that 24% of 228 patients had a difficult LC, while Gupta et al. [11] reported 36% and Vivek et al. [14] 33%. Lal and colleagues [8] and Nachnani and Supe [15], working in Indian tertiary centres, found broadly similar rates. The heterogeneity of these estimates reflects differences in patient selection, exclusion of emergency procedures, and the criteria used to define difficulty; nonetheless, the consistent finding that roughly a quarter to a third of elective laparoscopic cholecystectomies present technical challenges reinforces the value of preoperative risk stratification.

Gallbladder wall thickness on preoperative ultrasound was the single most powerful predictor in our cohort, with an adjusted odds ratio of 18.9 and an accuracy of 85.4%. This is in line with the observations of Nachnani and Supe [15], who found a wall thickness of more than 4 mm to be the strongest independent predictor of difficulty, and with the meta-analytic findings summarised by Hussain [4]. Wall thickening reflects chronic inflammation with subserosal fibrosis, which distorts Calot's triangle and increases both operative time and the risk of biliary injury [16]. The high specificity of this sign (93.5% in our series) makes it particularly useful for informed consent and for planning the operating list.

Previous attacks of acute cholecystitis were the second independent predictor (aOR 7.6), consistent with the results of Alponat et al. [17] and Rosen et al. [18], both of whom identified a history of acute inflammation as a determinant of conversion. Repeated inflammatory insults lead to fibrosis around the gallbladder, obliteration of the peritoneal plane between the gallbladder and the liver bed and dense adhesions to adjacent viscera. Kama et al. [19] incorporated this variable into a risk score for conversion. The clinical implication is straightforward: patients presenting for elective LC after one or more admissions for acute cholecystitis warrant additional caution and should not be scheduled at the end of a busy list.

An impacted stone at the neck was the third independent predictor (aOR 6.1). Its presence typically indicates chronic mucocoele or empyema, with a friable, tense gallbladder that is difficult to grasp and to retract, and it may herald Mirizzi syndrome [20]. Our finding echoes those of Sakuramoto et al. [21] and of Ibrahim et al. [22], who both emphasised the predictive value of a stone impacted at the neck or in Hartmann's pouch.

Male sex, older age, previous upper abdominal surgery, pericholecystic fluid and a contracted gallbladder were significant on univariate analysis but did not retain independence in the multivariable model. This is likely a reflection of two factors: collinearity — many of these variables share underlying pathophysiology (chronic inflammation and fibrosis) with the retained predictors — and the modest sample

size, which limits the statistical power to detect independent effects of smaller magnitude. Nonetheless, each of these variables has been highlighted in the wider literature as a contributor to operative difficulty [23,24,25], and their combined effect is captured by composite scores such as those of Randhawa and Pujahari [7] and Kama et al. [19]. Interestingly, body mass index above 27.5 kg/m² did not reach statistical significance in our cohort ($p = 0.099$), in contrast to some Western series [3,17]; the relatively lower prevalence of obesity in our population and the modest sample size are the most plausible explanations.

The performance of the Randhawa preoperative score in our cohort (AUC 0.88; sensitivity 88.2%, specificity 67.7% at the ≥ 6 cut-off) is consistent with independent validations by Bhondave et al. [26] and Agrawal et al. [27]. The score's high negative predictive value (91.3%) is particularly valuable: a score below 6 reliably identifies patients who are likely to have a straightforward operation and may be suitable for day-case or short-stay pathways. Its modest positive predictive value (60.0%), however, argues against using the score in isolation to reassign cases to more experienced operators. Combining the score with the individual sonographic variable of greatest predictive value in our data — a wall thickness of more than 4 mm — may improve pre-theatre planning; this warrants prospective evaluation in a larger cohort.

Difficult laparoscopic cholecystectomies were associated with significantly longer operative time (108 vs 54 minutes), a higher rate of intraoperative bile spillage and minor bleeding, and a longer postoperative hospital stay. The conversion rate of 4.2% is within the range reported from Indian [8,11] and international [17,18] series for elective LC. Importantly, no patient in our series suffered a major bile duct injury, a finding consistent with careful adherence to the critical view of safety and, where anatomy remained unclear, a low threshold for conversion — a principle strongly emphasised by Strasberg [12] and subsequently by Sugrue et al. [28] in their AAST-endorsed operative grading system.

4.1 Strengths and limitations

The strengths of this study include its prospective design with pre-specified predictor and outcome variables, the use of a validated intraoperative grading system, standardised preoperative ultrasonographic assessment by a consultant radiologist, and complete follow-up until hospital discharge. Limitations include the modest sample size (which restricts multivariable model complexity to three covariates and yields wide confidence intervals for uncommon exposures), the single-centre setting (which may limit external generalisability), the short recruitment window of three months, and the exclusion of emergency cases and patients with common-bile-duct pathology, whose operative difficulty and predictors may differ. Interobserver variability in sonographic measurements was not formally assessed, and the operating surgeon assigned Nassar's grade, introducing a theoretical risk of ascertainment bias. Larger, multicentre studies with prospective external validation of any composite scoring model, and comparison with contemporary systems such as the AAST/Sugrue grade [28] and the operative difficulty grading scale of Griffiths et al. [29], are needed to consolidate these findings.

5. Conclusion

In this prospective observational study, one in three patients undergoing elective laparoscopic cholecystectomy for symptomatic cholelithiasis had a technically difficult operation. A gallbladder wall thickness of more than 4 mm on

preoperative ultrasonography, a history of previous attacks of cholecystitis and an impacted stone at the gallbladder neck emerged as independent preoperative predictors of difficulty. The Randhawa preoperative scoring system provided good overall discrimination (AUC 0.88) and, in particular, a high negative predictive value that reliably identified patients likely to have a straightforward operation. Incorporating a structured preoperative assessment of these variables into routine surgical practice can facilitate realistic patient counselling, appropriate case scheduling and thoughtful allocation of operator experience, all of which contribute to safer laparoscopic cholecystectomy.

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