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Research Article

A Cross-Sectional Study to Determine Predicting Factors for Difficult Laparoscopic Cholecystectomy Using USG Criteria

[1]Dr. Anubhav Chittari, [2]Dr. Ashwin Aby Thomas, [3]Dr. Mahesh B. N

[1]Assistant Professor Department of General Surgery Sapthagiri Institute of Medical Sciences & Research Centre (SIMSRC) Bengaluru – 560090, Karnataka, India

[2] Assistant Professor Department of General Surgery Sapthagiri Institute of Medical Sciences & Research Centre (SIMSRC) Bengaluru – 560090, Karnataka, India

[3] Assistant Professor Department of General Surgery Sapthagiri Institute of Medical Sciences & Research Centre (SIMSRC) Bengaluru – 560090, Karnataka, India

*Corresponding Author
Dr. Anubhav Chittari

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Abstract: ***Introduction:*** Laparoscopic cholecystectomy (LC) is the gold standard for the management of symptomatic gallstone disease. However, a significant proportion of cases encounter intraoperative difficulty, potentially necessitating conversion to open surgery. Preoperative ultrasonography (USG) is a non-invasive, widely accessible imaging modality that may provide reliable predictors of a difficult procedure. This study aimed to evaluate USG-based parameters as predictors of difficult LC. **Methods:** This hospital-based cross-sectional study was conducted at Sapthagiri Institute of Medical Sciences & Research Centre (SIMSRC), Bengaluru, from January 2024 to December 2025. A total of 100 patients diagnosed with cholelithiasis who underwent elective LC were included. Preoperative USG parameters assessed included gallbladder (GB) wall thickness, number and size of stones, stone impaction, pericholecystic fluid, common bile duct (CBD) diameter, and GB contractility. Intraoperative difficulty was graded based on operative time, bile or stone spillage, bleeding, and conversion to open surgery. Chi-square test, univariate and multivariate logistic regression analyses were performed. Receiver operating characteristic (ROC) curves were constructed. **Results:** Of 100 patients, 32 (32%) had a difficult LC. On univariate analysis, GB wall thickness >4 mm (OR = 14.00; $p < 0.001$), impacted stone (OR = 9.64; $p < 0.001$), pericholecystic fluid (OR = 9.80; $p < 0.001$), contracted GB (OR = 9.12; $p < 0.001$), and CBD diameter >8 mm (OR = 7.27; $p < 0.001$) were significantly associated with difficulty. On multivariate logistic regression, GB wall thickness >4 mm (aOR = 8.42; 95% CI: 3.12–22.74; $p < 0.001$), impacted stone (aOR = 5.68; 95% CI: 1.82–17.72; $p = 0.003$), pericholecystic fluid (aOR = 4.95; 95% CI: 1.34–18.27; $p = 0.016$), and contracted GB (aOR = 4.12; 95% CI: 1.18–14.38; $p = 0.026$) emerged as independent predictors. The combined USG scoring system had an area under the ROC curve (AUC) of 0.891, with a sensitivity of 68.8% and specificity of 94.1% at a cut-off score of ≥3. **Conclusion:** Preoperative USG parameters, particularly GB wall thickness >4 mm, impacted stone, pericholecystic fluid, and contracted GB, are reliable predictors of difficult LC. A composite USG-based scoring system demonstrates good discriminatory performance and may assist surgeons in preoperative planning, resource allocation, and informed consent.

Keywords: Laparoscopic cholecystectomy, difficult cholecystectomy, ultrasonography, predictive factors, gallbladder wall thickness, impacted stone, conversion.

INTRODUCTION

Laparoscopic cholecystectomy (LC) has established itself as the gold standard surgical procedure for the management of symptomatic gallstone disease since its introduction in 1987 by Philippe Mouret. The procedure offers well-documented advantages over traditional open cholecystectomy, including reduced postoperative pain, shorter hospital stay, earlier return to normal activities, superior cosmesis, and lower overall morbidity. It is estimated that over 1.2 million cholecystectomies are performed annually worldwide, with the vast majority being initiated laparoscopically.

Despite the widespread adoption and refinement of laparoscopic techniques, a significant proportion of LC procedures—ranging from 5% to 35% in various reported series—are classified as "difficult." A difficult LC is characterised by one or more of the following: prolonged operative time (typically exceeding 60 minutes), significant intraoperative bleeding requiring haemostasis, bile or stone spillage, difficulty in delineating Calot's triangle anatomy, and the need for conversion to open cholecystectomy. The conversion rate from laparoscopic to open cholecystectomy has been reported between 2% and 15% in different studies, with consequences including increased operative morbidity, extended hospital stay, and greater healthcare costs.

The ability to predict intraoperative difficulty preoperatively carries substantial clinical importance. Anticipation of a difficult procedure allows for appropriate allocation of surgical expertise, availability of specialised instruments, adequate operating time scheduling, and comprehensive informed consent.

Several clinical and biochemical parameters have been evaluated as predictors of difficult LC, including patient demographics (age, sex, body mass index), clinical history (previous abdominal surgery, history of acute cholecystitis), and laboratory markers (total leucocyte count, liver function tests).

Ultrasonography (USG) remains the primary diagnostic imaging modality for gallstone disease and is routinely performed as the initial investigation in all patients with suspected biliary pathology. Beyond its diagnostic role, USG provides valuable information regarding the morphology of the gallbladder and surrounding structures that may correlate with intraoperative difficulty. Several USG parameters, including gallbladder wall thickness, number and size of gallstones, stone impaction at the neck or Hartmann's pouch, pericholecystic fluid collection, common bile duct (CBD) diameter, and gallbladder contractility, have been investigated as potential predictors of a difficult procedure.

While multiple scoring systems incorporating USG parameters have been proposed, there remains no universally accepted, standardised predictive model. Furthermore, regional variations in disease presentation, patient demographics, and healthcare settings underscore the need for institution-specific validation studies. The present study was therefore undertaken to systematically evaluate the predictive value of preoperative USG parameters for difficult LC in a cohort of patients at a tertiary care teaching hospital in Bengaluru, South India, and to develop a composite USG-based scoring system for clinical application.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based, cross-sectional analytical study conducted in the Department of General Surgery at Sapthagiri Institute of Medical Sciences & Research Centre (SIMSRC), Bengaluru, Karnataka, India, over a period of 24 months from January 2024 to December 2025.

Sample Size

The sample size was calculated using the formula $n = Z^2pq/d^2$, where Z = 1.96 (for 95% confidence interval), p = 0.30 (anticipated prevalence of difficult LC based on prior literature), q = 0.70, and d = 0.09 (absolute precision). The minimum sample size was estimated as 100 patients.

Inclusion Criteria

Patients aged 18 years and above, diagnosed with symptomatic cholelithiasis confirmed on ultrasonography, and scheduled for elective laparoscopic cholecystectomy were included in the study.

Exclusion Criteria

Patients with suspected or confirmed gallbladder malignancy, choledocholithiasis with obstructive jaundice requiring preoperative endoscopic retrograde cholangiopancreatography (ERCP), acute cholecystitis requiring emergency surgery, previous upper abdominal surgery, morbid obesity (BMI > 40 kg/m²), pregnancy, coagulopathy, and those unfit for general anaesthesia were excluded.

Preoperative Assessment

All patients underwent a thorough clinical evaluation including detailed history and physical examination. Baseline laboratory investigations (complete blood count, liver function tests, renal function tests, coagulation profile) and preoperative anaesthesia fitness assessment were performed. Transabdominal ultrasonography was performed by experienced radiologists using a 3.5–5 MHz curvilinear transducer after a minimum of 6 hours of fasting.

USG Parameters Evaluated

The following sonographic parameters were systematically recorded: (i) Gallbladder wall thickness (normal: ≤4 mm; thickened: >4 mm); (ii) Number of gallstones (single versus multiple); (iii) Size of the largest gallstone (in mm); (iv) Presence of stone impaction at the neck or Hartmann's pouch; (v) Pericholecystic fluid collection; (vi) Common bile duct diameter (normal: ≤8 mm; dilated: >8 mm); and (vii) Gallbladder contractility status (normal versus contracted gallbladder).

Surgical Procedure and Intraoperative Assessment

All procedures were performed under general anaesthesia using the standard four-port American technique. The operating surgeon was blinded to the preoperative USG scoring at the time of surgery. Intraoperative parameters documented included total operative time (skin incision to skin closure), estimated blood loss, bile or stone spillage, difficulty in dissecting Calot's triangle, need for additional ports, use of drain, and conversion to open cholecystectomy.

Definition of Difficult Laparoscopic Cholecystectomy

A laparoscopic cholecystectomy was classified as "difficult" if any one or more of the following criteria were met: (a) operative time exceeding 60 minutes; (b) bile or stone spillage during dissection; (c) intraoperative bleeding requiring active haemostasis beyond routine diathermy; (d) inability to achieve the critical view of safety (CVS); (e) need for conversion to open cholecystectomy.

Statistical Analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test as appropriate.

Continuous variables were expressed as mean ±standard deviation and compared using the independent samples t-test or Mann-Whitney U test. Univariate analysis was performed for each USG parameter. Variables with $p < 0.05$ on univariate analysis were entered into a multivariate binary logistic regression model using the forward stepwise method. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were calculated. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were computed for each USG parameter. Receiver operating characteristic (ROC) curves were constructed, and the area under the curve (AUC) was calculated. A p-value of < 0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Profile

A total of 100 patients with symptomatic cholelithiasis who underwent elective laparoscopic cholecystectomy were included in this study. Of these, 32 patients (32%) had a difficult LC and 68 patients (68%) had a non-difficult procedure. The mean age of the study population was 42.6 ±11.8 years (range: 21–68 years). The difficult LC group was significantly older (48.6 ±11.2 vs 39.8 ±10.5 years; $p < 0.001$). Females constituted 62% of the total study population. The mean BMI was significantly higher in the difficult group (27.8 ±3.6 vs 25.1 ±3.2 kg/m²; $p < 0.001$). The demographic and clinical characteristics are summarised in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population

Variable	Difficult LC (n = 32)	Non-Difficult LC (n = 68)	p-value
Age (years), Mean ± SD	48.6 ± 11.2	39.8 ± 10.5	**< 0.001***
Male, n (%)	16 (50.0)	22 (32.4)	0.094
Female, n (%)	16 (50.0)	46 (67.6)	0.094
BMI (kg/m²), Mean ± SD	27.8 ± 3.6	25.1 ± 3.2	**< 0.001***
Duration of symptoms (months), Mean ± SD	14.2 ± 8.6	8.4 ± 5.3	**< 0.001***
H/o acute cholecystitis, n (%)	18 (56.3)	14 (20.6)	**< 0.001***

**Statistically significant (p < 0.05); SD: Standard Deviation; BMI: Body Mass Index; H/o: History of*

Preoperative USG Findings

On preoperative ultrasonography, gallbladder wall thickness greater than 4 mm was observed in 36 patients (36%), of whom 24 (75.0%) had a difficult procedure compared to only 12 (17.6%) in the non-difficult group ($\chi^2 = 30.42$; $p < 0.001$). Multiple gallstones were found in 52 patients (52%), and though more frequent in the difficult group (68.8% vs 44.1%), the association was modest ($\chi^2 = 5.12$; $p = 0.024$). Impacted stones were present in 26 patients (26%) and showed a strong association with difficulty (56.3% vs 11.8%; $\chi^2 = 22.16$; $p < 0.001$). Pericholecystic fluid was detected in 19 patients (19%), with a markedly higher prevalence in the difficult group (43.8% vs 7.4%; $\chi^2 = 18.65$; $p < 0.001$). CBD diameter exceeding 8 mm was noted in 14 patients (14%) and was significantly associated with difficulty (31.3% vs 5.9%; $\chi^2 = 11.56$; $p < 0.001$). A contracted gallbladder was identified in 21 patients (21%), with a significantly higher prevalence in the difficult group (46.9% vs 8.8%; $\chi^2 = 18.42$; $p < 0.001$). The detailed univariate analysis of USG parameters is presented in Table 2.

Table 2: Univariate Analysis of USG Parameters and Difficulty of LC

USG Parameter	Difficult LC (n = 32)	Non-Difficult LC (n = 68)	χ^2	p-value	OR (95% CI)
GB Wall Thickness >4 mm	24 (75.0)	12 (17.6)	30.42	**< 0.001***	14.00 (5.06–38.73)
Multiple Stones	22 (68.8)	30 (44.1)	5.12	**0.024***	2.79 (1.13–6.89)

Impacted Stone	18 (56.3)	8 (11.8)	22.16	< **0.001***	9.64 (3.47–26.80)
Pericholecystic Fluid	14 (43.8)	5 (7.4)	18.65	< **0.001***	9.80 (3.06–31.38)
CBD Diameter >8 mm	10 (31.3)	4 (5.9)	11.56	< **0.001***	7.27 (2.04–25.92)
Contracted GB	15 (46.9)	6 (8.8)	18.42	< **0.001***	9.12 (3.01–27.63)

**Statistically significant (p < 0.05); OR: Odds Ratio; CI: Confidence Interval; GB: Gallbladder; CBD: Common Bile Duct*

Figure 1: Distribution of USG Parameters in Difficult vs Non-Difficult LC

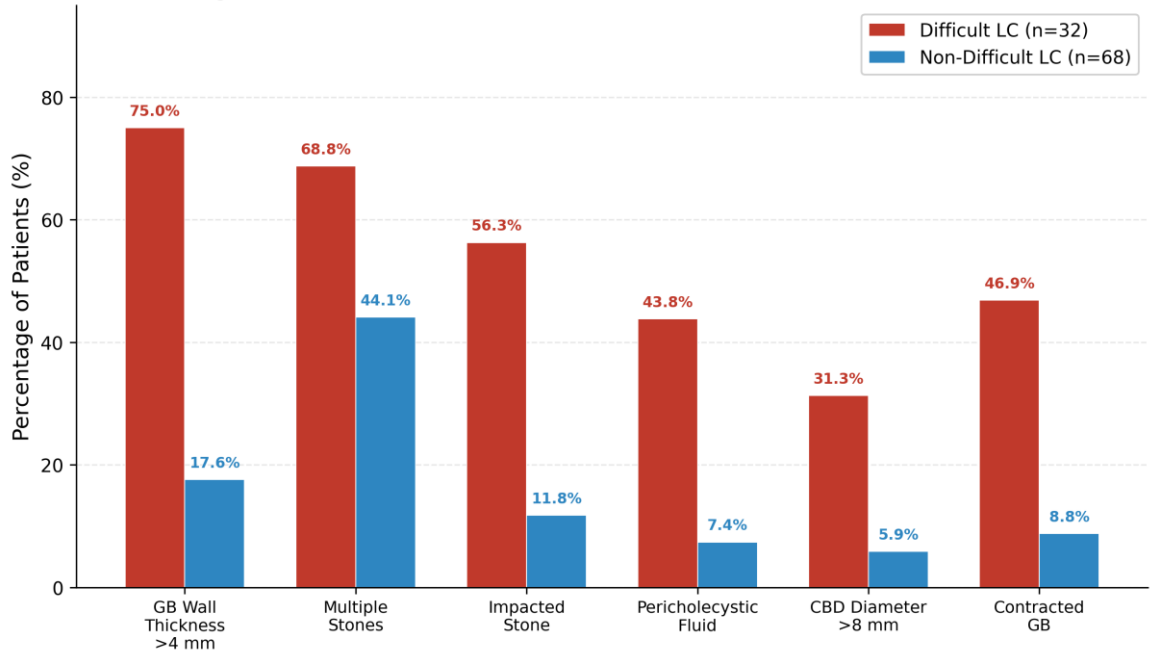

Figure 1: Distribution of USG parameters in difficult versus non-difficult laparoscopic cholecystectomy groups.

Multivariate Logistic Regression Analysis

All six USG parameters that were significant on univariate analysis were entered into a multivariate binary logistic regression model. Four variables emerged as independent predictors of difficult LC: GB wall thickness >4 mm (aOR = 8.42; 95% CI: 3.12–22.74; p < 0.001) was the strongest independent predictor, followed by impacted stone (aOR = 5.68; 95% CI: 1.82–17.72; p = 0.003), pericholecystic fluid (aOR = 4.95; 95% CI: 1.34–18.27; p = 0.016), and contracted GB (aOR = 4.12; 95% CI: 1.18–14.38; p = 0.026). CBD diameter >8 mm (aOR = 3.54; 95% CI: 0.87–14.42; p = 0.078) and multiple stones (aOR = 1.82; 95% CI: 0.68–4.88; p = 0.234) did not retain statistical significance after adjustment. The multivariate analysis results are presented in Table 3.

Table 3: Multivariate Logistic Regression Analysis of Predictors of Difficult LC

Variable	**Adjusted OR**	**95% CI**	**p-value**
GB Wall Thickness >4 mm	8.42	3.12 – 22.74	< **0.001***
Impacted Stone	5.68	1.82 – 17.72	**0.003***
Pericholecystic Fluid	4.95	1.34 – 18.27	**0.016***
Contracted GB	4.12	1.18 – 14.38	**0.026***
CBD Diameter >8 mm	3.54	0.87 – 14.42	0.078
Multiple Stones	1.82	0.68 – 4.88	0.234

**Statistically significant ($p < 0.05$); aOR: Adjusted Odds Ratio; CI: Confidence Interval*

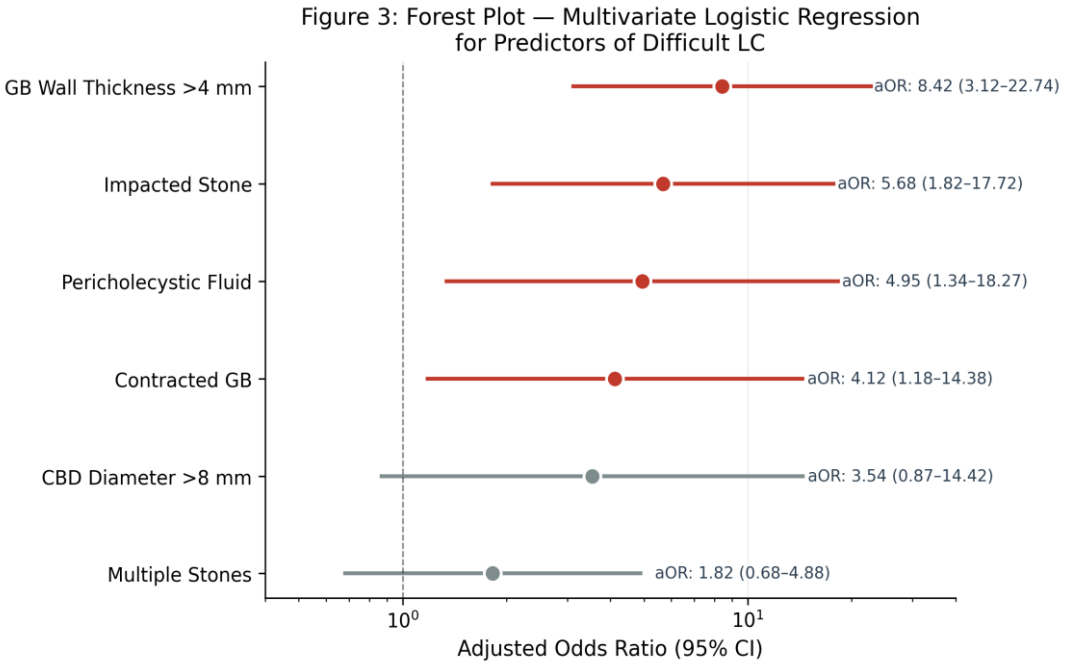

Figure 3: *Forest plot depicting adjusted odds ratios with 95% confidence intervals from multivariate logistic regression.*

Diagnostic Performance and ROC Analysis

Among individual USG parameters, GB wall thickness >4 mm demonstrated the best balance of sensitivity (75.0%) and specificity (82.4%), with an AUC of 0.787. Impacted stone had a sensitivity of 56.3% with high specificity (88.2%) and an AUC of 0.722. The highest specificity among individual parameters was observed for CBD diameter >8 mm (94.1%) and pericholecystic fluid (92.6%), albeit with lower sensitivities. A composite USG scoring system was developed, assigning one point for each positive finding across all six parameters. At an optimal cut-off score of ≥3, the combined scoring system achieved a sensitivity of 68.8%, specificity of 94.1%, PPV of 84.6%, NPV of 86.5%, and overall diagnostic accuracy of 86.0%, with an AUC of 0.891 (95% CI: 0.826–0.956). The diagnostic performance of individual and combined USG parameters is detailed in Table 4.

Table 4: Diagnostic Performance of Individual and Combined USG Parameters

USG Parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC
GB Wall >4 mm	75.0	82.4	66.7	87.5	80.0	0.787
Multiple Stones	68.8	55.9	42.3	79.2	60.0	0.623
Impacted Stone	56.3	88.2	69.2	81.1	78.0	0.722
Pericholecystic Fluid	43.8	92.6	73.7	77.8	77.0	0.682
CBD >8 mm	31.3	94.1	71.4	74.4	74.0	0.627
Contracted GB	46.9	91.2	71.4	78.5	77.0	0.690
Combined USG Score (≥3)	**68.8**	**94.1**	**84.6**	**86.5**	**86.0**	**0.891**

PPV: Positive Predictive Value; NPV: Negative Predictive Value; AUC: Area Under the Curve

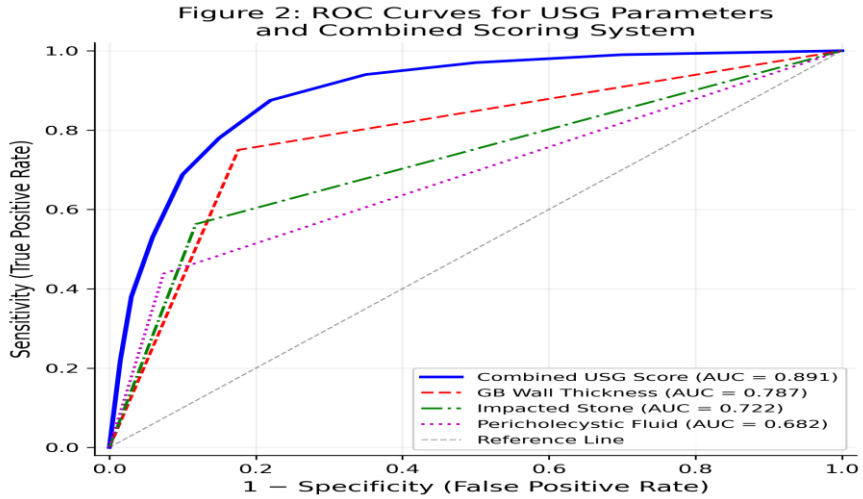

Figure 2: *Receiver operating characteristic (ROC) curves for individual USG parameters and the combined USG scoring system.*

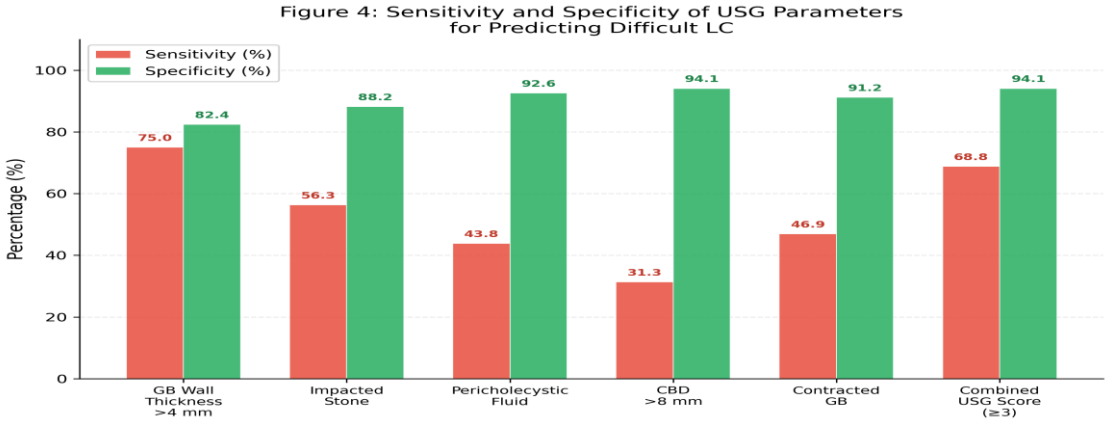

Figure 4: *Sensitivity and specificity of individual USG parameters and the combined scoring system.*

Operative Outcomes

The overall conversion rate from laparoscopic to open cholecystectomy was 8% (8/100). The mean operative time was significantly longer in the difficult group (84.7 ±18.4 min vs 42.3 ±11.8 min; $p < 0.001$). The difficult group also had significantly higher rates of bile spillage (37.5% vs 5.9%), stone spillage (25.0% vs 2.9%), drain placement (56.3% vs 8.8%), and longer mean hospital stay (4.2 ±1.8 vs 1.8 ±0.6 days). The operative outcomes are detailed in Table 5.

Table 5: Comparison of Operative Outcomes Between Difficult and Non-Difficult LC Groups

Operative Parameter	Difficult LC (n = 32)	Non-Difficult LC (n = 68)	p-value
Operative Time (min), Mean ± SD	84.7 ± 18.4	42.3 ± 11.8	**< 0.001***
Estimated Blood Loss (mL), Mean ± SD	95.6 ± 42.3	38.2 ± 15.6	**< 0.001***
Bile Spillage, n (%)	12 (37.5)	4 (5.9)	**< 0.001***
Stone Spillage, n (%)	8 (25.0)	2 (2.9)	**0.002***
Drain Placement, n (%)	18 (56.3)	6 (8.8)	**< 0.001***
Conversion to Open, n (%)	6 (18.8)	2 (2.9)	**0.014***
Hospital Stay (days), Mean ± SD	4.2 ± 1.8	1.8 ± 0.6	**< 0.001***

**Statistically significant ($p < 0.05$); SD: Standard Deviation*

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DISCUSSION

The prediction of intraoperative difficulty during laparoscopic cholecystectomy remains a clinically relevant challenge. The present study demonstrates that preoperative ultrasonographic assessment provides valuable predictive information regarding the likelihood of a difficult procedure, supporting the integration of USG-based scoring into routine preoperative evaluation. In this study, 32% of patients experienced a difficult laparoscopic cholecystectomy, a figure consistent with rates reported in contemporary literature. Ramírez-Giraldo et al. (2023), in their diagnostic trial comparing multiple predictive scores, reported a difficult cholecystectomy rate of 35% using the Nassar operative grading system. Similarly, Trehan et al. (2023) observed that approximately 30% of patients in their cohort had a difficult procedure when assessed by the Randhawa and Pujahari scoring system. The slightly higher rate in our study may reflect the tertiary referral nature of our institution, which receives patients with more complex disease presentations.

Gallbladder wall thickness exceeding 4 mm emerged as the strongest independent predictor of difficult LC in both univariate (OR = 14.00) and multivariate analyses (aOR = 8.42). This finding aligns with the observations of Khan et al. (2023), who studied 350 patients and demonstrated a statistically significant correlation between increased GB wall thickness and conversion rate, complications, operative time, and postoperative hospital stay. Thickened GB wall is a surrogate marker for chronic inflammation and fibrosis, which obliterates tissue planes around Calot's triangle, rendering dissection hazardous. Tongyoo et al. (2023) incorporated GB wall thickness as a key component of their modified Randhawa scoring system and confirmed its significant predictive value in a cohort of elective LC patients.

Stone impaction at the gallbladder neck or Hartmann's pouch was the second most powerful independent predictor (aOR = 5.68; p = 0.003). An impacted stone creates mechanical obstruction, leading to gallbladder distension, mucocele formation, and intense inflammatory adhesions, all of which increase surgical complexity. Gupta et al. (2023) reported that impacted stones and GB wall thickness greater than 3 mm on ultrasound were significant predictors of failure to achieve the critical view of safety during LC, further underscoring the clinical relevance of this finding.

The presence of pericholecystic fluid on preoperative USG was an independent predictor of difficulty (aOR = 4.95; p = 0.016), reflecting active or recent inflammatory process with potential adhesion formation and altered anatomy. This parameter has been highlighted in multiple studies, including the systematic review by Hu et al., which identified pericholecystic fluid as a risk factor for conversion across 30 studies. Teerawiwatchai et al. (2023) similarly found that pericholecystic fluid contributed to their validated predictive score for difficult elective LC.

A contracted gallbladder was identified as an independent predictor (aOR = 4.12; p = 0.026), consistent with findings by Shrestha et al. (2023), who reported that a small, contracted gallbladder is associated with chronic inflammation, thick-walled fibrotic changes, and difficulty in grasping and retracting the fundus during surgery. The contracted gallbladder also obscures the boundaries of the cystohepatic triangle, increasing the risk of bile duct injury.

While CBD diameter >8 mm showed a strong univariate association with difficulty (OR = 7.27), it did not retain independent significance on multivariate analysis (aOR = 3.54; p = 0.078). This finding is not unexpected, as dilated CBD may reflect associated choledocholithiasis rather than an intrinsic difficulty with the cholecystectomy itself. Similarly, the presence of multiple stones, while statistically significant on univariate analysis, was not an independent predictor on multivariate analysis, suggesting that stone multiplicity per se does not substantially increase operative complexity.

The composite USG scoring system developed in this study demonstrated excellent discriminatory performance, with an AUC of 0.891. At the optimal cut-off score of ≥3, the system achieved a sensitivity of 68.8% and specificity of 94.1%, with an overall diagnostic accuracy of 86.0%. These performance metrics are comparable to or exceed those reported by several contemporary scoring systems. Ramírez-Giraldo et al. (2023) reported AUCs ranging from 0.68 to 0.89 across different validated scoring systems. The high specificity of the combined score is particularly valuable in clinical practice, as it minimises false-positive predictions that might lead to unnecessary conversion preparations or avoidance of laparoscopic approach in patients who would otherwise have an uneventful procedure.

The overall conversion rate of 8% in this study falls within the reported range of 2–15% in the literature. Six of the eight conversions (75%) had been correctly predicted as difficult by the combined USG scoring system, suggesting its practical utility in preoperative risk stratification.

Strengths and Limitations

The strengths of this study include its prospective design, blinding of the operating surgeon to the preoperative score, use of standardised definitions for difficulty, and systematic assessment of multiple USG parameters with both univariate and multivariate analyses. The inclusion of a composite scoring system with ROC analysis adds practical clinical value.

However, certain limitations must be acknowledged. The sample size of 100, while adequate for the primary analysis, limits the statistical power for subgroup analyses and may affect the precision of some odds ratio estimates, as reflected in the wide confidence intervals for several variables. The study was conducted at a single tertiary centre, which may limit generalisability to community or rural settings. Interobserver variability in USG interpretation was not formally assessed, though all examinations were performed by experienced radiologists following a standardised protocol. The subjective component of "difficulty" assessment, despite using predefined criteria, introduces a degree of observer bias. Future multicentre studies with larger sample sizes and external validation of the proposed scoring system are warranted.

CONCLUSION

This study demonstrates that preoperative ultrasonographic parameters are reliable predictors of difficult laparoscopic cholecystectomy. Gallbladder wall thickness greater than 4 mm, impacted stone at the neck or Hartmann's pouch, pericholecystic fluid collection, and contracted gallbladder emerged as independent predictors of intraoperative difficulty on multivariate logistic regression. The composite USG-based scoring system, incorporating all six evaluated parameters, demonstrated excellent discriminatory performance with an AUC of 0.891 and an overall diagnostic accuracy of 86.0% at a cut-off score of ≥3.

These findings support the routine integration of a structured USG reporting protocol for patients scheduled for elective laparoscopic cholecystectomy. The identification of high-risk patients preoperatively enables appropriate surgical planning, including assignment of experienced surgeons, availability of specialised instrumentation, scheduling of adequate operative time, and comprehensive informed consent regarding the possibility of conversion. Future multicentre validation studies with larger sample sizes are recommended to confirm the generalisability and clinical utility of this scoring system.

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