Preoperative Predictors of Intraoperative Difficulty in Laparoscopic Cholecystectomy: A Prospective Study

Rehanullah Khan[1], Gaurav Bansal[2], Suryottam Kumar[3]

[1]M S Gen Surgery, Assistant Professor, Alfalah School of Medical Sciences and Research Center, Dhauj, Faridabad, Haryana, India

[2]MBBS, MS (General Surgery), Assistant Professor Department of General Surgery, Alfalah School of Medical Sciences and Research Centre, Dhouj, Faridabad, Haryana, India

[3]Associate Professor of Surgery, Alfalah School of Medical Sciences and Research Centre, Dhauj, Faridabad, India

Abstract:

Background: Laparoscopic cholecystectomy offers advantages over open surgery. However, challenges in cases of anatomical variations or inflammation necessitate accurate preoperative assessment. Predicting difficulty can optimize planning and patient counseling. We conducted a prospective study to comprehensively evaluate preoperative predictors of challenging laparoscopic cholecystectomy, aiming to enhance surgical decision-making and patient management.

Methods: This prospective cross-sectional study was conducted at a tertiary care hospital in North India. Consecutive adult patients scheduled for elective laparoscopic cholecystectomy due to symptomatic gallstone disease were enrolled. Operative techniques followed standard procedures, including the critical view of safety (CVS) technique. Preoperative patient data, intraoperative details, and outcomes were documented using standardized forms. Predictors with p-values < 0.05 were included in multivariate logistic regression analysis for identification of independent predictors using SPSS version 20.0.

Results: A total of 77 patients were included, with 40 (51.9%) aged below 50 and 37 (48.1%) above 50. Gender distribution comprised 28 (36.4%) males and 49 (63.6%) females. BMI < 23 kg/m² was in 31 (40.3%) patients, and BMI ≥ 23 kg/m² in 46 (59.7%). Smoking history was reported by 14 (18.2%), diabetes by 18 (23.4%), and hypertension by 24 (31.2%). Logistic regression analysis indicated that age ≥ 50 (aOR: 2.82), male gender (aOR: 2.75), palpable gallbladder (aOR: 4.62), positive Murphy's sign (aOR: 3.11), and gallbladder wall thickness ≥ 4 mm (aOR: 1.23) significantly associated with intraoperative difficulty ($p < 0.05$).

Conclusion: In conclusion, this study offers valuable information for clinicians involved in laparoscopic cholecystectomy by identifying preoperative variables associated with surgical complexity. The results emphasize the importance of considering age, gender, clinical indicators, and gallbladder wall thickness when assessing patients' risk profiles.

Keywords: Laparoscopic Cholecystectomy, Difficult Surgery, Predictive Factors, Intraoperative Difficulty, Preoperative Assessment.

Introduction

Laparoscopic cholecystectomy, a minimally invasive surgical procedure for gallbladder removal, has become the gold standard for treating gallstone-related diseases [1]. This technique offers advantages such as reduced postoperative pain, shorter hospital stays, and quicker recovery times compared to traditional open surgery [2]. However, despite its widespread adoption and success, laparoscopic cholecystectomy can still present challenges, particularly in cases where anatomical variations, inflammation, or other unforeseen factors complicate the procedure [3]. Difficult laparoscopic cholecystectomy, characterized by extended operative times, increased risk of intraoperative complications, and a potential need for conversion to open surgery,

underscores the importance of accurate preoperative assessment [3,4].

The ability to preoperatively predict the likelihood of encountering difficulties during laparoscopic cholecystectomy has the potential to significantly impact patient outcomes, optimize surgical planning, and improve resource allocation. Identifying patients at higher risk for difficult procedures allows surgical teams to tailor their approach, allocate additional time, and anticipate potential complications [5]. Moreover, this predictive capability can aid in counseling patients about potential risks and benefits, enabling them to make informed decisions about their surgical management [6].

Over the years, various clinical, radiological, and biochemical parameters have been proposed as potential predictors of difficult laparoscopic cholecystectomy [7]. These predictors encompass a wide range of factors, including patient demographics, gallbladder pathology, imaging findings, and laboratory values [8]. While some studies have reported promising associations between certain predictors and surgical outcomes, the lack of standardized criteria and consistent findings highlights the need for comprehensive research to establish reliable preoperative prediction models [4,8,9].

To address these gaps, we conducted a prospective cross-sectional study which aimed to comprehensively evaluate the preoperative predictors of difficult laparoscopic cholecystectomy. By prospectively enrolling a diverse cohort of patients scheduled for laparoscopic cholecystectomy, we aimed to rigorously assess a range of clinical, and imaging parameters for their potential predictive value. Our study endeavours to provide more accurate and clinically relevant insights into the factors contributing to procedural difficulty, thereby enhancing surgical decision-making and patient management.

Materials and Methods

Study Design and Setting

This prospective cross-sectional study was conducted at tertiary care hospital of North India, under the Department of General Surgery, over a period of 3 years from August 2020 to July 2023. The study protocol was approved by the Institutional Review Board (IRB). All participants provided written informed consent before enrolment.

Participants

Consecutive adult patients scheduled for elective laparoscopic cholecystectomy for symptomatic gallstone disease were eligible for inclusion. Patients with contraindications for laparoscopic surgery, history of previous upper abdominal surgery, or inadequate preoperative data were excluded from the study.

Sample Size Calculation

The sample size was calculated based on an estimated 30% prevalence of difficult laparoscopic cholecystectomy and a desired precision of $\pm$ 10% for the confidence interval. With a confidence level of 95%, the required sample size was determined to be 81 patients. During defined period of study, 81 patients were enrolled in the study, but the records were incomplete for the 4 patients and were excluded from the study, so the data of total 77 patients was analysed.

Operative Technique and Outcome Assessment

Before the procedure, patients were administered general anesthesia and placed in a supine position on the operating table. Pneumoperitoneum was established using a Veress needle or an open Hasson technique, and the intra-abdominal pressure was maintained at 10-12 mmHg. Standard four-port technique was utilized for trocar placement. A 10-mm trocar was inserted supraumbilically, serving as the primary camera port. Under direct vision, three additional 5-mm trocars were placed in the right upper quadrant: one in the midclavicular line just below the costal margin, another in the anterior axillary line at the level of the umbilicus, and the third in the subxiphoid region. The pneumoperitoneum was maintained throughout the procedure, and the laparoscope was inserted to visualize the abdominal cavity. The liver was retracted using atraumatic graspers to expose the gallbladder fossa. Dissection of Calot's triangle was performed using a combination of monopolar or bipolar cautery and ultrasonic shears.

The critical view of safety (CVS) technique was consistently employed to ensure the identification and protection of vital structures. After complete dissection of Calot's triangle, the cystic duct and artery were carefully dissected, double-clipped, and divided between the clips. Following CVS confirmation, the gallbladder was dissected off the liver bed, minimizing any trauma to adjacent structures. Adhesions, if present, were meticulously managed to prevent inadvertent injuries. The gallbladder was gently rotated and lifted to achieve appropriate tension for dissection. Upon complete mobilization, the gallbladder was placed within a retrieval bag and extracted through the umbilical port site. Care was taken to avoid spillage of bile or

gallstones during specimen removal. After gallbladder removal, careful inspection of the surgical field was conducted to ensure hemostasis. Any potential bleeders were cauterized or clipped as necessary. The port sites were closed using absorbable sutures or skin glue, and sterile dressings were applied. In cases where the predefined criteria for difficult laparoscopic cholecystectomy were met, a decision was made collectively by the surgical team to convert to open surgery.

Conversion was typically considered in the presence of extensive adhesions, severe inflammation, or difficulty in achieving the CVS due to anatomical variations. Any intraoperative complications, such as bleeding requiring transfusion, bile duct injury, visceral injury, or other unforeseen events, were documented in detail. The duration of the entire surgical procedure, from the initial skin incision to the closure of the last port site, was recorded in minutes.

Following the procedure, patients were monitored in the recovery room before being transferred to the surgical ward. Standard postoperative care protocols were followed, including pain management, early ambulation, and initiation of oral intake as tolerated. Discharge criteria were met in accordance with institutional guidelines. Cases were classified as "difficult" based on predefined criteria, including operative duration exceeding 120 minutes, intraoperative complications, or conversion to open surgery due to technical difficulties.

Data Collection

Preoperative patient data were collected prospectively using standardized data collection forms. Demographic information (age, gender, body mass index), and medical history (comorbidities, previous abdominal surgeries)were recorded. Preoperative imaging, including abdominal ultrasound was assessed for gallbladder size, presence of gallstones, and signs of inflammation. All intraoperative details, including surgical approach, operative duration, use of CVS technique, need for conversion, and any intraoperative complications, were recorded for subsequent analysis.

Statistical Analysis

Descriptive statistics were used to summarize demographic, clinical, and operative characteristics of the study population using the SPSS version 20.0. Continuous variables were presented as means ± standard deviations based on their distribution. Categorical variables were reported as frequencies and percentages.

Univariate analysis was conducted to assess the association between preoperative predictors and the occurrence of difficult laparoscopic cholecystectomy. Chi-square tests or Fisher's exact tests were used for categorical variables, and t-tests or Mann-Whitney U tests were used for continuous variables, as appropriate. Predictors with p-values < 0.05 in the univariate analysis were included in a multivariate logistic regression model to identify independent predictors of difficult procedures.

Ethical Considerations

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants, and patient confidentiality was ensured throughout the study.

Results

In our study, a total of 77 patients were enrolled in the study. The distribution of participants' characteristics is presented in Table 1. Of the participants, 40 (51.9%) were below 50 years of age, and 37 (48.1%) were aged 50 years or above. Gender-wise, 28 (36.4%) were male, and 49 (63.6%) were female. In terms of BMI, 31 (40.3%) had a BMI below 23 kg/m², and 46 (59.7%) had a BMI of 23 kg/m² or higher. Smoking history was reported by 14 (18.2%), while 63 (81.8%) did not smoke. Diabetes was present in 18 (23.4%), and hypertension was noted in 24 (31.2%) participants.

Table 1: Baseline characteristics of the patients (N=77)

Variable	Categories	Frequency	%
Age	< 50 years	40	51.9
	≥ 50 years	37	48.1
Gender	Male	28	36.4
	Female	49	63.6
BMI	< 23 kg/m²	31	40.3
	≥ 23 kg/m²	46	59.7
History of Smoking	Yes	14	18.2
	No	63	81.8
Diabetes Mellitus	Yes	18	23.4

	No	59	76.6
Hypertension	Yes	24	31.2
	No	53	68.8

The distribution of certain preoperative factors is outlined in Table 2. In terms of previous hospitalization due to acute cholecystitis, 20 (26.0%) participants had a history of hospitalization, while 57 (74.0%) did not. Similarly, 12 (15.6%) participants had undergone previous abdominal surgery, whereas 65 (84.4%) had not. Among those with a previous surgical abdominal scar, 9 (81.8%) were infraumbilical and 2 (18.2%) were supraumbilical. Palpable gallbladder was noted in 19 (24.7%) participants, while 58 (75.3%) did not have this feature. Murphy's sign was present in 33 (42.9%) participants, with 44 (57.1%) not exhibiting the sign.

Table 2: Clinical characteristics of the patients (N=77)

Variable	Categories	Frequency	%
Previous Hospitalization (Acute Cholecystitis)	Yes	20	26.0
	No	57	74.0
Previous Abdominal Surgery	Yes	12	15.6
	No	65	84.4
Previous Surgical Abdominal Scar	Infraumbilical	9	81.8
	Supraumbilical	2	18.2
Palpable Gallbladder	Yes	19	24.7
	No	58	75.3
Murphy's Sign	Yes	33	42.9
	No	44	57.1

The distribution of specific intraoperative characteristics is summarized in Table 3. Participants with gallbladder wall thickness of ≥ 4 mm were 42 (54.5%), while 35 (45.5%) had a thickness of < 4 mm. A contracted gallbladder was observed in 22 (28.6%) participants, whereas 55 (71.4%) did not exhibit this condition. Impacted gallbladder stone was present in 16 (20.8%) participants, and 61 (79.2%) did not have this condition. Pericholecystic fluid was detected in 47 (61%) participants, while 30 (39%) did not have it.

Table 3: Radiological characteristics of the patients (N=77)

Variable	Categories	Frequency	%
Gallbladder Wall Thickness	≥ 4 mm	42	54.5
	< 4 mm	35	45.5
Contracted Gallbladder	Yes	22	28.6
	No	55	71.4
Impacted Gallbladder Stone	Yes	16	20.8
	No	61	79.2
Pericholecystic Fluid	Present	47	61
	Absent	30	39

The distribution of key intraoperative variables is presented in Table 4. The time taken for laparoscopic cholecystectomy was less than 60 minutes for 25 participants (32.5%), while 42 participants (54.5%) had a duration of 60-120 minutes, and 10 participants (13%) required over 120 minutes. Bile spillage occurred in 18 participants (23.4%), while 59 participants (76.6%) had no bile spillage. Injury to the duct/artery was observed in 9 participants (11.7%), and 68 participants (88.3%) did not experience such injury. Regarding the need for conversion to open surgery, 5 participants (6.5%) required conversion, while 72 participants (93.5%) did not undergo conversion.

Table 4: Intraoperative characteristics of the patients (N=77)

Intraoperative Variables	Categories	Frequency	%
Time taken	< 60 min	25	32.5
	60-120 min	42	54.5
	> 120 min	10	13
Bile spillage	Yes	18	23.4
	No	59	76.6

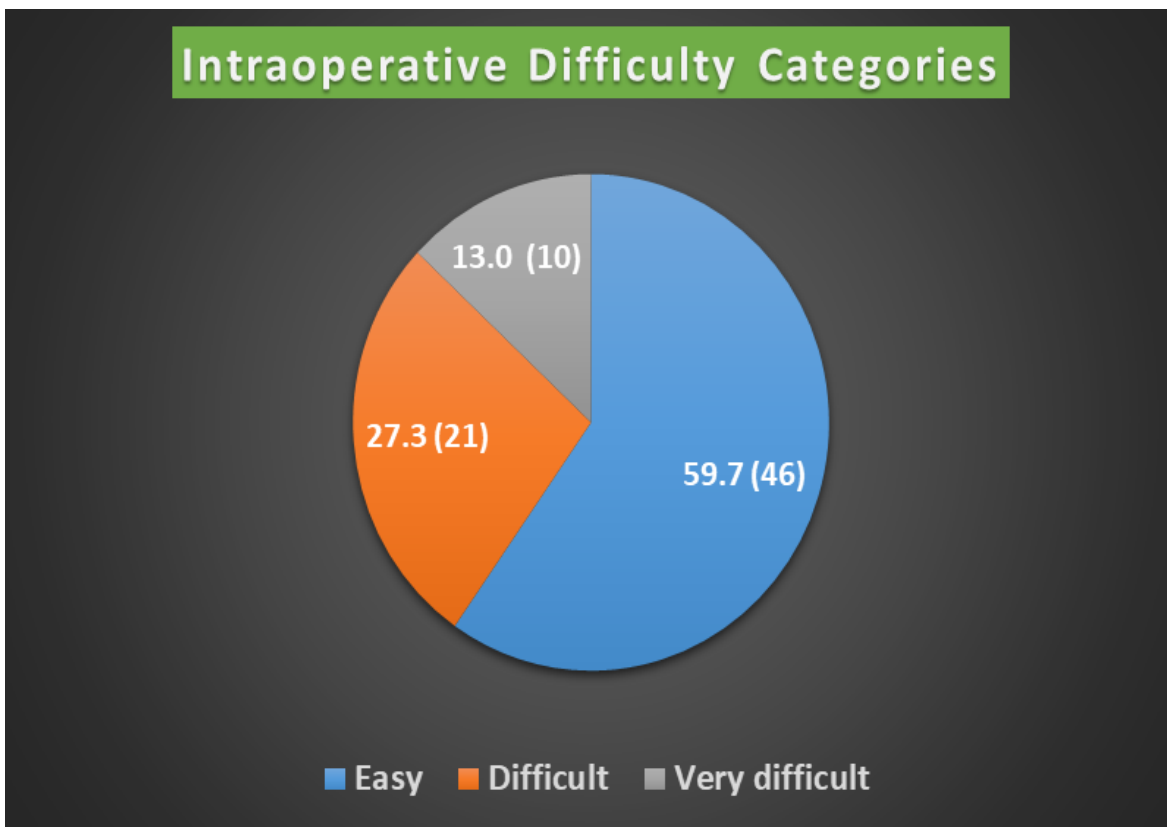|			
Injury to Duct/Artery	Yes	9	11.7
	No	68	88.3
Conversion to Open Surgery	Yes	5	6.5
	No	72	93.5

Figure 1: Intraoperative cholecystectomy difficulty categories distribution (N=77)

The levels of Intraoperative cholecystectomy difficulty are summarized in Figure 1. Among the cases, 46 (59.7%) were classified as "Easy," 21 (27.3%) as "Difficult," and 10 (13%) as "Very difficult." For analysis purpose the difficult and very difficult categories were clubbed and considered as "Difficult" (n=31).

The relationships between various preoperative variables and intraoperative difficulty levels (Easy vs. Difficult) are presented in Table 5. Among participants classified as "Easy," 30 (65.2%) were aged below 50 years, while 16 (34.8%) were aged 50 years or above. In contrast, among those classified as "Difficult," 10 (32.3%) were below 50 years, and 21 (67.7%) were aged 50 years or above.

Similar patterns are observed across other variables, such as gender, history of smoking, and presence of diabetes mellitus. Notably, variables like age (p=0.004), gender (p=0.005), previous hospitalization (p=0.036), previous abdominal surgery (p=0.042), palpable gallbladder (p=0.019), Murphy's sign (p=0.007), and gallbladder wall thickness (p=0.017) displayed statistically significant associations with intraoperative difficulty levels.

Table 5: Association of preoperative factors with the intraoperative difficulty among patients

Variable	Categories	Easy (n=46)	Difficult(n=31)	P-value
Age	< 50 years	30 (65.2)	10 (32.3)	0.004
	≥ 50 years	16 (34.8)	21 (67.7)	
Gender	Male	11 (23.9)	17 (54.8)	0.005
	Female	35 (76.1)	`	
BMI	< 23 kg/m²	21 (45.7)	10 (32.3)	0.239
	≥ 23 kg/m²	25 (54.3)	21 (67.7)	
History of Smoking	Yes	8 (17.4)	6 (19.4)	0.826

	No	38 (82.6)	25 (80.6)	
Diabetes Mellitus	Yes	9 (19.6)	9 (29.0)	0.335
	No	37 (80.4)	22 (71.0)	
Hypertension	Yes	14 (30.4)	10 (32.3)	0.865
	No	32 (69.6)	21 (67.7)	
Previous Hospitalization (Acute Cholecystitis)	Yes	8 (17.4)	12 (38.7)	0.036
	No	38 (82.6)	19 (61.3)	
Previous Abdominal Surgery	Yes	4 (8.7)	8 (25.8)	0.042
	No	42 (91.3)	23 (74.2)	
Previous Surgical Abdominal Scar	Infraumbilical	4 (8.7)	6 (19.4)	0.073
	Supraumbilical	0 (0.0)	2 (6.5)	
Palpable Gallbladder	Yes	7 (15.2)	12 (38.7)	0.019
	No	39 (84.8)	19 (61.3)	
Murphy's Sign	Yes	14 (30.4)	19 (61.3)	0.007
	No	32 (69.6)	12 (38.7)	
Gallbladder Wall Thickness	≥ 4 mm	20 (43.5)	22 (71.0)	0.017
	< 4 mm	26 (56.5)	9 (29.0)	
Contracted Gallbladder	Yes	14 (30.4)	8 (25.8)	0.659
	No	32 (69.6)	23 (74.2)	
Impacted Gallbladder Stone	Yes	7 (15.2)	9 (29.0)	0.142
	No	39 (84.8)	22 (71.0)	
Pericholecystic Fluid	Present	28 (60.9)	19 (61.3)	0.970
	Absent	18 (39.1)	12 (38.7)	

The results of the logistic regression analysis exploring the associations between preoperative variables and intraoperative difficulty levels are presented in Table 6. Several variables demonstrated significant associations with the likelihood of experiencing intraoperative difficulty. Patients aged $\geq$ 50 years had significantly higher odds of encountering difficult surgeries compared to those aged < 50 years (aOR: 2.82, 95% CI: 1.38-6.37, p = 0.002). Similarly, male patients exhibited higher odds of facing difficult surgeries than female patients (aOR: 2.75, 95% CI: 1.98-7.12, p = 0.001).The presence of certain clinical indicators also contributed to the likelihood of encountering difficulty during surgery. Patients with a history of acute cholecystitis-related hospitalization had substantially higher odds of experiencing difficult surgeries (aOR: 4.22, 95% CI: 0.99-10.46, p > 0.05). Palpable gallbladders were associated with increased odds of difficult surgeries (aOR: 4.62, 95% CI: 2.20-9.26, p = 0.0001), as were positive Murphy's signs (aOR: 3.11, 95% CI: 1.27-6.53, p = 0.016).

Gallbladder wall thickness also emerged as a significant factor. Patients with gallbladder wall thickness < 4 mm had lower odds of experiencing difficult surgeries compared to those with wall thickness ≥ 4 mm (aOR: 1.23, 95% CI: 1.04-5.21, p = 0.034).Other variables, such as previous abdominal surgery and previous surgical abdominal scars, showed associations with intraoperative difficulty, but their p-values did not reach statistical significance (p > 0.05).

Table 6: Univariate and multivariate analysis of preoperative variables with the intraoperative difficulty among patients

Variable	Easy (n=46)	Difficult (n=31)	OR (95% CI)	P value	aOR (95% CI)	P value
Age						
<50 years	30 (65.2)	10 (32.3)	3.93	0.004	2.82	0.002
$\geq$ 50 years	16 (34.8)	21 (67.7)	(1.49-10.35)		(1.38-6.37)	
Gender						
Male	11 (23.9)	17 (54.8)	3.86	0.005	2.75	0.001
Female	35 (76.1)	14 (45.2)	(1.45-10.28)		(1.98-7.12)	
Previous Hospitalization (Acute Cholecystitis)						
Yes	8 (17.4)	12 (38.7)	3.00	0.036	4.22	>0.05
No	38 (82.6)	19 (61.3)	(1.04-8.57)		(0.99-10.46)	
Previous Abdominal Surgery						

Yes	4 (8.7)	8 (25.8)	3.65	0.042	3.13	>0.05
No	42 (91.3)	23 (74.2)	(1.01-12.44)		(0.93-13.56)	
Palpable Gallbladder						
Yes	7 (15.2)	12 (38.7)	3.51	0.019	4.62	0.0001
No	39 (84.8)	19 (61.3)	(1.19-10.37)		(2.20-9.26)	
Murphy's Sign						
Yes	14 (30.4)	19 (61.3)	3.61	0.007	3.11	0.016
No	32 (69.6)	12 (38.7)	(1.38-9.42)		(1.27-6.53)	
Gallbladder Wall Thickness						
≥ 4 mm	20 (43.5)	22 (71.0)	3.17	0.017	1.23	0.034
< 4 mm	26 (56.5)	9 (29.0)	(1.20-8.38)		(1.04-5.21)	

OR: Odds ratio; aOR: Adjusted Odds ratio; CI: Confidence interval

Discussion

Laparoscopic cholecystectomy, a widely performed surgical procedure, has significantly improved patient outcomes due to its minimally invasive nature. However, intraoperative difficulties can pose challenges and impact surgical outcomes. This study aimed to identify preoperative predictors of difficult laparoscopic cholecystectomy and their associations with intraoperative difficulty.

Age and Gender Influence on Surgical Difficulty

The findings of this study underscore the importance of certain patient demographics and clinical indicators as potential predictors of intraoperative difficulty. Notably, age emerged as a significant factor, with patients aged ≥ 50 years being at higher risk of encountering difficult surgeries. This observation could be attributed to anatomical variations, tissue changes, or comorbidities associated with advanced age, which may hinder surgical maneuverability. These findings are in line with previous studies by Vijay et al., Elgammal et al., Rothman et al., Tripathi et al., and Gupta et al., [10-14].Gender also played a significant role, with male patients having increased odds of experiencing difficult surgeries. This finding is consistent with studies by Hussain et al., Rothman et al., and Gupta et al., which suggests that male gender might be associated with more complex anatomical variations or technical challenges during surgery [12,14,15].

Clinical Indicators of Surgical Complexity

Several clinical indicators provided valuable insights into the likelihood of intraoperative difficulty. A history of acute cholecystitis-related hospitalization was associated with a higher risk of encountering difficulties, indicating that patients with a history of inflammation might have anatomical changes that make dissection and visualization more challenging[16,17]. The presence of palpable gallbladders and positive Murphy's signs also predicted difficult surgeries, highlighting the significance of these clinical cues in preoperative assessment. These factors could indicate inflammation or adhesions that complicate dissection and increase the risk of bile spillage[18,19,20].

Gallbladder Wall Thickness and Surgical Complexity

Gallbladder wall thickness emerged as a noteworthy predictor, with thicker walls associated with a higher likelihood of encountering difficulties which was similar to the studies done by Atta et al., Nidoni et al., Buono et al., and Sugrue et al., [21-24]. Increased gallbladder wall thickness could suggest chronic inflammation or fibrosis, making dissection more intricate[25,26,27]. However, this finding could also have implications for preoperative planning, as surgeons might anticipate challenges in patients with thicker gallbladder walls.

In the context of previous abdominal surgeries and surgical scars, while the associations with intraoperative difficulty were observed, the p-values did not reach statistical significance. This suggests that although previous surgical history might play a role, its impact might be more nuanced and influenced by various patient-specific factors[28,29,30].

Limitations

While this study provides valuable insights, several limitations need to be acknowledged. The single-center nature of the study and the relatively modest sample size may limit the generalizability of the findings. Additionally, the study's retrospective design might introduce selection bias and potential confounding variables. Future research should involve larger multicenter studies to validate the current findings and explore other variables that could contribute to surgical difficulty, such as surgeon experience and technical skills.

Conclusion

In conclusion, this study offers valuable information for clinicians involved in laparoscopic cholecystectomy by identifying preoperative variables associated with surgical complexity. The results emphasize the importance of considering age, gender, clinical indicators, and gallbladder wall thickness when assessing patients' risk profiles. By doing so, surgical teams can better anticipate challenges and tailor their approaches accordingly, ultimately enhancing patient outcomes and safety during laparoscopic cholecystectomy. Further research is warranted to corroborate these findings and refine risk assessment models for surgical planning.

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