International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 11,November 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.11.2024.76

Original Research

Clinical, Biochemical, and Radiological Predictors of Difficult Laparoscopic Cholecystectomy and Conversion to Open Surgery

[1]Dr. Shreyans Patel, [2]Dr. Shalabh Gupta, [3]Dr. Naveen Kumar Solanki, [4]Dr. Shyam Nagpal, [5]Dr. Tripta S. Bhagat, [6]Dr. Gopal Agrawal, [7]Dr. Yogendra Kumar

[1]Postgraduate Resident, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
[2]Dean Academics and Professor, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
[3]Assistant Professor, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
[4]Professor, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
[5]Vice-Chancellor and Professor, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
[6]Assistant Professor, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
[7]Professor and Head, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.

Corresponding Author:
Dr. Shreyans Patel
Postgraduate Resident, Department of General Surgery, Santosh Medical College and Hospital, Santosh Deemed to be University, Ghaziabad (Uttar Pradesh), India.
ORCID: https://orcid.org/0009-0004-7504-7724
E-mail: dr.shreyanspatel@gmail.com

Received Date: 15 September 2024 Accepted Date: 17 October 2024

Abstract

Background: Laparoscopic cholecystectomy is a preferred surgical approach for gallbladder diseases. Predicting procedural complexity is vital for minimizing complications, enhancing surgical planning, and guiding surgeon selection. This study aimed to identify preoperative factors predicting difficult laparoscopic cholecystectomy.

Methods: This cohort study included 210 patients undergoing laparoscopic cholecystectomy. Patients requiring common bile duct exploration, those with gallbladder malignancy, or deemed unfit for laparoscopic surgery were excluded. A preoperative scoring system incorporating factors such as age, sex, history of cholecystitis, Body mass index, gallbladder wall thickness, and stone size was used. The Intraoperative parameters assessed were operative time, adhesions, spillage, injury, and conversion rates.

Results: Significant preoperative predictors of difficult laparoscopic cholecystectomy included a history of acute cholecystitis ($p = 0.00006$), presence of comorbidities ($p = 0.004$), higher ASA grade ($p = 0.0025$), thickened gallbladder walls ($p = 0.021$), larger stone size ($p = 0.022$), and elevated total leucocyte counts ($p = 0.00009$). Conversion to open surgery occurred in 6.7% of cases, primarily due to dense adhesions, impacted stones, and poor visualization of structures.

Conclusion: Preoperative factors such as history of acute cholecystitis, comorbidities, ASA grade, gallbladder wall thickness, large stone size, and elevated leucocyte counts were significantly associated with increased intraoperative difficulty and conversion rates. A standardized preoperative scoring system based on these predictors can improve surgical planning, reduce complications, and enhance patient outcomes.

Keywords: Laparoscopic Cholecystectomy, Preoperative Predictors, Surgical Difficulty, Gallbladder Wall Thickness, Conversion to Open Surgery, Acute Cholecystitis

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Introduction

Laparoscopic cholecystectomy is widely recommended as the preferred surgical approach for institutions with adequate expertise.[1]During the initial stages of adoption, a significant incidence of bile duct injuries and other complications occurred, largely due to the surgical learning curve.[2]Over time, however, the rate of severe lesions has declined, with reported incidences ranging from 0.08% to 0.12%, accounting for 1.5% of all cases.[2]Identified risk factors for conversion to open cholecystectomy include older men, history ofabdominal surgery, diabetes, obesity, thickened gallbladder wall, adhesions, and acute cholecystitis.[3]The procedure offers several advantages, such as reduced postoperative pain, shorter hospital stay, faster recovery, and improved cosmetic outcomes. Studies have consistently supported its association with lower levels of surgical trauma.[4]Despite extensive experience, the conversion rate for acute cholecystitis remains high at 28.5%, compared to 3.4% for nonacute cases, mainly due to dense adhesions and a friable, edematous gallbladder. Poor exposure of Calot's triangle and vascular adhesions complicates the procedure, increasing bleeding risks and obstructed visualization, which heightens the potential for bile duct injuries.[4]

Ultrasound being the preferred diagnostic tool due to its accuracy of up to 95% for gallstones and recommended foracute cholecystitis, with a sensitivity of 88% and specificity of 80%.[5]Predicting the complexity of laparoscopic cholecystectomy can guide the selection of an appropriate surgeon, facilitate optimal scheduling, enhance preoperative planning, and provide betterinformed consent, ultimately improving surgical outcomes.[6]An operative difficulty scale offers a valuable method for documenting disease severity and intraoperative complexity. Routine grading of operative difficulty is advisable for consistency and accuracy in clinical reporting.[7]

Study aimed to determine preoperative clinical, biochemical, and radiologicalparameters for predicting difficult laparoscopic cholecystectomy. Objective of the study was to determine correlation between preoperative findings and intraoperative findingsin operated cases of laparoscopic cholecystectomy.

Patients and Method

The study was conducted at Santosh Medical College and Hospital, Ghaziabad, and included 210 patients who underwent laparoscopic cholecystectomy from December 2022 to May 2024. Patients who required common bile duct exploration, presented with obstructive jaundice or gallbladder malignancy, or were deemed unfit for laparoscopic surgery were excluded. The institutional review board approved the study protocol.

Preoperative parameters included patient history, clinical factors, Ultrasound findingsand biochemical markers, and standardized scoring system.

Prediction of Difficulty Level Based on Score:

- 0-5: Easy
- 6-10: Difficult
- 11-20: Very difficult/conversion

Intraoperative Parameters Assessed:

The intraoperative parameters included duration of surgery, adhesions, bile or stone spillage, duct or artery injury, gallbladder extraction difficulty, and conversion to open cholecystectomy.

Criteria of Final Outcome Based on Intraoperative Parameters

- Easy Surgery: Surgery time ≤60 minutes with no other difficulties or >60 minutes without any difficulties.
- Difficult Surgery: Surgery time >60 minutes but ≤120 minutes with any difficulties.
- Very Difficult Surgery: Surgery time >120 minutes with any difficulties.

Statistical Analysis

Data were collected using a standardized form and analyzed using Microsoft Excel. Statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 26 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages. Group comparisons were performed using independent samples t-tests or Mann-Whitney U tests for continuous variables, and Chi-square or Fisher's exact tests for categorical variables. A p-value of <0.05 was considered statistically significant.

Result

In this study of 210 patients undergoing laparoscopic cholecystectomy, 74.76% were under 50 years old, and 73.81% were women. Diagnoses included asymptomatic cholelithiasis (54.76%), chronic calculus cholecystitis (19.52%) and acute calculus cholecystitis

DOI: 10.69605/ijlbpr_13.11.2024.76

(14.29%), mucocele of the gallbladder (5.71%), empyema of the gallbladder (3.33%), and ruptured gallbladder (1.43%).

Most patients (57.1%) had a BMI under 25, and 68.57% of patients had no comorbidities. Hypertension was observed in 10.48% of patients, followed by thyroid disorders in 9.52% and diabetes in 4.29%. Combined conditions included hypertension and diabetes in 2.38%, hypertension and thyroid disorder in 1.90%, and diabetes with thyroid disorder in 1.43%. 30.47% were having ASA grade 2 and 1 patient having grade 3.

Overdistended gallbladders were observed in 14.28% and contracted in 11.43% of patients, with 12.4% having thickened wall, 61.9% having stones larger than 1 cm and 2.9% having pericholecystic fluid collection. Out all cases 9.5% had raised total leucocyte counts and 10% had elevated alkaline phosphatase.

Intraoperative outcomes of laparoscopic cholecystectomy in 210 patients revealed that 36.2% of surgeries lasted ≤60 minutes, 43.8% took 61-120 minutes, and 20% exceeded 120 minutes. Dense adhesions were encountered in 39.5% of cases. However, bile spillage occurred in 5.7%, bile and stone spillage in 4.8%, and stone spillage alone in 1%, 1.9% experienced artery injury and 0.5% had combined artery and duct injury. Difficult gallbladder extraction was noted in 55.7% of patients. Conversion to open cholecystectomy occurred in 6.7% of cases. Overall, 48.1% of surgeries were classified as easy, 33.3% as difficult, and 18.6% as very difficult.

Table: 1 Proposed Pre-Operative Scoring System

NO	PREOPERATIVE PARAMETERS	FINDINGS	SCORE
History			
1	Age	<50/≥50 years	0/1
2	Gender	Women/Men	0/1
3	History of cholecystitis	No/Yes	0/4
4	Comorbidities with ASA grade	No with ASA 1/Yes with ASA 2 or ASA 3	0/1
Clinical Factors			
5	Body Mass Index (BMI)	<25/25-27.5/>27.5	0/1/ 2
6	Palpable gallbladder	No/Yes	0/1
7	Abdominal scar	No/Infra-umbilical/Supra-umbilical	0/1/2
Ultrasound Findings			
8	Gallbladder status	Normal/Contracted/Distended	0/1
9	Pericholecystic collection	No/Yes	0/1
10	Wall thickness	Thin ≤4mm/Thick >4mm	0/2
11	Impacted stone	No/Yes	0/1
12	Stone size	<1cm/≥1cm	0/1
Biochemical Markers			
13	Total Leucocyte Count	Normal/Raised	0/1
14	Alkaline Phosphatase	Normal/Raised	0/1
	Total		**20**

ASA: American Association of Anesthesiologists, ASA grade ≥4 excluded.

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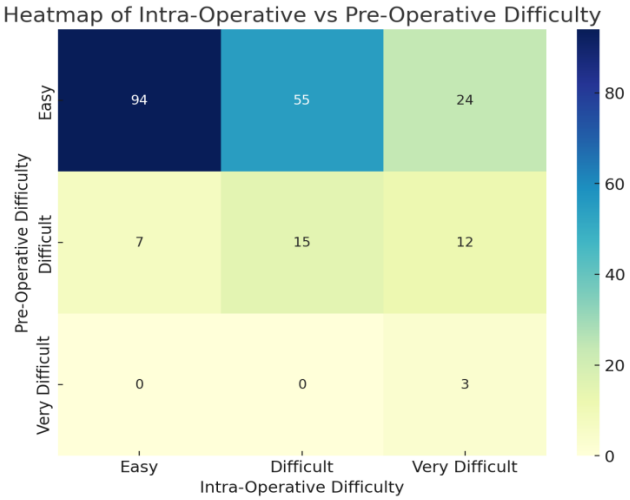

Figure 1 The heatmap illustrates the distribution of intra-operative difficulty across different pre-operative difficulty levels. The color intensity indicates the number of cases.

Table 2 Association between preoperative parameters and operative findings

Preoperative Parameters	Operative Time Association (P-Value) *	Adhesion Association (P-Value) *	Spillage Association (P-Value) *	Injury Association (P-Value) *	Extraction Difficulty Association (P-Value) *
Age	0.120	**0.033**	0.471	1.000	0.111
Gender	0.232	**0.029**	0.274	1.000	0.718
History Of Cholecystitis	**0.0001**	**0.003**	0.315	1.000	0.353
Comorbidity	0.104	**0.024**	0.317	0.625	0.512
ASA Grade	0.054	**0.024**	**0.018**	0.888	0.386
Body Mass Index	0.191	0.341	0.951	0.727	0.472
Palpable Gall Bladder	0.524	1.000	1.000	1.000	1.000
Abdominal Scar	**0.013**	0.566	0.890	0.245	0.715
Gallbladder Status	**0.007**	**0.007**	0.152	0.212	0.608
GallbladderWallThickness	**0.018**	**0.025**	1.000	0.870	1.000
Gall Stone Size	0.552	1.000	1.000	0.872	**0.0001**
Peri-Cholecystic Fluid	0.130	1.000	1.000	1.000	0.241
Impacted Stone	**0.008**	**0.008**	1.000	1.000	0.392
Total Leucocyte Count	**0.0003**	**0.0007**	0.426	1.000	0.194
Alkaline Phosphatase	0.244	0.845	0.731	1.000	0.220
Preoperative Score	**0.001**	**0.0001**	0.038	0.999	0.677

ASA: American Association of Anesthesiologist, *p-value <0.05 is significant.

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Table:3 Association between Operative Difficulty and Conversion to Open Surgery Based on Preoperative Parameters

Preoperative Parameters	Category	Operative Difficulty				Conversion To Open		
		Easy (%)	Difficult (%)	Very Difficult (%)	Difficulty (P-Value) *	No (%)	Yes (%)	Conversion (P-Value) *
Age	<50	81(80.1)	49(70)	27(69.2)	0.217	147(93.6)	10(6.4)	1.000
	>=50	20(19.8)	21(30)	12(90.7)		49(92.5)	4(7.5)	
Gender	Women	76(75.2)	55(78.5)	24(61.5)	0.137	147(94.8)	8(5.2)	0.248
	Men	25(24.7)	15(21.4)	15(38.4)		49(89.1)	6(10.9)	
History Of Cholecystitis	Acute	2(1.9)	7(10)	10(25.6)	**0.0006**	12(63.2)	7(36.8)	**0.0001**
	Chronic	99(98.0)	63(90)	29(74.3)		184(96.3)	7(3.7)	
Comorbidity	None	80(79.2)	39(55.7)	25(64.1)	**0.0040**	133(92.3)	11(7.6)	0.592
	Present	21(20.7)	31(44.2)	14(35.8)		63(95.45)	3(4.55)	
Asa Grade	Asa1	81(80.1)	39(55.7)	25(64.1)	**0.0025**	134(92.4)	11(7.6)	0.714
	Asa2	20(19.8)	31(44.2)	13(33.3)		61 (95.3)	3 (4.7)	
	Asa3	0(0.0)	0(0.0)	1(2.5)		1 (100)	0 (0.0)	
Body Mass Index	<25	60(59.4)	42(60.0)	18(46.1)	0.346	115(95.8)	5 (4.2)	0.080
	25-27.5	26(25.7)	20(28.5)	11(28.2)		53 (93.0)	4 (7.0)	
	>27.5	15(14.8)	8(11.4)	10(25.6)		28 (84.8)	5(15.2)	
Palpable Gallbladder	No	101(100)	69(98.5)	39(100)	0.366	195(93.3)	14(6.7)	1.000
	Yes	0(0.0)	1(1.4)	0(0.0)		1 (100.0)	0 (0.0)	
Abdominal Scar	No	64(63.3)	37(52.8)	29(74.3)	**0.045**	120(92.3)	10(7.7)	**0.0001**
	Infraumbilical	37(36.6)	32(45.7)	8(20.5)		75 (97.4)	2 (2.6)	
	Supraumbilical	0(0.0)	1(1.4)	1(2.5)		1 (50.0)	1(50.0)	
	Infra And Supra Umbilical	0(0.0)	0(0.0)	1(2.5)		0 (0.0)	1(100.0)	
Gallbladder Status	Normal	86(85.1)	49(70.0)	21(53.8)	**0.002**	150(96.2)	6 (3.8)	**0.017**
	Contracted	8(7.9)	9(12.8)	7(17.9)		21 (87.5)	3 (12.5)	
	Overdistended	7(6.9)	12(17.1)	11(28.2)		25 (83.3)	5 (16.7)	
Gallbladder Wall Thickness	Normal	95(94.0)	58(82.8)	31(79.4)	**0.021**	173(94.0)	11 (6.0)	0.519
	Thickened	6(58.4)	12(17.1)	8(20.5)		23 (88.5)	3 (11.5)	
Gall Stone Size	<1 Cm	42(41.5)	15(21.4)	13(33.3)	**0.022**	65 (92.9)	5 (7.1)	1.000
	>=1 Cm	59(58.4)	55(78.5)	26(66.6)		131(93.6)	9 (6.4)	
Pericholecystic Fluid	No	98(97.0)	70(100)	37(94.8)	0.209	192(93.7)	13 (6.3)	0.762
	Yes	3(2.9)	0(0.0)	2(5.1)		4 (80.0)	1 (20.0)	
Impacted Stone	No	100(99.0)	66(94.2)	33(84.6)	**0.002**	188(94.5)	11 (5.5)	**0.028**
	Yes	1(0.9)	4(5.7)	6(15.3)		8 (72.7)	3 (27.3)	
Total Leucocyte Count	Normal	97(96.0)	64(91.4)	28(71.7)	**0.00009**	178(94.2)	11 (5.8)	0.310
	Raised	4(3.9)	6(8.5)	11(28.2)		18 (85.7)	3 (14.3)	
Alkaline Phosphatase	Normal	96(95.0)	63(90.0)	33(84.6)	0.123	179(93.2)	13 (6.8)	1.000
	Raised	5(4.9)	7(10.0)	6(15.3)		17 (94.4)	1 (5.6)	
Preoperative Score	Easy	94(54.3)	55(31.7)	24(13.8)	**0.0003**	167(96.5)	6(3.4)	**0.0001**
	Difficult	7(20.5)	15(44.1)	12(35.2)		28(82.3)	6(17.6)	
	Very Difficult	0(0.0)	0(0.0)	3(100.0)		1(33.3)	2(66.6)	

ASA: American Association of Anesthesiologists, *p-value <0.05 is significant.

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Discussion

This study analyzed 210 cases to identify predictive factors for difficult laparoscopic cholecystectomy based on history, biochemical, and radiological parameters. The majority of patients were aged 40-49 years (29.05%), consistent with established gallstone demographics.[8]Most were women (73.81%), aligned with previous reports from Gupta et al. (2018).[9]indicating a higher prevalence of gallstones in women. Men were not significantly associated with surgical difficulty ($p = 0.137$), as reported by both Gupta et al. (2018)[9] and Rosen et al. (2002).[10]

A history of acute cholecystitis was a significant predictor of difficulty, with 63.16% of these cases facing challenges. The number of acute cholecystitis episodes correlated strongly with intraoperative difficulty ($p = 4\times10^{-7}$). Previous infraumbilical surgeries were significantly linked to conversion to open surgery ($p = 0.015$), supported by studies from Ercan et al. (2010)[11] and Kama et al. (2001)[12],though contradicted by Randhawa et al. (2009).[13]

Comorbidities were significant predictors of intraoperative adhesions ($p = 0.0241$) and surgical difficulty ($p = 0.004$). Higher ASA grades were associated with greater operative difficulty ($p = 0.0025$), consistent with the findings of Griffiths et al. (2019)[7]. In contrast, BMI did not significantly impact surgical outcomes ($p = 0.114$ for BMI 25-27.5 and $p = 0.21$ for BMI >27.5), similar to observations by Philip et al. (2023).[14]A palpable gallbladder was present in only one patient, showing no statistical correlation with difficulty.

Elevated preoperative leucocyte counts significantly predicted dense adhesions ($p = 0.0007$), prolonged surgery ($p = 0.0003$), and surgical difficulty ($p = 0.00009$), consistent with Buono et al. (2021)[15] and Lipman et al. (2007).[16]Conversely, alkaline phosphatase (ALP) levels were not significantly related to surgical difficulty ($p = 0.1235$) or conversion ($p = 1.000$), in agreement with other studies.[10][15]

Gallbladder status played a critical role; overdistended gallbladders were linked with increased operative time ($p = 0.0078$), dense adhesions ($p = 0.007$), and higher conversion rates ($p = 0.0171$). Thickened gallbladder walls were predictive of adhesions ($p = 0.0251$), prolonged surgery ($p = 0.0182$), and increased operative difficulty ($p = 0.012$), consistent with previous findings.[14][10][17]Stone size and impaction significantly affected surgical outcomes, with larger stones correlating with extraction difficulties ($p = 0.0001$) and operative challenges ($p = 0.0228$). Impacted stones were associated with prolonged operative time ($p = 0.0085$), bile and stone spillage ($p = 0.0001$), dense adhesions ($p = 0.0085$), and conversion ($p = 0.0282$), consistent with findings by Ibrahim et al. (2018)[18]and Bhardwaj et al. (2018).[19]

Preoperative risk scores correlated significantly with intraoperative difficulty ($p = 3.05\times10^{-5}$) and conversion rates ($p = 1.50\times10^{-6}$). This study's conversion rate (6.7%) aligns with Gupta et al. (2018)[9], which reported a 4% rate.Reasons for conversion included dense adhesions, frozen Calot’s triangle, poor visualization of critical structures, and gangrenous gallbladders. Conversion cases in patients preoperatively graded as "easy" were often due to anatomical variations and anomalies in the Calot’s region.The calculated values for Positive Predictive Value (PPV) and Negative Predictive Value (NPV) are 27.52% and 93.07%, respectively. This indicates that while the model's ability to correctly predict "difficult" cases is moderate, it is highly reliable in identifying "easy" cases based on pre-operative difficulty scores.

Implementing a standardized scoring system for predicting difficult laparoscopic cholecystectomy can enhance global surgical practice, improving patient outcomes through consistent evaluations and preparedness for intraoperative challenges, including timely conversion to open surgery if necessary.

Conclusion

This study identified significant preoperative factors predicting difficult laparoscopic cholecystectomy, including a history of acute cholecystitis, comorbidities, ASA grade, gallbladder status, wall thickness, stone size, and total leucocyte counts. These factors were significantly associated with longer surgery times, increased adhesions, and higher rates of conversion to open surgery. Implementing a standardized scoring system based on these predictors can enhance preoperative planning, patient counseling, and intraoperative decision-making, ultimately improving surgical outcomes and reducing complications.

Declarations

Funding: The authors did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests: The authors have no relevant financial or non-financial interests to disclose and declare that there are no conflicts of interest regarding the publication of this article.All aspects of the study were conducted with full academic independence.

Ethics Approval: This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional ethics committee.

DOI: 10.69605/ijlbpr_13.11.2024.76

Informed Consent: All participants provided informed consent prior to their inclusion in the study. The confidentiality of the participants' personal information was strictly maintained throughout the study.

Consent to Publish: The authors affirm that human research participants provided informed consent for the publication of any potentially identifying images or data included in this article.

Data Availability: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.Due to patient confidentiality access has been restricted.

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