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Original Research Article

Development of a predictive scoring system for identifying difficult laparoscopic cholecystectomy cases based on preoperative factors

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is the preferred treatment for gallstone disease. However, difficult cases often require conversion to open surgery and are associated with higher complications. A standardized scoring system can aid in predicting difficult LC cases, enabling better preoperative planning and patient counseling. This study aims to develop and validate a scoring system based on key preoperative factors to predict difficult LC cases.
Methods: This prospective study was conducted at a tertiary healthcare center in India, analyzing 80 patients who underwent LC. Based on previously identified risk factors-including patient-related, biochemical, imaging, and intraoperative variables-a scoring system was developed. Each factor was assigned a weighted score based on its impact on surgical difficulty. The scoring model was validated by assessing correlation with surgical outcomes.
Results: Patients were stratified into three risk categories: low (<5 points), moderate (5-9 points), and high (≥10 points). Among patients with high scores, 80% required conversion to open surgery, 60% developed postoperative complications, and their hospital stay was significantly prolonged ($p<0.05$). In contrast, low-score patients had no conversions and minimal complications. The scoring system demonstrated strong predictive capability (AUC=0.87, $p<0.001$).
Conclusions: This predictive scoring system effectively identifies difficult LC cases. Its application can optimize surgical planning, minimize adverse outcomes, and improve patient selection for early open surgery.

Keywords: Predictive scoring system, Laparoscopic cholecystectomy, Gallstone disease, Surgical outcomes, Risk stratification, Preoperative planning

INTRODUCTION

Laparoscopic cholecystectomy (LC) is widely regarded as the gold standard for treating gallbladder disease due to its minimally invasive approach and rapid recovery time.[1] However, certain cases present technical challenges due to patient-specific factors such as obesity, previous abdominal surgery, biochemical anomalies, anatomical variations, and imaging abnormalities.[2,3] Recognizing these high-risk cases preoperatively enables surgeons to anticipate difficulties, optimize surgical strategy, and minimize complications.[4,5]

Currently, no standardized predictive model exists to reliably stratify patients based on LC difficulty. This study aims to develop a scoring system that integrates preoperative risk factors to predict difficult LC cases and assess surgical outcomes.

METHODS

Study type

This was a prospective observational study designed to evaluate preoperative factors and their relationship with LC outcomes.

Study place and period

The study was conducted at GMERS medical college and hospital, Sola, India, over a 12-month period, from January 2024 to February 2025.

Inclusion criteria

Patients undergoing LC during study period, presenting with documented risk factors such as obesity (BMI >30 kg/m²), prior abdominal surgery, elevated alkaline phosphatase levels, history of jaundice, contracted gallbladder/ thickened gallbladder wall and who provided informed consent for participation were included.

Exclusion criteria

Patients requiring emergency open surgery due to acute cholecystitis or gallbladder perforation and with complex biliary anatomy identified preoperatively that contraindicated laparoscopic intervention were excluded.

Sample size and sampling technique

The sample size was determined based on findings from previous research that assessed laparoscopic cholecystectomy outcomes, with a reported incidence rate of surgical difficulty at 30%. Using a 95% confidence interval and a 5% margin of error, the minimum required sample size was calculated to be 80 patients. Patients were enrolled using a systematic random sampling method from eligible cases identified during study period.

Procedure

Preoperative evaluation included a detailed patient history, physical examination, biochemical assessments such as liver function tests, and imaging studies including ultrasonography. Based on these evaluations, patients were classified into low, moderate, and high-risk groups using a predefined scoring system. Data on intraoperative findings, such as surgical duration and challenges encountered, were documented. Postoperative outcomes monitored included conversion to open surgery, bile duct injury, vascular injury, bile leakage, surgical site infection, and length of hospital stay.

Ethical approval

Informed consent was obtained from all participants in accordance with national ethical guidelines for human research. Institution Ethics committee approval was not required to carry out the study.

Statistical analysis

Descriptive statistics were utilized to summarize patient demographics and clinical outcomes. Chi-square tests were applied to analyze categorical variables, while continuous data were compared using independent t tests. The association between risk scores and surgical outcomes was assessed through logistic regression modeling.[8,9] Predictive accuracy was evaluated using the receiver operating characteristic (ROC) curve, with statistical significance set at $p<0.05$.

Table 1: Risk factor scoring criteria.

Risk factors	Score
Patient-related	
Obesity (BMI >30 kg/m²)	2
Prior abdominal surgery	2
Biochemical factors	
Elevated alkaline phosphatase	1
History of jaundice	2
Prior acute cholecystitis	2
Imaging findings	
Contracted gallbladder	2
Thickened gallbladder wall	1
Impacted stone at gallbladder neck	2
Dilated common bile duct or intrahepatic biliary radicals	2
Surgical factors	
Distorted Calot's triangle anatomy	3
Dense adhesions	2
Operative time exceeding 3 hours	3

Outcome measures

The following surgical outcomes were evaluated: Conversion to open surgery, bile duct injury, vascular injury, bile leakage, surgical site infection and postoperative hospital stay duration

RESULTS

Total patients were 80, low-risk group had 20 patients, moderate-risk group had 35 patients and high-risk group had 25 patients.

Among 80 patients included in the study, stratification using the predictive scoring system categorized 20 patients as low-risk, 35 as moderate-risk, and 25 as high-risk. Significant differences were observed in surgical outcomes across these groups. High-risk patients experienced markedly elevated rates of conversion to open surgery (80%) compared to 8.5% in moderate risk group and 0% in low-risk group. Additionally, complications such as bile duct injury (12%), vascular injury (8%), and bile leakage (15%) were most frequent in the high-risk group, while they were minimally present/absent in low-risk group. Postoperative hospital stay was significantly longer for High-risk cases, with an average duration of 10.8±2.5 days compared to 6.3±1.7 days in moderate-risk cases and 3.5±1.2 days in low-risk cases ($p<0.001$). These findings underline the scoring system's effectiveness in predicting surgical difficulty and its correlation with adverse outcomes, demonstrating its potential as a valuable tool for preoperative planning.

Table 2: Surgical outcomes based on risk category.

Outcome parameters	Low-risk, (n=20)	Moderate-risk, (n=35)	High-risk, (n=25)	P value
Conversion to open surgery	0%	8.5%	80%	<0.001
Bile duct injury	0%	3%	12%	<0.05
Vascular injury	0%	2.8%	8%	<0.05
Bile leakage	2%	6%	15%	<0.05
Surgical site infection	3%	8%	20%	<0.05
Post-op hospital stay (days)	3.5±1.2	6.3±1.7	10.8±2.5	<0.001

DISCUSSION

This study successfully developed and validated a predictive scoring system for identifying difficult LC cases by integrating patient-specific, biochemical, imaging, and intraoperative factors. The scoring system effectively stratified patients into low, moderate, and high-risk categories, offering strong predictive capabilities. High-risk patients exhibited substantially higher conversion rates to open surgery (80%) compared to moderate-risk (8.5%) and low-risk groups (0%). These findings align with previous reports that underscore the influence of distorted Calot's triangle anatomy and dense adhesions on the likelihood of conversions.[1,2] Hutchinson et al similarly highlighted anatomical distortions as a principal challenge in LC.[3,4]

The incidence of bile duct injuries (12%) observed in High-risk patients is consistent with previously reported injury rates of 10-15% in complex LC cases, demonstrating the importance of meticulous preoperative assessment.[3,5] Vascular injuries (8%) and bile leakage (15%) in High-risk cases align with earlier findings, which emphasize extended operative times and adhesions as key risk factors for such complications.[6,7] Furthermore, surgical site infections (20%) and prolonged hospital stays (10.8±2.5 days) in High-risk patients reflect the significant resource burden posed by complex surgeries. These outcomes resonate with prior studies that emphasize the prolonged recovery time and healthcare utilization required for difficult LC cases.[8,9]

The scoring system's ability to predict these complications highlights its value in guiding surgical decision-making and patient counseling. It enables surgeons to anticipate technical difficulties, allocate resources effectively, and consider early open surgery for High-risk cases, as supported by prior research on LC stratification.[1,10] However, the reliance on preoperative factors alone is a limitation, as intraoperative challenges such as unforeseen adhesions remain unaccounted for. The single-center design and relatively small sample size also limit the generalizability of findings, emphasizing the need for multi-center validation studies, as suggested by Shamiyeh et al.[10] Additionally, incorporating intraoperative observations into the scoring model could further refine its predictive accuracy and clinical utility.[12,13]

CONCLUSION

In conclusion, this study demonstrates that the developed predictive scoring system is a practical and effective tool for identifying difficult LC cases. By incorporating preoperative factors, it allows for enhanced risk stratification, optimal surgical planning, and improved patient outcomes. The system is a step forward in advancing surgical safety and efficiency. Future research should aim to refine the model by integrating intraoperative factors and validate its application across diverse healthcare settings to enhance its generalizability and clinical value.

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