International Surgery Journal
Freire LFL et al. Int Surg J. 2026 Apr;13(4):582-589
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902
DOI: https://dx.doi.org/10.18203/2349-2902.isj20260847

Systematic Review

Difficult cholecystectomy: a systematic review of predictive factors, surgical approaches and outcomes

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Received: 30 January 2026
Revised: 10 March 2026
Accepted: 23 March 2026

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ABSTRACT

Laparoscopic cholecystectomy is the standard surgical treatment for benign gallbladder disease; however, a substantial proportion of procedures are classified as difficult due to anatomical distortion, inflammation, or technical factors, resulting in increased operative complexity and higher complication rates. This literature review aims to synthesize current evidence regarding predictive factors, classification systems, surgical strategies, and clinical outcomes associated with difficult cholecystectomy. A systematic search was conducted in PubMed (Medline), Scopus, Web of Science, SciELO, and Google Scholar for studies published from 2010 and 2025 in English or Spanish addressing difficult cholecystectomy, predictive factors, classification systems, surgical approaches, and outcomes. The literature consistently identifies advanced age, male sex, obesity, comorbidities, previous abdominal surgery, acute cholecystitis, elevated inflammatory markers, and ultrasonographic findings such as gallbladder wall thickening and impacted stones as key predictors of difficult cholecystectomy. Classification systems including the Tokyo Guidelines, Nassar scale, Parkland grading, and G10 scoring system demonstrate high predictive value for operative difficulty, conversion, and complications. Bailout strategies such as subtotal laparoscopic cholecystectomy, fundus-first technique, and timely conversion to open surgery are associated with improved safety in complex cases. Early identification of predictive factors and systematic use of validated classification systems are essential to optimize surgical planning, reduce complications, and improve patient outcomes in difficult cholecystectomy.

Keywords: Difficult cholecystectomy, Predictive factors, Classification systems, Surgical approach, Complications

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the gold standard for the treatment of benign gallbladder disease and represents one of the most frequently performed surgical procedures worldwide. Its widespread adoption is supported by reduced postoperative pain, shorter hospital stay, faster recovery, and lower overall morbidity compared with open cholecystectomy.[1,2] Despite these advantages, a significant proportion of procedures are technically challenging and are classified as difficult cholecystectomies, particularly in emergency settings and in patients with advanced inflammatory disease.[3-5] Preoperative suspicion of difficult laparoscopic cholecystectomy has also been emphasized as a key element in surgical planning.[6]

The reported incidence of difficult LC ranges from 11% to 30%, depending on patient population, disease severity, and applied definitions.[1,7-9] Difficult cholecystectomy is commonly characterized by distorted anatomy, dense adhesions, severe inflammation, fibrosis, scleroatrophic gallbladder, or gangrenous changes, all of which hinder safe dissection of the hepatocystic triangle and achievement of the critical view of safety (CVS).[7,10-13]

Multiple preoperative predictive factors have been consistently associated with increased operative difficulty and risk of conversion to open surgery. These include advanced age, male sex, obesity, diabetes mellitus, previous abdominal surgery, acute or recurrent cholecystitis, and systemic inflammatory response.[4,6,8,14-20] Laboratory markers such as leukocytosis and elevated C-reactive protein have also been shown to correlate with increased technical complexity and adverse intraoperative conditions.[6,21-23]

Imaging findings play a crucial role in preoperative risk stratification. Ultrasonographic predictors of difficult LC include gallbladder wall thickening (>4 mm), pericholecystic fluid, impacted stones in Hartmann's pouch, scleroatrophic gallbladder, and bile duct dilatation.[1,4,16,17,24,25] Recently, radiologic nomograms and composite imaging-based scores have demonstrated improved predictive performance for difficult LC.[23,26-30]

To standardize assessment and improve surgical planning, several classification systems and predictive scoring tools have been developed, including the Tokyo Guidelines severity grading, the Nassar scale, Parkland grading system, AAST classification, and the G10 scoring system.[16,22,24,28]

When safe dissection cannot be achieved, bailout strategies are strongly recommended to minimize the risk of bile duct injury and other major complications. These include subtotal laparoscopic cholecystectomy, fundus-first (retrograde) dissection, lateral dorsal infundibular approaches, and timely conversion to open surgery.[3,13,17-19,29,31-34] Subtotal cholecystectomy, in particular, has gained increasing acceptance as a safe alternative in difficult cases, supported by systematic reviews and meta-analyses.[13,18,35,36]

The objective of this study is to systematically review the current literature regarding difficult cholecystectomy, focusing on the identification of preoperative predictive factors, available classification and grading systems, surgical strategies used in complex cases, and the clinical outcomes associated with these procedures. By synthesizing the existing evidence, this review aims to provide surgeons with an updated overview that may facilitate preoperative risk stratification, guide intraoperative decision-making, and improve patient safety in the management of difficult cholecystectomy.

METHODS

A systematic literature review was conducted to identify and analyze evidence related to difficult cholecystectomy, including definitions, predictive factors, classification systems, surgical approaches, outcomes, complications, and impact on clinical results and quality of life.

Inclusion criteria

Original studies and systematic reviews published between 2010 and 2025; articles in English or Spanish; studies addressing difficult cholecystectomy, predictive factors, classification systems, surgical approaches, and complications were included.

Exclusion criteria

Articles without specific data on cholecystectomy; opinion pieces, editorials, letters to the editor, or conference abstracts without full text; duplicate or inaccessible full-text articles were excluded.

Data sources and search strategy

Databases searched included PubMed (Medline), Scopus, Web of Science, SciELO, and Google Scholar. Search terms included:

"Difficult cholecystectomy," "predictive factors," "classification systems," "surgical approach," "complications," and "clinical outcomes," combined using Boolean operators.

The following search strategy was applied: ("difficult cholecystectomy" OR "complex cholecystectomy") AND ("predictive factors" OR "risk factors") AND ("surgical approach" OR laparoscopic OR open OR conversion) AND (outcomes OR complications), in order to identify relevant studies addressing predictive factors, surgical approaches, and outcomes of difficult cholecystectomy.

The databases were searched from January 2010 to January 2026.

Study selection followed PRISMA 2020 guidelines. Titles and abstracts were screened, followed by full-text review. Disagreements were resolved by consensus (Figure 1).[37]

A total of 1,200 records were identified through database searching, 280 duplicates were removed, 920 records were screened, 150 full-text articles were assessed for eligibility, and 50 studies were included in the final qualitative synthesis.

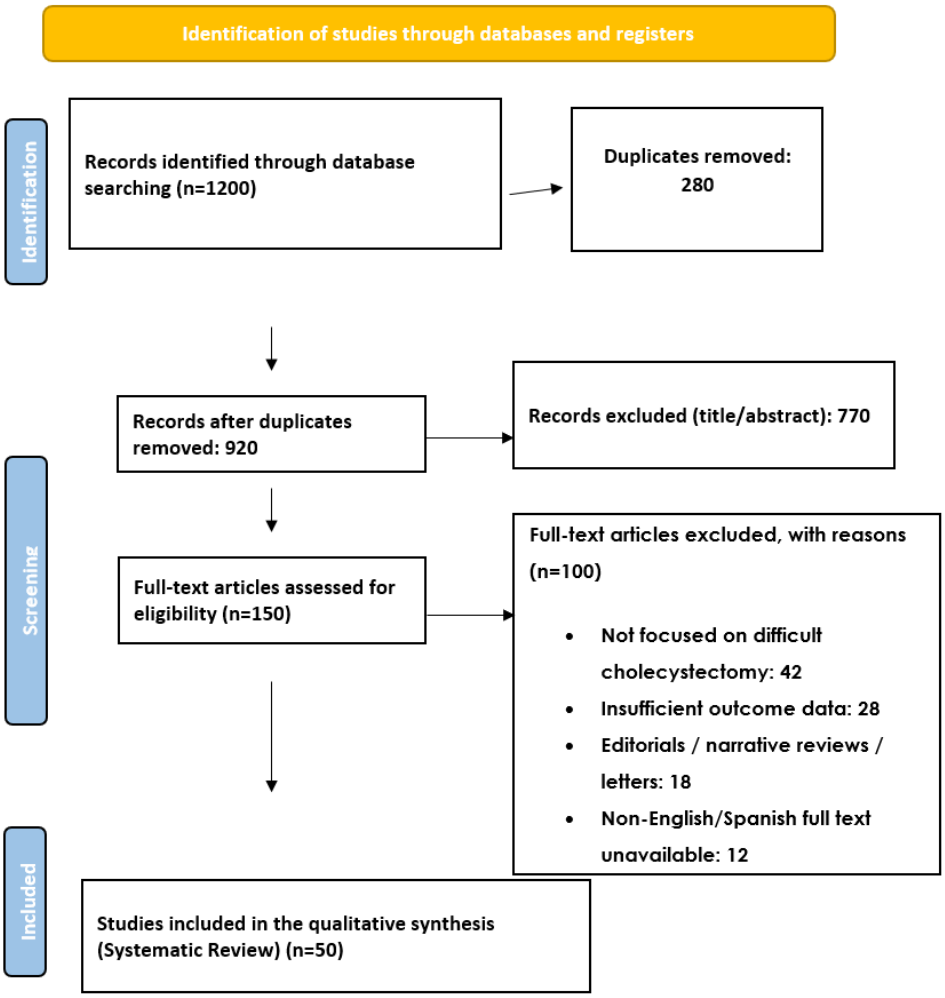

Figure 1: PRISMA 2020 flow diagram for study selection.

RESULTS

Laparoscopic cholecystectomy remains the standard approach, with success rates of approximately 90% in elective cases and 70% in emergency settings. Difficult cholecystectomy cases were consistently associated with longer operative time, increased blood loss, prolonged hospital stay, and higher conversion rates.

The available literature shows that difficult cholecystectomy is consistently associated with a set of both preoperative and intraoperative predictive factors, which significantly influence technical complexity, the need for conversion to open surgery, and postoperative outcomes. Clinical studies and reviews report that preoperative factors such as a history of recurrent cholecystitis attacks, increased gallbladder wall thickness, presence of large or multiple gallstones, gallbladder distension, and previous biliary endoscopic procedures are strongly associated with increased operative difficulty during laparoscopic cholecystectomy and a higher likelihood of conversion to an open approach.

In addition, sociodemographic and patient-related variables, including advanced age, obesity (high body mass index), male sex, and previous abdominal surgery, have been identified as significant predictors in multiple studies, although their relative impact varies depending on the population and clinical setting analyzed.

Regarding surgical outcomes, cases classified as difficult are associated with longer operative times, higher complication rates, increased use of alternative techniques such as subtotal cholecystectomy, and prolonged hospital stay compared with procedures considered technically easy. Several studies highlight the clinical usefulness of preoperative predictive scoring systems, such as the Randhawa and Pujahari score, which demonstrate good diagnostic performance in anticipating operative difficulty. These tools facilitate preoperative planning, risk communication with patients, and the implementation of contingency strategies, including early conversion when necessary, thereby improving surgical safety.

Concerning surgical approaches, laparoscopic cholecystectomy remains the standard of care; however, a

relevant proportion of difficult cases require conversion to open surgery, particularly in the presence of severe inflammation, dense adhesions, or distorted biliary anatomy. Such conversions are associated with increased operative time and postoperative morbidity.

Predictive factors

Advanced age, male sex, obesity, significant comorbidities, previous abdominal surgery, and acute cholecystitis were the most consistently reported predictors of difficulty. Laboratory markers including leukocytosis (>11,000/mm³), elevated C-reactive protein and fibrinogen levels, and anemia (Hb < 9 g/dl) were associated with increased operative complexity.

Ultrasonographic predictors included gallbladder wall thickening (>4 mm), pericholecystic fluid, impacted Hartmann's pouch stones, scleroatrophic gallbladder, and bile duct dilatation.

Intraoperatively, dense adhesions, severe inflammation, unclear anatomy, bleeding, and prolonged dissection of the hepatocystic triangle (>30 minutes) were strongly associated with difficult procedures and conversion (Table 1).

Table 1: Preoperative, ultrasonographic, and intraoperative predictors of difficult cholecystectomy identified in the literature.

Stage of assessment	Predictor	Specific criterion / definition	Clinical or surgical impact
Preoperative – Demographic	Advanced age	≥60 years	Increased operative difficulty and higher conversion rates
	Male sex	Male gender	Higher incidence of dense adhesions and prolonged dissection
	Obesity	BMI ≥30 kg/m²	Reduced surgical field visibility and increased operative time
	Significant comorbidities	ASA ≥III	Higher perioperative risk and complication rates
	Previous abdominal surgery	Upper abdominal procedures	Increased adhesions and distorted anatomy
	Acute cholecystitis	Clinical and imaging diagnosis	Strong predictor of difficult dissection and conversion
Preoperative – Laboratory	Leukocytosis	>11,000 cells/mm³	Marker of active inflammation and operative complexity
	Elevated C-reactive protein	>10 mg/l	Associated with severe inflammation and tissue friability
	Elevated fibrinogen	>400 mg/dl	Correlates with inflammatory severity and bleeding risk
	Anemia	Hemoglobin <9 g/dl	Increased perioperative risk and technical difficulty
Preoperative – Ultrasonographic	Gallbladder wall thickening	>4 mm	Indicates chronic or acute inflammation
	Pericholecystic fluid	Presence on ultrasound	Suggests severe inflammation or perforation risk
	Impacted Hartmann's pouch stone	Non-mobile stone	Distortion of Calot's triangle anatomy
	Scleroatrophic gallbladder	Contracted, fibrotic gallbladder	Strongly associated with difficult cholecystectomy
	Bile duct dilatation	>6 mm	Suggests biliary obstruction or chronic disease
Intraoperative	Dense adhesions	Extensive fibrotic adhesions	Prolonged dissection and increased conversion risk
	Severe inflammation	Friable, edematous tissues	Higher risk of bleeding and bile duct injury
	Unclear anatomy	Inability to achieve critical view of safety	Necessitates alternative techniques or conversion
	Intraoperative bleeding	Significant blood loss	Reduced visibility and increased complication risk
	Prolonged hepatocystic triangle dissection	>30 minutes	Strong predictor of difficult surgery and conversion

Table 2: Classification systems for predicting difficult cholecystectomy.

Classification system	Main purpose	Clinical implications of higher scores
Tokyo guidelines	Severity grading of acute cholecystitis	Increased operative difficulty, higher conversion and complication rates
Nassar scale	Intraoperative difficulty assessment	Greater need for subtotal cholecystectomy and prolonged operative time
Parkland grading system	Laparoscopic difficulty stratification	Higher rates of conversion and bile leakage
AAST classification	Anatomic and clinical severity grading	Increased morbidity and complex surgical decision-making
G10 scoring system	Preoperative and intraoperative risk prediction	Excellent discriminatory ability (AUC ≈ 0.88); higher rates of conversion, bile leakage, and longer operative time

Table 3: Surgical approaches for difficult cholecystectomy.

Surgical approach	Indication / role	Key advantages or outcomes
Subtotal laparoscopic cholecystectomy	Failure to achieve critical view of safety	Most supported bailout strategy; significantly reduces bile duct injury risk
Fundus-first (retrograde) dissection	Severe inflammation or distorted Calot's triangle	Improves safety when standard dissection is not feasible
Conversion to open surgery	Unclear anatomy, bleeding, or severe adhesions	Essential safety option to prevent major complications
Robotic cholecystectomy	Selected complex cases	Enhanced visualization and instrument articulation; potential reduction in technical difficulty
Endoscopic or percutaneous gallbladder drainage / cholecystostomy	High-risk surgical candidates	Minimally invasive alternatives to control infection and inflammation

Classification systems

The Tokyo Guidelines, Nassar scale, Parkland grading system, AAST classification, and G10 scoring system demonstrated high predictive value. Higher scores were associated with increased rates of subtotal cholecystectomy, conversion, bile leakage, and prolonged operative time. The G10 system showed excellent discriminatory ability (AUC ≈ 0.88) (Table 2).

Surgical approaches

Subtotal laparoscopic cholecystectomy emerged as the most widely supported bailout strategy, significantly reducing bile duct injury risk when critical view of safety cannot be achieved.[3,13,17-19,38,39] Fundus-first (retrograde) dissection and timely conversion to open surgery remain important safety options.[14,40,41] Robotic cholecystectomy has shown potential benefits in selected complex cases due to enhanced visualization and instrument articulation.[5,15] Endoscopic, percutaneous gallbladder drainage, and percutaneous cholecystostomy techniques are reserved for high-risk surgical candidates (Table 3).[11,42]

The majority of heavily cited studies were conducted in tertiary academic centers in Europe, Asia, and Latin America, with a smaller proportion from community hospitals and single-center cohorts.

DISCUSSION

Difficult laparoscopic cholecystectomy represents a complex surgical scenario associated with increased operative time, blood loss, length of hospital stay, and higher rates of conversion, subtotal cholecystectomy, and postoperative complications.[1,6,9,20,25] The multifactorial nature of operative difficulty underscores the importance of comprehensive preoperative assessment and intraoperative vigilance.

Consistent evidence supports advanced age, male sex, obesity, acute cholecystitis, and significant comorbidities as major predictors of difficult LC.[1,4,6,8,12,26,27,30,43] Inflammatory burden, reflected by elevated leukocyte count and C-reactive protein, has been independently associated with adverse intraoperative conditions and higher conversion rates.[6,21,26,30] These findings highlight the importance of early surgical timing and appropriate patient selection, particularly in acute cholecystitis, as supported by evidence favoring early cholecystectomy and optimized emergency pathways.[44-47]

Imaging-based predictors remain fundamental in preoperative planning. Gallbladder wall thickening, pericholecystic fluid, impacted stones, and scleroatrophic gallbladder are consistently reported as strong predictors of technical difficulty.[1,4,12,23,24,28,31-34,48] Emerging radiologic nomograms and composite scoring systems

have demonstrated superior predictive accuracy compared with single-parameter assessments, supporting their integration into routine preoperative evaluation.[23,28]

The adoption of validated classification systems allows objective stratification of surgical difficulty and facilitates standardized reporting and comparison across studies. The Nassar scale, G10 scoring system, Tokyo Guidelines severity grading, and other composite tools have demonstrated high discriminatory ability for predicting difficult LC, conversion to open surgery, and postoperative complications.[16,22,24,28] These systems are particularly valuable in training environments, for surgical planning, and for benchmarking institutional performance.

Bailout strategies play a pivotal role in ensuring patient safety when the critical view of safety cannot be achieved. Subtotal laparoscopic cholecystectomy has emerged as the most widely supported bailout procedure, with robust evidence demonstrating reduced risk of bile duct injury compared with continued dissection in hostile anatomy.[3,13,17-19,29,49,50] Recent cohort studies and long-term outcome analyses further support subtotal cholecystectomy as a safe and effective alternative to open conversion in appropriately selected patients.[42,51]

Fundus-first (retrograde) dissection and alternative anatomical approaches, such as the lateral dorsal infundibular technique, have also been shown to facilitate safe completion of difficult cases while minimizing biliary injury.[14,40,41] Importantly, conversion to open surgery should not be regarded as a failure but rather as a proactive safety strategy in cases of uncontrolled bleeding, unclear anatomy, or severe inflammation.[10,20,35]

Technological advances, including robotic cholecystectomy and fluorescence-guided surgery using indocyanine green, have shown promising results in selected difficult cases by enhancing visualization and anatomical identification.[5,15,49] However, their widespread adoption is limited by cost, availability, and learning curve considerations, particularly in low- and middle-income settings.

Bile duct injury remains the most feared complication of difficult LC and is strongly associated with distorted anatomy and forced dissection in inflamed fields.[25,37] Systematic reviews emphasize that adherence to the critical view of safety, early use of bailout strategies, and avoidance of excessive traction are key measures to reduce this risk.[7,10,25,37]

For high-risk surgical candidates or patients with severe sepsis or organ dysfunction, percutaneous and endoscopic gallbladder drainage techniques, including percutaneous cholecystostomy, represent important temporizing or definitive management options.[11,50] These approaches may stabilize patients and allow delayed definitive surgery in selected cases.

In addition to technical strategies, perioperative management plays a role in optimizing outcomes. Systematic reviews have evaluated perioperative pain control strategies in laparoscopic cholecystectomy, including wound infiltration with local anesthetics, which may contribute to enhanced recovery protocols and improved patient comfort.[48]

Overall, current evidence supports a structured, risk-adapted approach to difficult cholecystectomy, integrating preoperative prediction, standardized grading, and timely application of bailout techniques. Such an approach is essential to optimize outcomes, reduce major complications, and enhance patient safety.

CONCLUSION

Difficult cholecystectomy represents a major surgical challenge due to the multifactorial nature of operative complexity. Early identification of predictive factors and routine application of validated classification systems are essential to optimize surgical planning and minimize complications.

Individualized surgical strategies, including subtotal laparoscopic cholecystectomy and timely conversion to open surgery, significantly improve patient safety. Integration of evidence-based tools with expert clinical judgment is fundamental to achieving optimal outcomes in difficult cholecystectomy.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Freire LFL, Vizuete NGS, Vásconez LDCA, Miranda JPP. Difficult cholecystectomy: a systematic review of predictive factors, surgical approaches and outcomes. Int Surg J 2026;13:582-9.