

Factors Predictive of Achieving Critical View of Safety in Laparoscopic Cholecystectomy in A Tertiary Care Hospital

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Author's Contribution

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ABSTRACT

Objective: To determine the proportion of LC cases in which CVS is achieved and to identify preoperative and intraoperative factors predictive of its achievement.

Methodology: This Cross-sectional study was conducted from April to September 2024 at Islamabad Medical Complex, enrolling 152 consecutive adult patients undergoing elective or emergency LC for benign gallbladder pathology. CVS was defined according to SAGES criteria. Data on demographic, preoperative, intraoperative, and postoperative variables were collected using a structured proforma. Operative difficulty was graded using the modified Nassar scale.

Results: The mean patient age was 46.6 ± 14.5 years, with a male-to-female ratio of 1:2.3. CVS was achieved in 117 cases (77%) and not achieved in 35 cases (23%). Preoperative gallbladder wall thickening >3 mm was significantly associated with CVS failure ($p = 0.03$). Intraoperative factors linked to CVS non-achievement included higher operative difficulty grades III–V ($p < 0.001$), severe gallbladder pathology such as mucocele/empyema/gangrene/Mirizzi ($p < 0.001$), adhesions with the duodenum ($p < 0.001$) or colon ($p = 0.02$), abnormal Calot's triangle anatomy ($p = 0.04$), operative time >1 hour ($p < 0.001$), cystic duct ligation with sutures ($p < 0.001$), non-complete cholecystectomy ($p < 0.001$), and drain placement ($p < 0.001$). Postoperatively, CVS non-achievement was associated with prolonged antibiotic use ($p = 0.02$) and longer hospital stay ($p < 0.001$). No BDI or conversions occurred.

Conclusion: CVS can be achieved in most LC cases, but its likelihood is reduced by preoperative gallbladder wall thickening, higher operative difficulty grades, severe inflammatory pathology, adhesions, and abnormal anatomy. Early recognition of these predictors facilitates surgical planning, timely use of bailout strategies, and improved patient safety.

Keywords: Laparoscopic cholecystectomy, Critical View of Safety, bile duct injury, predictors, operative difficulty, gallbladder pathology

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Introduction

Laparoscopic cholecystectomy (LC) is currently regarded worldwide as the gold standard for the treatment of symptomatic cholelithiasis, having largely replaced the open approach over the past three decades due to its clear advantages in terms of postoperative recovery. Compared to open cholecystectomy, LC is associated with reduced postoperative pain, shorter hospital stay, faster return to daily activities, and improved cosmetic outcomes.^{1,2}

These benefits have contributed to its widespread adoption in both elective and emergency settings.

Despite these advantages, LC is not without risks. The overall complication rate is estimated at around 10%, with a higher incidence of bile duct injury (BDI) compared to the open approach — reported between 0.1% and 1.5% for LC versus 0.1% to 0.2% for open procedures.³ Although recent data indicate a declining trend in BDI rates (0.32–0.52%), no significant changes

have been observed in overall morbidity or mortality following LC.^{3,4}

BDI remains a serious complication, as its management often requires additional interventions such as endoscopic retrograde cholangiopancreatography (ERCP), complex biliary reconstruction, or even hepatic transplantation in selected cases. Such injuries are associated with substantial postoperative morbidity, increased mortality risk, and significant healthcare costs.^{1,5} Importantly, most BDIs are preventable through adherence to structured, evidence-based surgical protocols.

One of the primary causes of major bile duct injury is the misidentification of the common bile duct as the cystic duct or artery during dissection of Calot's triangle.⁶ To address this, Strasberg et al. introduced the concept of the "Critical View of Safety" (CVS) in 1995, providing a systematic method to identify biliary structures before division.⁶

The CVS technique has since been incorporated into the Safe Cholecystectomy Program of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) as one of six recommended strategies to reduce BDI risk.⁷ The three essential elements of CVS are: (1) clearance of the hepatocystic triangle of all fibrofatty tissue, (2) identification of only two tubular structures entering the gallbladder, and (3) separation of at least the lower one-third of the gallbladder from the cystic plate.^{6,7}

Emerging data affirm that achieving CVS dramatically reduces BDI risk and enhances surgical safety. A multicenter Italian study found that CVS is feasible and reproducible in both routine cases and complex scenarios, while also serving as a reliable method for trainee education.¹ Other research supports that CVS attainment correlates with lower rates of conversion to open surgery, fewer complications, and greater surgeon confidence.^{8,9} A systematic review further concluded that CVS was associated with a significant reduction in major bile duct injuries compared with non-CVS approaches.⁹

However, achieving CVS is not always feasible—particularly in cases of acute cholecystitis, chronic inflammation, dense adhesions, or abnormal anatomy—which may obscure vital landmarks and complicate dissection.^{6,10} In such cases, alternative "bail-out" techniques, such as subtotal cholecystectomy or fundus-first dissection, are recommended to preserve safety and prevent BDI.^{7,10}

Given the importance of CVS in ensuring safe LC, it is clinically relevant to determine how often CVS can be

achieved in real-world practice and to identify factors that may predict failure to obtain it. Such predictive factors can guide intraoperative decision-making, surgical training, and patient counseling, particularly in high-risk cases.

The present study was conducted to determine the proportion of LC cases in which CVS could be achieved despite the surgeon's best efforts and to identify preoperative and intraoperative predictors influencing its achievement. Understanding these factors will help in optimizing operative planning, enhancing safety, and ultimately reducing the incidence of bile duct injuries.⁶

Methodology

This cross-sectional study was conducted over a six-month period from April to September 2024 at at Islamabad Medical Complex. A total of 152 consecutive patients undergoing either elective or emergency LC for symptomatic cholelithiasis or other benign gallbladder pathologies were enrolled. The study population comprised adult patients aged 18 years or older. The patients requiring conversion to open surgery or those exhibiting malignant gallbladder pathology to maintain homogeneity of the sample were excluded from the study. Ethical Approval was taken from the institutional review board Ref no NESCOM-44(33)/2024-IMC dated March 29, 2024. All participants provided written informed consent prior to their inclusion in the study.

Sample size was determined using the WHO sample size calculator, with parameters set to detect an expected CVS achievement rate of 82.8% (derived from preliminary institutional data) with a 6% margin of error at 95% confidence level, resulting in a required sample of 152 patients.

The CVS was defined on by standards established by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), requiring fulfilment of three essential anatomical criteria: complete clearance of fibrofatty tissue from the hepatocystic triangle, positive identification of only two tubular structures (the cystic duct and artery) entering the gallbladder, and adequate separation of at least the lower third of the gallbladder from its cystic plate. All surgical procedures were performed by experienced consultant surgeons, utilizing a standardized four-port laparoscopic technique to ensure procedural consistency across cases.

A predesigned performa was used to record preoperative, intraoperative, and postoperative findings. All the

information regarding demographic profiling, comorbidities (particularly diabetes and hypertension), classification of admission type, duration of symptoms, history of previous abdominal surgeries, and ultrasound findings were noted.

The modified Nassar scale was employed to grade operative difficulty (ranging from I to V). Additional intraoperative variables included detailed assessment of Calot's triangle anatomy, surgical duration, method of cystic duct ligation (clips versus sutures), type of cholecystectomy performed (complete, subtotal, or amputation), and the decision regarding drain placement. Postoperative outcomes included complication rates, duration of antibiotic therapy, length of hospital stay, and any requirement for subsequent ERCP procedures.

Modified Nassar Scale for Operative Difficulty Grading.	
Grade	Description
I	Gallbladder: Floppy, non-adherent Cystic Pedicle: Thin and clear Adhesions: Simple up to the neck/Hartmann's pouch
II	Gallbladder: Mucocele, packed with stones Cystic Pedicle: Fat laden Adhesions: Simple up to the body
III	Gallbladder: Deep fossa, acute cholecystitis, contracted, fibrosis, Hartmann's adherent to CBD, impaction Cystic Pedicle: Abnormal anatomy or cystic duct—short, dilated, or obscured Adhesions: Dense up to fundus; involving hepatic flexure or duodenum
IV	Gallbladder: Completely obscured, empyema, gangrene, mass Cystic Pedicle: Impossible to clarify Adhesions: Dense, fibrosis, wrapping the gallbladder, duodenum or hepatic flexure difficult to separate
V	Mirizzi Syndrome type 2 or higher, cholecysto-cutaneous, cholecysto-duodenal or cholecysto-colic fistula

Statistical analysis was conducted using IBM SPSS version 26. Continuous variables were expressed as mean values with standard deviations and compared using Student's t-tests, while categorical variables were presented as frequencies and percentages, with chi-square or Fisher's exact tests used for comparisons as appropriate. The threshold for statistical significance was set at $p \leq 0.05$ for all analyses.

Results

Table I presents the overall demographic, preoperative, intraoperative, and postoperative characteristics of the study sample. The mean age was 46.6 ± 14.5 years. Females were 106 (69.7%) and males 46 (30.3%). Comorbidities were present in 43 (28.3%) participants, and diabetes in 21 (13.8%). Most admissions were

through OPD 136 (89.5%), with 20 (13.2%) having previous gallstone-related admissions. History of gallbladder disease was ≤ 30 days in 89 (58.6%) and > 30 days in 63 (41.4%). Preoperative ultrasound revealed pericholecystic fluid in 20 (13.2%), stone at the neck in 17 (11.2%), and wall thickening > 3 mm in 18 (11.8%). Operative difficulty grades I-II were observed in 130 (85.5%) and grades III-V in 22 (14.5%). Normal Calot's triangle anatomy was seen in 148 (97.4%) cases. Complete cholecystectomy was performed in 142 (93.4%), with drain placement in 66 (43.4%). Postoperatively, 138 (90.8%) had smooth recovery, 13 (8.6%) required intravenous antibiotics beyond 24 hours, and 1 (0.7%) required ERCP. Length of stay was 1 day in 121 (79.6%), 2 days in 22 (14.5%), and more than 2 days in 9 (5.9%).

Table II compares preoperative variables between the two groups. Gallbladder wall thickening > 3 mm on ultrasound was more frequent in the CVS not achieved group 8 (22.9%) compared to 10 (8.5%) in the CVS achieved group ($p = 0.03$). There were no statistically significant differences between groups for age, comorbidities, diabetes, gender, mode of admission, previous admissions, duration of symptoms, diagnosis at admission, previous abdominal surgery, previous ERCP, pericholecystic fluid, or stone at the neck.

Table III compares intraoperative variables between the two groups. CVS not achieved cases had higher operative difficulty grades III-V in 13 (37.2%) compared to 9 (7.7%) in the CVS achieved group ($p < 0.001$). Severe gallbladder pathology (mucocele, empyema, gangrenous, or Mirizzi) was found in 11 (31.5%) vs. 8 (6.8%) ($p < 0.001$). Adhesions with the duodenum were present in 12 (34.3%) vs. 10 (8.5%) ($p < 0.001$), and adhesions with the colon in 4 (11.4%) vs. 2 (1.7%) ($p = 0.02$). Abnormal Calot's triangle was observed in 3 (8.6%) vs. 1 (0.8%) ($p = 0.04$). Longer operative time > 1 hour occurred in 14 (40.0%) vs. 2 (1.7%) ($p < 0.001$). Cystic duct ligation with sutures was performed in 10 (28.6%) vs. 4 (3.4%) ($p < 0.001$). Non-complete cholecystectomy was performed in 9 (25.7%) vs. 1 (0.8%) ($p < 0.001$). Drain placement was done in 28 (80.0%) vs. 38 (32.5%) ($p < 0.001$).

Table IV compares postoperative outcomes. Prolonged postoperative antibiotics were required in 7 (20.0%) vs. 6 (5.1%) ($p = 0.02$). Hospital stay of 1 day occurred in 20 (57.2%) vs. 101 (86.3%), 2 days in 10 (28.6%) vs. 12

Table I: Demographics, preop intraop and postop variables of all participants.

Variable	Summary	Variable	Summary
Age (years)	Mean 46.6 ± 14.5	Duration of surgery	≤ 1 hr 89.4%, >1 hr 10.6%
Gender	Male 30.3%, Female 69.7%	CVS achieved	Yes 77%, No 23%
Comorbidities	Present 28.3% (≥ 1), None 71.7%	Cystic duct ligation	Clip 90.8%, Suture 9.2%
Diabetes	Yes 13.8%, No 86.2%	Nature of surgery	Complete 93.4%, Others 6.6%
Mode of admission	Emergency 10.5%, OPD 89.5%	Drain placement	Yes 43.4%, No 56.6%
Previous gallstone admission	13.2%	Adhesions (duodenum)	Present 14.5%, Absent 85.5%
History of GB disease	≤ 30 days 58.6%, >30 days 41.4%	Adhesions (colon)	Present 3.9%, Absent 96.1%
Previous abdominal surgery	34.2% (Upper abdominal 0.7%)	Calot's triangle anatomy	Normal 97.4%, Abnormal 2.6%
Previous ERCP	3.9%	Accessory cystic duct	Yes 2%, No 98%
Ultrasound findings	Pericholecystic fluid 13.2%, Stone at neck 11.2%, Wall >3 mm 11.8%	Operative difficulty	Grade I-II: 85.5%, Grade III-V: 14.5%
Pre-op diagnosis	Acute infection 17.1%, Biliary colic 77.7%, Others 5.3%	Operative findings	Normal 56.6%, Cholecystitis/Contracted 30.9%, Others 12.5%
Postop course	Smooth 90.8%, IV antibiotics >24 h 8.6%, ERCP 0.7%	LOS	1 day 79.6%, 2 days 14.5%, >2 days 5.9%

Table II: Comparison of pre-op variables among two groups.

Variable	CVS Not Achieved (n=35)	CVS Achieved (n=117)	P-value
Age (years) (Mean \pm SD)	49.29 ± 16.36	45.75 ± 13.80	0.202
Comorbidities			
None	22 (62.8%)	87 (74.4%)	
1 comorbid	9 (25.7%)	15 (12.8%)	0.102
≥ 2 comorbidities	4 (11.4%)	15 (12.8%)	
Diabetes	7 (20.0%)	14 (12.0%)	0.171
Gender			
Male	10 (28.6%)	36 (30.8%)	
Female	25 (71.4%)	81 (69.2%)	0.492
Emergency admission	6 (17.1%)	10 (8.6%)	0.130
Previous admission for gallstones	5 (14.3%)	15 (12.8%)	0.503
Duration of GB disease			
≤ 30 days	23 (65.7%)	66 (56.4%)	
31–180 days	8 (22.9%)	29 (24.8%)	0.702
>180 days	4 (11.4%)	22 (18.8%)	
Diagnosis at admission			
Acute cholecystitis	9 (25.7%)	17 (14.5%)	
Biliary colic	23 (65.7%)	95 (81.2%)	0.283
Other (pancreatitis, GB polyp)	3 (8.6%)	5 (4.3%)	
Previous abdominal surgery	14 (40.0%)	38 (32.5%)	0.271
Previous ERCP	4 (11.4%)	2 (1.7%)	0.500
Ultrasound findings			
Pericholecystic fluid	5 (14.3%)	15 (12.9%)	0.50
Stone at neck	3 (8.6%)	14 (12.0%)	0.40
Wall thickness >3 mm	8 (22.9%)	10 (8.5%)	0.03
Infection at admission	9 (25.7%)	17 (14.5%)	0.10

(10.2%), and >2 days in 5 (14.3%) vs. 4 (3.4%) ($p < 0.001$).

Table III: Comparison of Intraoperative variables among two groups.

Variable	CVS Not Achieved (n=35)	CVS Achieved (n=117)	p-value
Operative difficulty grade			
Grade I-II	22 (62.8%)	108 (92.3%)	0.000
Grade III-V	13 (37.2%)	9 (7.7%)	
Gallbladder condition (per-op)			
Normal GB	16 (45.7%)	70 (59.8%)	0.000
Cholecystitis	2 (5.7%)	22 (18.8%)	
Contracted GB	6 (17.1%)	17 (14.5%)	
Mucocele/Empyema/Gangrenous/Mirizzi	11 (31.5%)	8 (6.8%)	
Adhesions			
With duodenum	12 (34.3%)	10 (8.5%)	0.000
With colon	4 (11.4%)	2 (1.7%)	0.021
Abnormal Calot's triangle	3 (8.6%)	1 (0.8%)	0.042
Accessory cystic duct	0 (0%)	3 (2.6%)	0.451
Duration of surgery			
≤ 1 hour	21 (60.0%)	115 (98.3%)	0.000
>1 hour	14 (40.0%)	2 (1.7%)	
Cystic duct ligation with sutures	10 (28.6%)	4 (3.4%)	0.000
Type of surgery			
Complete cholecystectomy	26 (74.3%)	116 (99.2%)	0.000
Amputation cholecystectomy	3 (8.6%)	0 (0%)	
Subtotal cholecystectomy	6 (17.1%)	1 (0.8%)	
Drain placement	28 (80.0%)	38 (32.5%)	0.000

Table IV: Comparison of outcome variables among two groups

Variable	CVS Not Achieved (n=35)	CVS Achieved (n=117)	p-value
Prolonged postoperative antibiotics	7 (20.0%)	6 (5.1%)	0.022
Length of hospital stay			
1 day	20 (57.2%)	101 (86.3%)	
2 days	10 (28.6%)	12 (10.2%)	0.000
>2 days	5 (14.3%)	4 (3.4%)	

Discussion

In this study, the Critical View of Safety (CVS) was successfully achieved in 77% of laparoscopic cholecystectomy (LC) cases, a proportion consistent with findings from recent literature, which report CVS achievement rates ranging from 70% to 90% depending on patient selection, operative difficulty, and surgeon experience.^{11,12} Our results reinforce the importance of CVS as a cornerstone in preventing bile duct injury (BDI), a complication still reported in up to 0.5% of LC procedures despite advances in technique and training.¹³

Operative difficulty emerged as a key determinant of CVS achievement in our study, with higher Nassar grades (III–V) significantly reducing the likelihood of success. Similar associations have been reported by Nassar et al., who demonstrated that dense adhesions, contracted gallbladders, and severe inflammation compromise exposure of Calot's triangle and hinder safe dissection.¹⁴ Acute and chronic inflammatory changes were also predictive in our cohort, with severe gallbladder pathology (mucocele, empyema, gangrenous cholecystitis, or Mirizzi syndrome) more frequent in the CVS not achieved group. These findings align with recent systematic reviews highlighting inflammation and anatomical distortion as major contributors to CVS failure.¹⁵

Preoperative gallbladder wall thickening (>3 mm) was significantly associated with CVS non-achievement. Wall thickening is a known ultrasonographic marker of acute or chronic cholecystitis, correlating with operative complexity and longer dissection times.¹⁶ In our study, CVS non-achievement was linked to operative durations >1 hour, increased use of sutures for cystic duct ligation, and higher rates of subtotal or amputation cholecystectomy. These are well-recognised surrogate markers of intraoperative difficulty and have been previously reported as predictors for conversion to open surgery or alternative “bail-out” techniques.¹⁷

Adhesions with the duodenum and colon significantly impacted CVS attainment, reflecting the challenges of safe dissection in distorted anatomy. The presence of abnormal Calot's triangle anatomy, though rare in our cohort (2.6%), was also associated with CVS failure. This supports previous anatomical studies emphasising that congenital or acquired variations increase the risk of misidentifying biliary structures.¹⁸

Postoperative outcomes were notably worse when CVS was not achieved. Patients in this group had significantly longer hospital stays and higher requirements for prolonged postoperative antibiotics. While no BDI occurred in our study, literature suggests that inability to achieve CVS - if not managed with an appropriate alternative strategy, substantially increases the risk of major bile duct injury.^{13,19} The absence of BDI in our series may be attributed to early recognition of difficult anatomy and the timely adoption of bail-out procedures, as recommended by the SAGES Safe Cholecystectomy Program.²⁰

Identification of predictors such as wall thickening, severe gallbladder pathology, and high Nassar grade can alert surgeons to anticipate technical challenges and consider early use of adjunctive techniques. Furthermore, our findings highlight the need for structured training in both CVS and safe bail-out options to maintain patient safety when CVS cannot be achieved.

Limitations of this study include its single-centre design and the lack of long-term follow-up to detect delayed biliary complications. This study underscores the importance of preoperative risk stratification. Nevertheless, the prospective design and consecutive patient inclusion strengthen the validity of the findings.

In conclusion, while CVS is achievable in most LC cases, certain preoperative and intraoperative factors significantly reduce its likelihood. Recognizing these factors early, adhering to evidence-based safety protocols, and maintaining proficiency in alternative techniques are critical to minimizing complications and ensuring optimal patient outcomes.

Conclusion

The Critical View of Safety is achievable in the majority of laparoscopic cholecystectomy cases; however, its success is significantly influenced by operative difficulty, severe gallbladder pathology, adhesions, and abnormal anatomy. Preoperative identification of these predictors allows better surgical planning and early adoption of alternative techniques, reducing the risk of complications. Adherence to structured safety protocols and proficiency in bail-out strategies remain essential to ensuring optimal outcomes and preventing bile duct injuries. Preoperative identification of high-risk features such as gallbladder wall thickening, severe inflammation, and difficult anatomy should guide surgical planning. When CVS is not achievable, surgeons should promptly adopt safe bail-

out techniques. Regular training in CVS and alternative strategies is essential to minimise bile duct injury and optimise outcomes.

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