

Research Article

Association of Gallbladder Position and Anatomical Variations on Ultrasound with Operative Difficulty during Laparoscopic Cholecystectomy

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Received: 18.07.2026, Revised: 22.08.2026, Accepted: 28.08.2026

ABSTRACT

Background: The surgical procedure of choice for symptomatic gallbladder disease is laparoscopic cholecystectomy; however, anatomic variations and inflammatory changes can complicate the procedure. Ultrasonography can provide useful information in the preoperative phase concerning gallbladder position, morphology, wall thickness and abnormalities that predict difficult procedure.

Objective: To determine the association of gallbladder position and anatomical variations detected on preoperative ultrasonography with operative difficulty during laparoscopic cholecystectomy.

Methodology: This prospective observational study was conducted at Khyber Teaching Hospital, Peshawar and Rawal Institute of Health Sciences Islamabad from January 2026 to June 2026 and included 87 patients undergoing elective laparoscopic cholecystectomy. The position of the gallbladder, morphological variations, gallbladder wall thickness, impacted stones of the neck of the gallbladder, pericholecystic fluid and other findings were determined using ultrasonography before operation. The level of difficulty was classified as easy, moderate, difficult or very difficult. Appropriate statistical tests were used to determine the correlations between ultrasonographic findings and operative difficulty, with $p < 0.05$ deemed significant.

Results: Difficult or very difficult laparoscopic cholecystectomy occurred in 28 (32.2%) patients. Abnormal gallbladder position was significantly associated with difficult surgery compared with normal position (58.3% vs. 22.2%, $p = 0.003$). Anatomical or morphological variations were also associated with increased difficulty (56.3% vs. 18.2%, $p = 0.001$). Gallbladder wall thickness >3 mm was associated with difficult surgery in 55.6% of cases ($p < 0.001$). The highest proportions of difficult procedures were observed in patients with an impacted stone at the gallbladder neck or Hartmann's pouch (84.6%, $p < 0.001$) and pericholecystic fluid (80.0%, $p = 0.002$). Conversion to open surgery was required in 5.7% of patients.

Conclusion: Gallbladder position and anatomical variations identified on preoperative ultrasonography are significantly associated with operative difficulty during laparoscopic cholecystectomy. Particular attention should be given to abnormal gallbladder position, wall thickening, impacted neck stones, and pericholecystic fluid, as these findings may help surgeons anticipate technically challenging procedures and improve operative planning.

Keywords: Gallbladder, Ultrasonography, Anatomical Variation, Laparoscopic Cholecystectomy, Operative Difficulty, Gallstones.

INTRODUCTION

Laparoscopic cholecystectomy is the ideal surgical technique for symptomatic cholelithiasis and many other benign gallbladder disorders, due to lower postoperative pain, shorter hospitalization, quick recovery and better cosmetic results

when compared with open cholecystectomy. Although there are these benefits, laparoscopic cholecystectomy is technically challenging in some patients. The procedure may be longer due to difficult dissection, poor anatomical landmarks, heavy adhesions, and/or an

abnormal biliary anatomy, which can lead to complications or open surgery (1-3).

Difficult laparoscopic cholecystectomy has been linked to several patient and disease related factors, such as thin gallbladder walls, inflammatory changes around the gallbladder, impacted stones, previously performed upper abdominal surgery, previous attacks of acute cholecystitis, and advanced age. Position of the gall bladder and anatomy are also significant factors that determine the difficulty of the operation. A high or subhepatic gallbladder, a low-lying gallbladder, a transverse position, partial intrahepatic position, septations, abnormal folds, and variations of the neck and fundus can affect the anticipated surgical anatomy and may make it more difficult to gain exposure or dissection (4-6).

Gallbladder ultrasonography is still the imaging modality of choice for gallbladder disease, as it is non-invasive and widely available, relatively inexpensive and very useful for the identification of gallstones and inflammatory changes. Besides stone detection, ultrasound allows assessment of the thickness of the gallbladder wall, distention/contraction of the gallbladder, pericholecystic fluid, common bile duct diameter, stone impaction and selected anatomical variations. These results may be useful in helping to predict the difficulty of an operation before the patient enters the operating room (7-11).

The accurate identification of a potential "difficult" laparoscopic cholecystectomy is clinically useful. It can provide more opportunity for the surgeon to plan the procedure, give sufficient operating time, utilize more experienced surgical staff if needed, inform the patient about the possibility of conversion to open surgery and prepare for difficult anatomical dissection. Several predictive scoring systems have included ultrasonographic parameters, but gallbladder position and morphological parameters are not always scored systematically as independent parameters (12).

There remains a need to evaluate how preoperative ultrasonographic identification of gallbladder position and anatomical variation relates to actual intraoperative difficulty. Therefore, the present study was conducted to determine the association of gallbladder position and anatomical variations on ultrasound with operative difficulty during laparoscopic cholecystectomy. The study also aimed to assess the relationship of additional ultrasonographic findings, including gallbladder

wall thickening, impacted neck stones, and pericholecystic fluid, with difficult surgery.

METHODOLOGY

This prospective observational study was conducted at Khyber Teaching Hospital, Peshawar and Rawal Institute of Health Sciences Islamabad from January 2026 to June 2026. A total of 87 patients scheduled for elective laparoscopic cholecystectomy were included. Patients were enrolled through non-probability consecutive sampling after fulfillment of the predefined eligibility criteria. The study was designed to determine whether gallbladder position and anatomical variations identified on preoperative ultrasonography were associated with increased operative difficulty during laparoscopic cholecystectomy. Ethical approval was obtained from the relevant institutional review committee before initiation of data collection, and written informed consent was taken from all participants.

Patients of gallstone disease who were to proceed with laparoscopic cholecystectomy were deemed to be eligible if they were adults of both sexes and had symptoms. Patients with acute severe cholangitis, suspected or confirmed gallbladder malignancy, major common bile duct pathology that indicated another operative plan, previous extensive hepatobiliary surgery, and incomplete ultrasonographic evaluation were excluded. The relevant data such as age, gender, BMI, recurrent biliary colic, previous attack of acute cholecystitis, previous hospitalization for gallbladder disease, history of jaundice and previous upper abdominal surgery were documented on a structured data collection form.

All subjects had abdominal ultrasound that was performed before surgery by a highly experienced radiologist with a high-resolution ultrasound system. The anatomy of the gall bladder was evaluated with respect to its normal position, high or subhepatic, low lying, transverse or horizontal, and partially intrahepatic. The other morphological changes observed were folded or Phrygian-cap configuration, septations, contracted gallbladder, elongation and abnormalities of the neck or fundus. Other ultrasonographic features examined were gallbladder wall thickness, the presence of multiple gallstones, the presence of impacted stones, at the neck of the gallbladder or the Hartmann's pouch, pericholecystic fluid, and common bile duct diameter. A wall thickness of more than 3 mm

was deemed a thickening of the gallbladder wall.

Surgeons with wide hepatobiliary experience performed a laparoscopic cholecystectomy through the typical multiport approach under general anesthesia. During the procedure, the findings were noted on the spot, after the procedure. Operative difficulty was evaluated by predesigned surgical criteria such as dense adhesions around the gallbladder, difficult retraction of the gallbladder, difficult identification and dissection of Calot's triangle, difficult control of the cystic duct and artery, gallbladder perforation, spillage of bile or stones, need for additional port, placement of a drain, subtotal cholecystectomy, or conversion to open surgery. All procedures were classified as easy, moderately difficult, difficult, and very difficult based on the overall findings during surgery. Difficult procedures were grouped with very difficult procedures for the primary analysis, and were compared to easy and moderately difficult procedures.

IBM SPSS Statistics was used to enter and analyze the data. Continuous variables like age, BMI, operative time, gall bladder wall thickness, and hospital stay after the surgery were summarized as mean $\pm$ SD or median (IQR),

depending on the data distribution. Categorical variables were reported as frequencies and percentages. The relationship between the position of gallbladder, ultrasonographic anatomical variations and the difficulty of the operation were evaluated by Chi-square test and Fisher's exact test as appropriate. Independent-samples t-test or Mann-Whitney U test was used to compare continuous variables between groups. The p value of less than 0.05 was deemed statistically significant and results, if applicable, were presented with a 95% confidence interval.

RESULTS

A total of 87 patients who had undergone laparoscopic cholecystectomy (LC) were included in the study. The mean age of the participants was 44.63 ± 12.18 years, with an age range of 21–69 years. The majority of patients (61, 70.1%) were females and 26 (29.9%) were males. The mean body mass index was 27.18 ± 4.06 kg/m². Fifty-four (62.1%) patients reported a previous history of recurrent biliary colic, and 22 (25.3%) patients had a previous episode of acute cholecystitis. The baseline characteristics are given in Table 1.

Table 1. Demographic and clinical characteristics of the study participants (n = 87)

Variable	n (%) / Mean $\pm$ SD
Age, years	44.63 $\pm$ 12.18
Male	26 (29.9)
Female	61 (70.1)
BMI, kg/m ²	27.18 $\pm$ 4.06
BMI ≥ 30 kg/m ²	22 (25.3)
Recurrent biliary colic	54 (62.1)
Previous acute cholecystitis	22 (25.3)
Previous hospitalization for gallbladder disease	17 (19.5)
Previous upper abdominal surgery	9 (10.3)
History of jaundice	7 (8.0)

The preoperative ultrasound examination revealed that 63 (72.4%) patients had a normal gallbladder position and a positional variation in 24 (27.6%). Of 90, 9 (10.3%) patients had a high or subhepatic gallbladder, 6 (6.9%) had a transverse gallbladder, 5 (5.7%) had a low-lying gallbladder and 4 (4.6%) had an intrahepatic part of the gall bladder. Variation

of anatomical/morphological was seen in 32 (36.8%) cases. The most common variation was a configuration in which the form was folded or had a Phrygian-cap. In 36 (41.4%) patients, the gallbladder wall had a thickness > 3 mm, and an impacted stone at the neck/Hartmann's pouch was found in 13 (14.9%) patients.

Table 2. Preoperative ultrasonographic findings (n = 87)

Ultrasound finding	n (%)
Gallbladder position	
Normal position	63 (72.4)
High/subhepatic position	9 (10.3)

Transverse/horizontal position	6 (6.9)
Low-lying position	5 (5.7)
Partially intrahepatic position	4 (4.6)
Morphological/anatomical variation present	32 (36.8)
Folded/Phrygian-cap gallbladder	10 (11.5)
Contracted gallbladder	8 (9.2)
Septate appearance	5 (5.7)
Distended/elongated gallbladder	5 (5.7)
Other neck/fundal variation	4 (4.6)
Gallbladder wall thickness >3 mm	36 (41.4)
Multiple gallstones	58 (66.7)
Single gallstone	29 (33.3)
Impacted stone at neck/Hartmann's pouch	13 (14.9)
Pericholecystic fluid	10 (11.5)
Dilated common bile duct	8 (9.2)

In intraoperatively, 31 (35.6%) procedures were easy, 28 (32.2%) moderate, 20 (23.0%) difficult and 8 (9.2%) very difficult. Thus, 28 (32.2%) patients were classified as having a difficult or very difficult laparoscopic cholecystectomy. Twenty-seven (31.0%) patients were found to have dense pericholecystic adhesions, and 21 (24.1%)

were able to identify or dissect Calot's triangle. In 11 (12.6%) cases, there was bile or stone spilling into the surrounding tissues, causing perforation of the gallbladder. The mean working time was 73.45 ± 24.37 minutes. In 5 (5.7%) patients, open cholecystectomy was necessary.

Table 3. Operative characteristics and difficulty of laparoscopic cholecystectomy

Operative variable	n (%) / Mean $\pm$ SD
Easy operation	31 (35.6)
Moderate difficulty	28 (32.2)
Difficult operation	20 (23.0)
Very difficult operation	8 (9.2)
Difficult/very difficult combined	28 (32.2)
Dense gallbladder adhesions	27 (31.0)
Difficult gallbladder retraction	18 (20.7)
Difficult Calot's triangle dissection	21 (24.1)
Gallbladder perforation/bile spillage	11 (12.6)
Additional port required	7 (8.0)
Drain placement	16 (18.4)
Conversion to open surgery	5 (5.7)
Operative duration, minutes	73.45 ± 24.37
Postoperative hospital stay, days	1.82 ± 0.94

Statistically significant association with operative difficulty was found for gall bladder position. In 63 patients who had a normal position of the gallbladder, 14 (22.2%) had a difficult operation or a very difficult operation. The rate of difficult surgery was 14 of 24 (58.3%) for patients with an abnormal position of the gallbladder compared to 6 of 42 (14.3%) for those with a normal gallbladder position.

Statistically significant differences were observed ($\chi^2 = 8.79$, $p = 0.003$). High / subhepatic, transverse and intrahepatic gallbladder positions were statistically more associated with difficult surgery. Patients with high / subhepatic, transverse and intrahepatic gallbladder positions had a higher proportion of difficult surgeries.

Table 4. Association between gallbladder position and operative difficulty

Gallbladder position	Easy/moderate n (%)	Difficult/very difficult n (%)	Total	p-value
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Normal position	49 (77.8)	14 (22.2)	63	
Abnormal position	10 (41.7)	14 (58.3)	24	0.003
Total	59 (67.8)	28 (32.2)	87	

Multiple individual ultrasonographic characteristics were also found to be related to operative difficulty. Compared with patients whose wall thickness was 3 mm or less, 20 of 36 (55.6%) patients with gallbladder wall thickness more than 3 mm had difficult or very difficult surgery. Twenty of 36 (55.6%) patients with gallbladder wall thickness greater than 3 mm had difficult or very difficult surgery compared to 8 of 51 (15.7%) patients with wall thickness 3 mm or less ($p < 0.001$). Likewise, an impacted stone in the neck of the gallbladder or the Hartmann's pouch was significantly associated with difficult surgery, with 11 of 13

(84.6%) patients with an impacted stone having difficult or very difficult dissection, versus 17 of 74 (23.0%) for those without an impacted stone ($p < 0.001$). Morphological variations were also related to increased operative difficulty. Of 32 patients with an anatomical variation, 18 (56.3%) had difficult or very difficult surgery while 10 (18.2%) of 55 patients without an anatomical variation had difficult or very difficult surgery ($p = 0.001$). Difficulty was also associated with a contracted gallbladder and the presence of pericholecystic fluid.

Table 5. Association of ultrasonographic findings with difficult laparoscopic cholecystectomy

Ultrasound finding	Difficult/very difficult n/N (%)	p-value
Abnormal gallbladder position	14/24 (58.3)	0.003
Any anatomical/morphological variation	18/32 (56.3)	0.001
Gallbladder wall >3 mm	20/36 (55.6)	<0.001
Contracted gallbladder	12/16 (75.0)*	<0.001
Impacted stone at neck/Hartmann's pouch	11/13 (84.6)	<0.001
Pericholecystic fluid	8/10 (80.0)	0.002
Multiple gallstones	21/58 (36.2)	0.254
Dilated common bile duct	4/8 (50.0)	0.251

*For analytical comparison, contracted or poorly distended gallbladder appearances were grouped where applicable.

The mean operative duration increased progressively with the degree of surgical difficulty. Mean operative time was 52.8 ± 11.6 minutes for easy procedures, 70.4 ± 14.2 minutes for moderately difficult procedures, 91.7 ± 17.8 minutes for difficult procedures, and 118.5 ± 22.4 minutes for very difficult procedures. Patients with abnormal gallbladder position and significant anatomical variations also had greater frequencies of dense

adhesions, difficult Calot's triangle dissection, drain placement, and conversion to open surgery. Overall, the findings indicate that abnormal gallbladder position, morphological variation, increased gallbladder wall thickness, impacted neck stones, and pericholecystic inflammatory changes were important preoperative ultrasound indicators of increased operative difficulty during laparoscopic cholecystectomy.

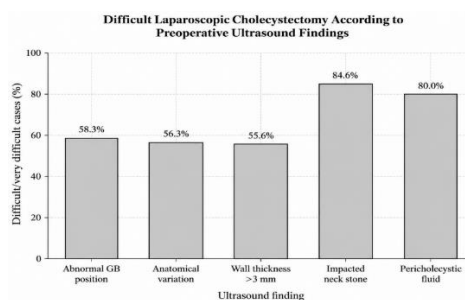


Figure 1. Percentage of difficult laparoscopic cholecystectomy according to major ultrasonographic findings.

Figure 1. Percentage of difficult or very difficult laparoscopic cholecystectomy according to major preoperative ultrasonographic findings. The highest proportion of difficult procedures was observed in patients with an impacted gallbladder neck stone (84.6%) and pericholecystic fluid (80.0%), followed by

abnormal gallbladder position (58.3%), anatomical variation (56.3%), and gallbladder wall thickness >3 mm (55.6%).

DISCUSSION

The present study demonstrated that preoperative ultrasonographic characteristics of the gallbladder were significantly associated with operative difficulty during laparoscopic cholecystectomy. Difficult or very difficult procedures occurred in 32.2% of patients, while conversion to open surgery was required in 5.7% of cases. Patients with an abnormal gallbladder position had a substantially greater frequency of difficult surgery than those with a normally positioned gallbladder (58.3% vs. 22.2%, $p = 0.003$). Similarly, the presence of an anatomical or morphological variation was associated with a significantly higher rate of difficult cholecystectomy (56.3% vs. 18.2%, $p = 0.001$). These findings indicate that preoperative assessment should extend beyond the presence of gallstones alone and should include careful evaluation of gallbladder location, orientation, shape, and its relationship with adjacent structures. Recognition of these variations before surgery can assist the operating surgeon in anticipating problems with exposure, traction, and identification of anatomical landmarks (13-15).

One ultrasound parameter, gallbladder wall thickness (GWT) > 3 mm, was an important indicator of operative difficulty among the individual ultrasound parameters. The gallbladder wall thickness of 3 mm or less was associated with no difficult or very difficult surgical procedures, while a wall thickness greater than 3 mm was associated with 15.7% of patients experiencing a very difficult surgical procedure or 55.6% with a difficult surgical procedure. This is supported by other studies that found that thickening of the gallbladder wall is associated with repeated or persistent inflammation, oedema, fibrosis and adhesions that can complicate the separation of the gallbladder from its hepatic bed. Another study found that the thicker the gallbladder wall, the more challenging the surgery to remove the gallbladder becomes. A study also found that there were significant associations between a thickened gallbladder wall, a contracted gallbladder, impacted stones and a difficult laparoscopic surgery. These are in keeping with the potential merit of gallbladder wall thickness as a convenient and easily accessible preoperative marker of technical difficulty (16, 17).

The most significant correlation in the present study was with an impacted stone at the

gallbladder neck or Hartmann's pouch, where 84.6% of patients had a difficult or very difficult surgery. This correlation was very significant ($p < 0.001$). Studies on patients also showed that the presence of thickened gallbladder wall, contracted gallbladder and neck stone impaction were risk factors for difficult laparoscopic cholecystectomy: however, neck stone impaction was the only ultrasonographic parameter independent in the multivariable analysis (ORs > 7). There are also previous prospective data that demonstrate that stone impaction is an independent predictor of operative difficulty. An impacted stone can cause local inflammation, distortion of the contour of the gallbladder neck, inability to grasp the gallbladder, and loss of clear tissue planes surrounding Calot's triangle. Therefore, if an impacted neck stone is detected on ultrasound, the surgeon should be aware of a possibly long and complicated dissection (18, 19).

Another particularly important ultrasound finding in this study was pericholecystic fluid. The surgery was difficult or very difficult in 80.0% (8/10 patients) with pericholecystic fluid ($p = 0.002$). This finding is biologically valid as the pericholecystic fluid is usually associated with marked inflammation around the gall bladder and can present with concurrent edema, adhesion, friable tissue and altered surgical anatomy. Available evidence points to pericholecystic fluid, contracted or abnormal gallbladder morphology, thicker wall and impacted gallstones as the most helpful ultrasound parameters in the difficult laparoscopic cholecystectomy. However, in the present study, no significant correlation was found between multiple gallstones and/or common bile duct dilatation and operative difficulty. This indicates that the inflammatory effect and site of gallstones may be more clinically relevant than the number of stones. The findings of this study further support this concept, as the operative time of easy to very difficult procedures increased as the anatomical and inflammatory parameters increased (20).

The present findings have practical implications because ultrasonography is widely available, non-invasive, inexpensive, and routinely performed before laparoscopic cholecystectomy. Gall bladder position, morphological variations, gall bladder wall thickness, impacted neck stones and presence of pericholecystic fluid may assist in the

identification of patients that will require more time for operation, expertise in surgical procedures and careful counselling about conversion and preparedness for difficult dissection. However, there are certain limitations in the study. It was carried out in one institution, and the numbers of patients studied were relatively small (87 patients) and a few unusual gallbladder positional variations were not represented. Additionally, the difficulty of the operation can vary depending on the surgeon's experience and their judgment during the procedure, leading to a possible subjectivity. In addition, multivariable predictive modelling was not done to establish the independent value of each anatomical variation. Future multi-center trials with greater numbers are needed to establish and externally validate a risk stratification score using ultrasound imaging that includes gallbladder position, anatomical variation, inflammatory features and patient-related features for a more accurate prediction of difficult laparoscopic cholecystectomy.

CONCLUSION

Preoperative ultrasonography provides valuable information for anticipating operative difficulty during laparoscopic cholecystectomy. Abnormal gallbladder position, anatomical or morphological variations, gallbladder wall thickness greater than 3 mm, impacted stone at the gallbladder neck or Hartmann's pouch, and pericholecystic fluid were significantly associated with difficult surgery. Among these findings, an impacted neck stone and pericholecystic fluid showed the highest proportions of difficult procedures. Careful evaluation and reporting of these ultrasonographic features before surgery may improve operative planning, facilitate appropriate allocation of experienced surgical teams, and help counsel patients regarding the possibility of prolonged surgery or conversion to an open procedure.

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