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Original Research Article

Ultrasonographic gallbladder wall thickness as a risk stratification tool in elective laparoscopic cholecystectomy: a cross-sectional study from a tertiary care center

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is the gold standard for gallstone diseases. Preoperative ultrasonography findings can have a significant impact on the perioperative and postoperative outcomes. This study aimed to evaluate the influence of preoperative gallbladder (GB) wall thickness, measured by ultrasonography, on the perioperative outcomes of patients undergoing elective LC.
Methods: This prospective, cross-sectional study was conducted at a tertiary care center and included 60 patients undergoing LC. Preoperative GB wall thickness was measured via ultrasonography, and patients were stratified into four groups: <2 mm, 2-4 mm, 4-6 mm, and >6 mm. Intraoperative complications, postoperative complications, and the duration of hospital stay were prospectively documented and correlated with GB wall thickness. Statistical analysis was performed using ANOVA and chi-square tests to compare outcomes among the four groups.
Results: The mean age was 44±13 years, and 68.3% were female. A GB wall thickness of 2-4 mm was the most common finding (40%), followed by <2 mm (30%). Patients with a thicker GB wall had significantly more intraoperative complications (p=0.001). Thicker GB wall was significantly associated with postoperative bile leak (p=0.007) and wound infection (p=0.041). The mean hospital stay was also significantly longer for patients with a thicker GB wall (p=0.001).
Conclusions: Preoperative GB wall thickness on ultrasonography is a strong predictor of operative difficulty, postoperative complications, and prolonged hospitalization following LC. Incorporating this simple, non-invasive measure into routine preoperative assessment may improve risk stratification and surgical planning.

Keywords: Gallbladder wall thickness, Ultrasonography, Laparoscopic cholecystectomy, Perioperative outcomes, Surgical risk prediction

INTRODUCTION

Cholelithiasis (gallstone disease) is one of the most prevalent gastrointestinal disorders and a leading indication for surgical intervention.[1] The introduction of LC in the late 20th century revolutionized the treatment of GB disease. This minimally invasive approach offers well-established benefits over traditional open surgery, including reduced postoperative pain, shorter

hospitalizations, and a faster return to daily activities.[2] As LC became the standard of care, efforts have focused on identifying preoperative predictors of surgical complexity and potential complications to optimize patient outcomes and operative planning.

One such predictor, easily measured by ultrasonography (USG), is GB wall thickness. A normal GB wall is typically less than 3 mm thick.[3] A thickness greater than 3 mm is considered abnormal and often signifies underlying inflammatory changes, such as acute or chronic cholecystitis. Patients with increased GB wall thickness are known to face more complex laparoscopic procedures, a higher likelihood of conversion to open surgery, and an elevated risk of complications.[4]

Although USG is routinely used in the evaluation of GB disease, the prognostic value of wall thickness is often overlooked in clinical practice.[5] While several studies have linked a thicker GB wall to increased surgical difficulty, their findings vary due to inconsistencies in study design and patient populations.[6] According to Bose et al GB wall thickening is among the most sensitive indicators of technical complexity during LC.[7] As a preoperative marker, it offers valuable insight by alerting surgeons to potential challenges in identifying anatomical structures and performing dissection. Ultrasonography, widely used in routine clinical settings, has demonstrated high reliability in measuring GB wall thickness, with an accuracy of ±1 mm in approximately 93% of cases.[3] Recognizing patients who may face difficult surgeries at an early stage allows for better planning, including optimized use of resources, preparedness of the surgical team, and individualized perioperative strategies.[8] Therefore, evaluating the role of GB wall thickness as a predictive tool holds significant clinical relevance for improving surgical outcomes in LC .[9]

Patients with gallstone disease who were scheduled for LC underwent preoperative ultrasonography to assess GB wall thickness. A recent prospective study of 350 patients stratified cases by US GB wall thickness into four categories (normal ≤2 mm, mild 3-4 mm, moderate 5-6 mm, severe >6 mm). This stratification revealed a clear, stepwise increase in both operative difficulty and adverse outcomes with greater wall thickness. These groups were analyzed for associations with several operative variables, including operative time, conversion rates, complication frequency, and postoperative hospital stay.[3,10] While prior studies have explored the link between wall thickening and cholecystitis, this investigation takes a more structured approach-categorizing patients by specific wall thickness ranges and evaluating the direct impact of each range on surgical outcomes.[11]

Unlike many previous reports that broadly describe the presence or absence of thickening, this research quantifies the degree of thickness and correlates it with specific outcome metrics.

This study hypothesizes that increasing GB wall thickness, as determined by ultrasonography, is definitively associated with greater surgical complexity during LC. It aims to provide robust evidencethat preoperative ultrasonographic assessment of wall thickness can serve as an effective predictor of operative challenges, such as prolonged operative time, conversion to open surgery, and higher rates of intraoperative and postoperative complications.

By classifying patients based on wall thickness, the study aims to develop a practical, stratified risk model to support preoperative counseling and personalized surgical planning.[12] These findings have the potential to enhance perioperative preparedness and improve outcomes, particularly in resource-limited settings or where surgical experience may vary.

METHODS

This was a prospective, hospital-based cross-sectional study designed to investigate the impact of GB wall thickness, measured by ultrasonography, on surgical outcomes following LC. The sample size was calculated using OpenEpi version 3.0, based on an expected prevalence of 20% from prior literature. This yielded a required sample of 54, which was increased to 60 to account for a 10% potential loss to follow-up.[13]

Following ethical clearance, the study was conducted over a 9-month period from May 2024 to January 2025 at the Department of General Surgery, Rajiv Gandhi Government General Hospital, Chennai-a multi-specialty tertiary care center. Patients undergoing elective LC for gallstone disease, with a normal common bile duct on imaging, were enrolled after informed written consent.

Exclusion criteria included refusal to participate, conversion to open surgery, clinical or imaging evidence of acute inflammation, elevated liver function tests, intraoperative complications beyond GB or common bile duct injury, or coexisting cholelithiasis with choledocholithiasis.

Pre-operative assessment

Comprehensive clinical evaluation included a detailed history of pain characteristics, aggravating and relieving factors, and time since the last attack, along with a thorough physical examination. Standard laboratory investigations were performed, including complete blood count, random blood sugar, renal function tests, liver function tests, serum amylase and lipase, viral markers (HIV, HBsAg and HCV), ECG, and chest and abdominal X-rays.

Preoperative ultrasonography, conducted by a radiologist, assessed GB wall thickness and other features. Based on wall thickness, patients were classified into four groups: normal (<2 mm), mildly thickened (2-4 mm),

moderately thickened (4-6 mm), and severely thickened (>6 mm).

Surgical procedure

All procedures were performed under general anesthesia using a standard four-port laparoscopic technique by experienced surgeons. Pneumoperitoneum was established via Hasson's open technique using two 10 mm and two 5 mm ports. After dissection of Calot's triangle and peritoneal inspection, adhesions (if present) were released. The cystic duct and artery were ligated using titanium clips.

A subhepatic drain was placed when indicated. Postoperative pain was managed using NSAIDs and antiemetics. Oral intake was resumed after the return of bowel sounds. Patients were discharged once mobilized, pain was controlled, and oral feeding was well-tolerated. They were encouraged to resume routine activities as early as feasible.

Data were collected prospectively using a pre-validated, structured proforma, capturing demographic data, clinical findings, complications, and hospital stay. Patients were analyzed in four categories according to GB wall thickness on ultrasound.

Statistical analysis

Data analysis was performed using SPSS version 22.0 (Gouda). Categorical variables were summarized as frequencies and percentages, while continuous variables were reported as mean±standard deviation. The Chi-square test or Fisher's Exact test (as appropriate) was used for associations between categorical variables. ANOVA was used to compare continuous variables across GB wall thickness groups. A $p<0.05$ was considered statistically significant.

RESULTS

The mean age of participants was 44±13 years; 68.3% were female. Intraoperative complications occurred in 33.3% of cases (20 patients), while 66.7% had no such complications. Hemorrhage (15%) was the most frequent issue, followed by adhesions (13.3%) and bile duct injuries (3.3%).

Postoperatively, 88.3% of patients did not have bile leaks, while 11.7% experienced them. Wound infection occurred in only 5% of cases. The mean duration of hospitalization was 5±2 days.

GB wall thickness was 2-4 mm in 40% of patients and <2 mm in 30%. Moderate (4-6 mm) and severe (>6 mm) thickening were found in 20% and 10% of patients, respectively. This indicates that most cases fell within the 2-4 mm range, with a smaller proportion showing thickness beyond 4 mm.

Association of age and gender distribution with GB thickness

Patients with GB wall thickness <2 mm had a mean age of 44.6 years, whereas those in the 2-4 mm group were younger (mean 41.6 years). Interestingly, the 4-6 mm group had the highest mean age (53.4 years), while those in the >6 mm group were younger on average (33.7 years). ANOVA demonstrated a statistically significant age difference across the four thickness categories ($p=0.006$), indicating a non-linear association between age and wall thickening (Table 2).

In terms of gender, females comprised most of 2-4 mm group (43.9%), and 29.3% were in <2 mm group. Among males, the distribution was more uniform across thickness categories. No significant association was found between GB wall thickness and gender ($p=0.406$) (Table 3).

Adhesions occurred exclusively in patients with thicker GB walls, most commonly in the 4-6 mm group (87.5%). Bile duct injuries were split between the 4-6 mm and >6 mm groups. Hemorrhage was most frequent in the >6 mm category (44.4%), with some occurrence in the 2-4 mm and 4-6 mm groups.

Patients with GB wall thickness <4 mm were less likely to face complications; 95% of those with thickness <2 mm and 87.5% of 2-4 mm group had no intraoperative issues. In contrast, all patients in the >6 mm group experienced at least one complication. The association between wall thickness and intraoperative complications was statistically significant ($p=0.001$) (Table 4).

Post-operative complications across GB wall thickness groups

The majority (88.3%) of patients did not experience a bile leak post-surgery. Bile leaks occurred in 57.1% of patients with 4-6 mm thickness and 28.6% of those with >6 mm. Only one case (14.3%) occurred in the <2 mm group, and none were reported in the 2-4 mm group. The correlation between GB wall thickness and bile leak was statistically significant ($p=0.007$) (Table 5).

Out of 60 participants, only 3 patients developed wound infections after surgery. Wound infections followed a similar trend: 66.7% of cases occurred in the 4-6 mm group, and 33.3% in the >6 mm group. No wound infections were reported in patients with wall thickness below 4 mm. This association also reached statistical significance ($p=0.041$) (Table 6).

Patients with GB wall thickness <4 mm had a mean hospital stay of 3.67 days. In contrast, those with 4-6 mm thickness stayed an average of 6.58 days, and those with >6 mm stayed 7.33 days. ANOVA confirmed a significant difference in hospital stay across thickness groups ($p=0.001$), with longer durations linked to increased wall thickness (Table 7).

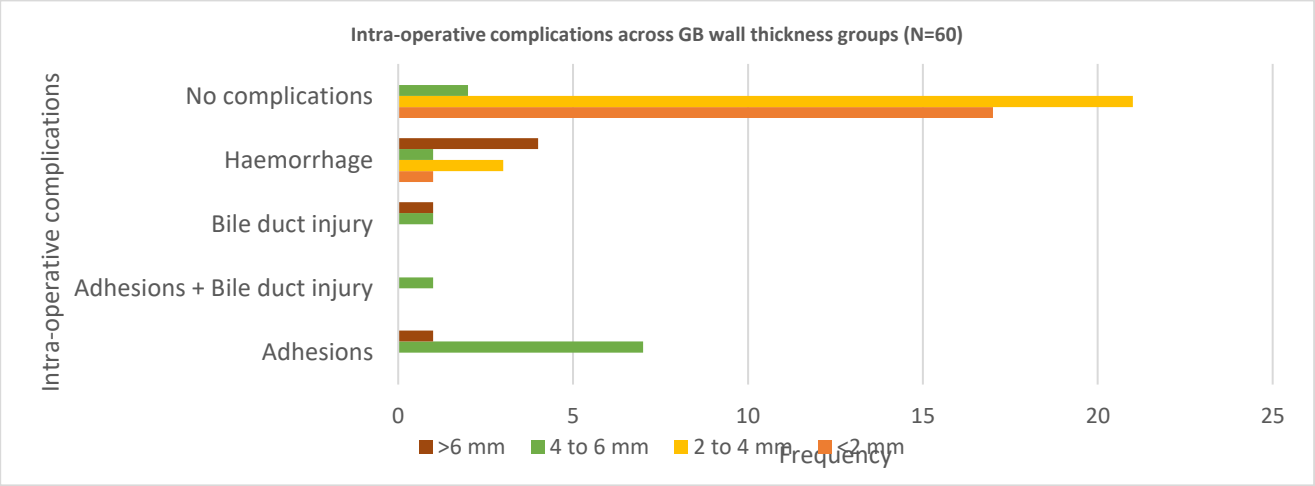

Figure 1: Association of intra-operative complications across GB thickness groups.

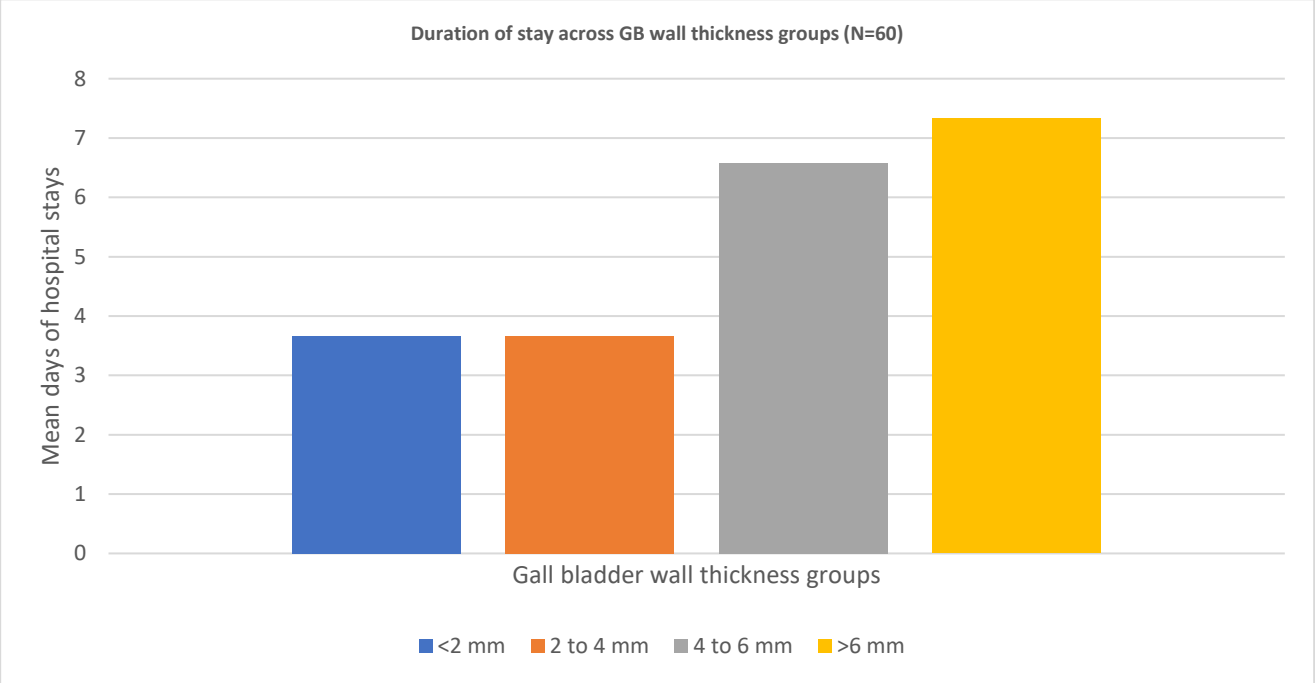

Figure 2: Association of mean duration of stay across GB wall thickness groups.

Table 1: Baseline and clinical characteristics of the study population, (n=60).

Variables	Categories	N	Percentage
Age (in years) (mean ± SD)		44±13	
Sex	Female	41	68.3%
	Male	19	31.7%
Intraoperative complications	Adhesions	8	13.3%
	Adhesions and bile duct injury	1	1.7%
	Bile duct injury	2	3.3%
	Hemorrhage	9	15.0%
	Nil	40	66.7%
Post-operative bile leak	Nil	53	88.3%
	Yes	7	11.7%
Wound infection	Nil	57	95.0%
	Yes	3	5.0%

Continued.

Variables	Categories	N	Percentage
Duration of stay (mean±SD)		5±2	
GB wall thickness by USG in mm	<2 mm	18	30.0%
	2 to 4 mm	24	40.0%
	4 to 6 mm	12	20.0%
	>6 mm	6	10.0%

Table 2: Association of age with GB thickness, (n=60).

Variables	N	Mean age (in years)	SD	95% CI for mean		Minimum	Maximum
				Lower bound	Upper bound		
GB wall thickness							
<2 mm	18	44.56	10.766	39.20	49.91	28	65
2 to 4 mm	24	41.63	12.201	36.47	46.78	22	65
4 to 6 mm	12	53.42	12.795	45.29	61.55	30	67
>6 mm	6	33.67	6.408	26.94	40.39	23	42
Total	60	44.07	12.518	40.83	47.30	22	67
ANOVA		**Sum of squares**	**Df**	**Mean square**		**F**	**P value**
Between groups		1845.414	3	615.138		4.655	0.006
Within groups		7400.319	56	132.149			
Total		9245.733	59				

Table 3: Association of gender with GB thickness, (n=60).

Variables		GB Wall thickness by USG in mm				Total
		<2 mm	2 to 4 mm	4 to 6 mm	>6 mm	
Sex	Female	12	18	6	5	41
		29.3%	43.9%	14.6%	12.2%	100.0%
	Male	6	6	6	1	19
		31.6%	31.6%	31.6%	5.3%	100.0%
Total		18	24	12	6	60
		30.0%	40.0%	20.0%	10.0%	100.0%
Chi-square tests		**Value**	**Df**	**P value**		
Pearson chi-square		3.004	3	0.406		
Fisher's exact test		2.817		0.425		
N of valid cases		60				

Table 4: Intra-operative complications across GB wall thickness groups (N=60)

Variables	GB wall thickness by USG in mm				Total
	<2 mm	2 to 4 mm	4 to 6 mm	>6 mm	
Intraoperative complications					
Adhesions	0	0	7	1	8
	0.0%	0.0%	87.5%	12.5%	100.0%
Adhesions, bile duct injury	0	0	1	0	1
	0.0%	0.0%	100.0%	0.0%	100.0%
Bile duct injury	0	0	1	1	2
	0.0%	0.0%	50.0%	50.0%	100.0%
Haemorrhage	1	3	1	4	9
	11.1%	33.3%	11.1%	44.4%	100.0%
No complications	17	21	2	0	40
	42.5%	52.5%	5.0%	0.0%	100.0%
Total	18	24	12	6	60
	30.0%	40.0%	20.0%	10.0%	100.0%
Chi-square tests	**Value**	**Df**	**P value**		
Pearson chi-square	57.725	12	0.001		
Fisher's exact test	47.451		0.001		
N of valid cases	60				

Table 5: Post-operative bile leak across GB wall thickness groups, (n=60).

Variables	GB wall thickness by USG in mm				Total
	<2 mm	2 to 4 mm	4 to 6 mm	>6 mm	
Post op bile leak					
Nil	17	24	8	4	53
	32.1%	45.3%	15.1%	7.5%	100.0%
Yes	1	0	4	2	7
	14.3%	0.0%	57.1%	28.6%	100.0%
Total	18	24	12	6	60
	30.0%	40.0%	20.0%	10.0%	100.0%
Chi-square tests	**Value**	**Df**	**P value**		
Pearson chi-square	12.022	3	0.007		
Fisher's exact test	10.991		0.004		
N of valid cases	60				

Table 6: Wound infection across GB wall thickness groups, (n=60).

Variables	GB Wall thickness by USG in mm				Total
	<2 mm	2 to 4 mm	4 to 6 mm	>6 mm	
Wound infection					
Nil	18	24	10	5	57
	31.6%	42.1%	17.5%	8.8%	100.0%
Yes	0	0	2	1	3
	0.0%	0.0%	66.7%	33.3%	100.0%
Total	18	24	12	6	60
	30.0%	40.0%	20.0%	10.0%	100.0%
Chi-square tests	**Value**	**Df**	**P value**		
Pearson chi-square	7.368	3	0.041		
Fisher's exact test	6.295		0.042		
N of valid cases	60				

Table 7: Duration of stay across GB wall thickness groups, (n=60).

Variables	N	Mean duration of stay	SD	95% CI for mean		Minimum	Maximum
				Lower bound	Upper bound		
GB wall thickness by USG							
<2 mm	18	3.67	0.767	3.29	4.05	3	6
2 to 4 mm	24	3.67	0.868	3.30	4.03	3	6
4 to 6 mm	12	6.58	2.193	5.19	7.98	3	10
>6 mm	6	7.33	1.033	6.25	8.42	6	9
Total	60	4.62	1.905	4.12	5.11	3	10
ANOVA		**Sum of squares**		**Df**	**Mean square**	**F**	**P value**
Between groups		128.600		3	42.867	28.049	0.001
Within groups		85.583		56	1.528		
Total		214.183		59			

DISCUSSION

The mean age of study participants was 44±13 years. This age distribution aligns with findings from larger cohort studies, which show that LC is most commonly performed in middle-aged individuals, particularly those between 18 and 49 years, although a growing proportion is seen in patients over 50 years.[14] Female participants comprised 68.3% of the study population. This finding is consistent with existing literature, where women account for 66% to over 80% of all cholecystectomy cases, confirming that women represent approximately 68.3% of cholecystectomy patients.[15,16] The gender and age distribution observed in this study reflects underlying biological and hormonal influences, such as estrogen exposure, which increase the risk of gallstone formation in middle-aged women.[17-19]

The overall intraoperative complication rate in this study (33.3%) is slightly higher than typically reported in large-scale studies, where rates range from approximately 10.8% to 17%.[20,21] Hemorrhage (15%) was the most common complication, followed by adhesions (13.3%) and bile duct injuries (3.3%). While the incidence is

relatively elevated, the nature and pattern of complications observed align with trends documented in other surgical cohorts.[21-23] Most patients did not experience postoperative complications, though 11.7% had bile leaks and 5% developed wound infections. These rates are somewhat higher than in larger studies but remain within the expected clinical spectrum for more complex laparoscopic procedures.

The average hospital stay in this study was 5±2 days, which is consistent with standard recovery durations following uncomplicated LC.[21] This suggests that despite the higher complication rate, most patients achieved recovery milestones within the typical timeframe.

In our data, most participants (40%) had a GB wall thickness of 2-4 mm by ultrasound, which aligns with published NCBI studies indicating that a normal GB wall is typically less than 3 mm, and increased thickness (>4 mm) is less common and usually associated with pathological conditions such as cholecystitis.[3,9]

A statistically significant variation in mean age across the four wall thickness groups (p=0.006) was observed. The group with a thickness of 4-6 mm had the highest average age (53.42 years), suggesting a trend toward age-related thickening. This is in agreement with previous studies which report increased GB wall thickness among individuals aged 51-60 years.[24]

Gender did not show a significant correlation with GB wall thickness (p=0.406). This supports the findings of prior research, which report that while the overall prevalence of GB disease is higher in women, wall thickness measurements themselves are not significantly different between sexes.[24]

A strong, statistically significant association was found between increasing wall thickness and intraoperative complications (p=0.001). This reflects findings in literature, where increased GB wall thickness is consistently associated with greater operative difficulty, elevated risk of conversion to open surgery, and longer operative duration.[3,5,25] Similarly, in this study, wall thickness was also significantly associated with postop complications, particularly bile leak (p<0.01) and wound infection (p=0.042).

Duration of hospital stay significantly longer in patients with increased GB wall thickness (p=0.001). These results corroborate previous studies-such as those by Chandra et al and others-which show that patients with thickened GB walls require substantially longer postop recovery periods, often extending from 8 to 14 days in more severe cases compared to 2.8-4.7 days in patients with normal wall thickness.[3,5,7,26]

In summary, our study found that increasing GB wall thickness was consistently associated with older patient age, higher intra- and postoperative complication rates, and longer hospitalization. These findings reinforce the clinical utility of preoperative ultrasonographic assessment in predicting surgical complexity and guiding intraoperative decision-making.

This study has several limitations that warrant consideration. The relatively small sample size of 60 patients may limit the generalizability of the findings and the statistical power to detect smaller effect sizes, particularly for rare complications. The single-center design at a tertiary care hospital may introduce selection bias, as the patient population may differ from that in community hospitals or primary care settings. The exclusion of patients with conversion to open surgery, acute inflammation, and elevated liver function tests may have resulted in a cohort that does not fully represent the spectrum of GB disease encountered in routine clinical practice. Inter-operator variability in ultrasonographic measurements, despite being performed by radiologists, was not formally assessed and could influence the accuracy of wall thickness categorization. The cross-sectional design precludes assessment of long-term outcomes and does not capture complications that may manifest after hospital discharge. Finally, the study did not include assessment of operative time or conversion rates, which are important markers of surgical difficulty that could have further strengthened the predictive value of GB wall thickness. Future multicenter studies with larger sample sizes and inclusion of broader patient populations are needed to validate these findings and develop robust predictive models for the clinical application.

CONCLUSION

This prospective cross-sectional study demonstrates that preoperative ultrasonographic measurement of GB wall thickness is a clinically valuable predictor of perioperative outcomes in elective LC. Wall thickness ≥4 mm was significantly associated with increased intraoperative complications, postoperative bile leaks and wound infections, and prolonged hospital stays. These findings advance current understanding by providing quantitative evidence that routine ultrasonographic assessment of GB wall thickness can effectively stratify surgical risk and guide preoperative planning. Practical implications are particularly relevant for resource-limited settings and institutions with varying surgical expertise, where early identification of high-risk cases enables optimized resource allocation and informed patient counseling. By establishing GB wall thickness as a simple, non-invasive, and reproducible predictor of surgical complexity, this study contributes to evidence-based perioperative risk assessment and personalized surgical care in LC.

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