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The Predictive Value of Ultrasonographic Gallbladder Wall Thickness for Complications in Laparoscopic Cholecystectomy

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Research Article

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Abstract

Background

Laparoscopic cholecystectomy is the standard surgical treatment for symptomatic gallbladder disease; however, operative difficulty and perioperative complications vary among patients. Gallbladder wall thickness measured on preoperative ultrasonography may reflect inflammation or fibrosis and could help predict technically difficult surgery. This study aimed to evaluate the association between ultrasonographic gallbladder wall thickness and operative duration, intraoperative events, length of hospital stay, and postoperative complications in patients undergoing laparoscopic cholecystectomy.

Methods

This observational analytical study was conducted at Shahid Madani Educational Hospital, Karaj, Iran. Patients who underwent laparoscopic cholecystectomy during the study period were included using consecutive sampling. Gallbladder wall thickness was measured by preoperative ultrasonography and categorized as normal, mildly increased, or increased. Operative duration, intraoperative events, length of hospital stay, and 30-day postoperative complications were recorded. Statistical analysis was performed using SPSS, and a p-value < 0.05 was considered statistically significant.

Results

A total of 180 patients were included in the final analysis. Based on ultrasonographic gallbladder wall thickness, 117 patients had normal wall thickness, 46 patients had mildly increased wall thickness, and 17 patients had increased wall thickness. The mean operative time increased from 48.92 minutes in the normal group to 59.35 minutes in the mildly increased group and 69.41 minutes in the increased wall-thickness group ($p < 0.001$). At least one intraoperative event occurred in 32 patients with normal wall thickness, 37 patients with mildly increased wall thickness, and 15 patients with increased wall thickness ($p < 0.001$). Postoperative complications occurred in 4 patients, 6 patients, and 5 patients in the normal, mildly increased, and increased wall-thickness groups, respectively ($p < 0.001$). Gallbladder wall thickness also increased significantly with longer hospital stay ($p < 0.001$).

Conclusion

Increased ultrasonographic gallbladder wall thickness was significantly associated with longer operative duration, more frequent intraoperative events, longer hospitalization, and higher postoperative complication rates in patients undergoing laparoscopic cholecystectomy. Preoperative assessment of gallbladder wall thickness may help surgeons anticipate operative difficulty and improve perioperative planning.

1. Introduction

Cholelithiasis and other gallbladder disorders remain among the most common causes of abdominal surgery worldwide. Laparoscopic cholecystectomy has become the gold standard for treating symptomatic gallstones due to its minimally invasive nature, reduced postoperative pain, shorter hospital stay, and faster return to daily activities. Despite these advantages, the procedure can still be challenging in certain cases, where dense adhesions, inflammation, or anatomical variations complicate the operation and increase the risk of intraoperative or postoperative complications(1). Therefore, identifying preoperative predictors of surgical difficulty remains a significant clinical goal. Among various diagnostic tools, abdominal ultrasonography plays a central role in evaluating gallbladder pathology. It is widely available, inexpensive, noninvasive, and provides real-time assessment of the biliary system. In recent years, the thickness of the gallbladder wall observed on ultrasonography has been proposed as a potential indicator of the severity of inflammation and fibrosis(2, 3). A thickened wall may reflect acute or chronic cholecystitis, edema, or associated hepatic and systemic diseases. Because these pathologic changes can alter tissue planes and visibility during laparoscopy, wall thickness could be a valuable parameter for anticipating surgical difficulty(4, 5).

Several studies have investigated the relationship between gallbladder wall thickness and operative outcomes such as conversion to open surgery, blood loss, or prolonged operative time. Although many reports suggest that an increased wall thickness is associated with higher morbidity and conversion rates, the findings remain inconsistent due to differences in patient selection, imaging criteria, and surgical expertise(4, 6). Moreover, the direct correlation between preoperative sonographic measurements and postoperative pathological findings is still not fully clarified. Predicting the complexity of laparoscopic cholecystectomy before surgery can improve patient counseling, surgical planning, and allocation of experienced surgeons(7, 8). A reliable preoperative marker would also help reduce intraoperative surprises, optimize operating room resources, and ultimately improve patient safety and outcomes. Therefore, evaluating gallbladder wall thickness as a noninvasive predictor of intraoperative and postoperative complications is both clinically relevant and cost-effective(9).

The present study was designed to assess the relationship between gallbladder wall thickness and surgical outcomes including operative duration, intraoperative complications, length of hospital stay, and postoperative morbidity among patients undergoing laparoscopic cholecystectomy. By comparing preoperative ultrasonographic and postoperative pathological findings, this research aims to provide practical insight into the prognostic value of gallbladder wall thickness and its potential role in guiding surgical decision-making.

2. Methods

2.1. Study Design, Setting, and Participants

This observational analytical study was conducted at Shahid Madani Educational Hospital, Karaj, Iran, affiliated with Alborz University of Medical Sciences. The study evaluated patients who underwent laparoscopic cholecystectomy during the year 1402. The primary aim was to assess whether gallbladder

wall thickness, measured before surgery by ultrasonography and after surgery by histopathology, was associated with operative duration, intraoperative complications, length of hospital stay, and postoperative complications.

The study population consisted of patients scheduled for laparoscopic cholecystectomy at the Department of Surgery. Participants were selected using consecutive sampling until the required sample size was reached. All eligible patients who met the inclusion criteria during the study period were considered for enrollment. Eligible patients were those aged 16 to 65 years who underwent laparoscopic cholecystectomy during the study period. Patients were included after assessment against the predefined eligibility criteria and after obtaining informed consent. Patients were excluded if they had major comorbid conditions that could independently affect gallbladder wall thickness or surgical outcomes, including underlying cardiac, hepatic, renal, or diabetic disease. Additional exclusion criteria were previous hepatobiliary surgery, pregnancy, body mass index greater than 50 kg/m², incomplete ultrasonographic data, or missing outcome information.

2.2. Variables, Measurements, and Data Collection

The main exposure variable was gallbladder wall thickness. This was assessed preoperatively using abdominal ultrasonography and postoperatively using the histopathology report of the resected gallbladder. Ultrasonographic wall thickness was recorded in millimeters based on the radiologist's report, while pathological wall thickness was recorded according to the pathologist's evaluation. For analysis, ultrasonographic gallbladder wall thickness was treated both as a continuous variable and as a categorized variable. Patients were classified into three predefined groups: normal wall thickness, defined as < 3 mm; mildly increased wall thickness, defined as 3–5 mm; and increased wall thickness, defined as > 5 mm.

The main outcome variables were operative duration, intraoperative complications, length of hospital stay, and postoperative complications within 30 days after surgery. Operative duration was recorded in minutes. Length of hospital stay was recorded in days from admission to discharge after surgery. Intraoperative events included conversion to open cholecystectomy, major bleeding, bile spillage or gallbladder perforation, common bile duct injury, and drain placement. Postoperative complications included surgical site infection, respiratory or urinary tract infection, postoperative bleeding, wound dehiscence, bile leakage or biloma, hepatic hematoma, and rectus sheath hematoma. Demographic and clinical variables were extracted from hospital records and structured data collection forms. These included age, sex, body mass index, smoking status, alcohol use, underlying disease history, duration of preoperative symptoms, and final postoperative diagnosis. Surgical findings and intraoperative events were recorded by the operating surgeon, while postoperative outcomes were documented during routine postoperative visits up to 30 days after surgery.

To improve consistency, data from the surgeon, radiologist, and pathologist were entered into a predefined checklist. The use of separate clinical, radiologic, operative, and pathological data sources allowed comparison between preoperative imaging and postoperative tissue findings. Patients with

incomplete core data, particularly missing ultrasonographic wall-thickness measurement or missing outcome information, were excluded from the final analysis.

2.3. Sample Size, Bias Control, Statistical Analysis, and Ethics

The sample size was calculated using G*Power software. Based on the thesis protocol, the calculation used an effect size of 0.25, alpha error probability of 0.05, statistical power of 80%, numerator degrees of freedom of 10, and four comparison groups, resulting in a required sample size of 180 patients. Consecutive sampling was used to reduce selection bias and to include all eligible patients during the study period until the target sample size was achieved.

Several steps were considered to reduce bias. Eligibility criteria were defined before data collection, and patients with conditions that could independently influence gallbladder wall thickness or postoperative outcomes were excluded. Ultrasonographic measurements were obtained from radiology reports, pathological measurements from pathology reports, and operative outcomes from the surgeon's documentation. However, because ultrasonography measurement is operator-dependent, the absence of formal interobserver reliability testing should be acknowledged as a potential limitation. Data were analyzed using SPSS 26.0.0.0 software. Quantitative variables were summarized as mean and standard deviation when normally distributed, and qualitative variables were reported as frequencies and percentages. Comparisons between gallbladder wall thickness groups were performed using independent samples t-test or one-way analysis of variance for continuous variables, and chi-square or Fisher's exact test for categorical variables, depending on expected cell counts. A p-value below 0.05 was considered statistically significant.

Multivariable logistic regression was performed to identify factors independently associated with intraoperative and postoperative complications. Variables entered into the model included age, sex, BMI, and ultrasonographic gallbladder wall thickness. Results were reported using p-values, and statistical significance was defined as $p < 0.05$. Ethical approval was obtained from the Ethics Committee of Alborz University of Medical Sciences, and informed consent was obtained from participants before inclusion. Patient information was kept confidential and used only for research purposes.

3. Results

3.1. Patient Characteristics and Baseline Findings

During the study period, all eligible patients scheduled for laparoscopic cholecystectomy were assessed for inclusion. After applying the predefined inclusion and exclusion criteria, 180 patients had complete ultrasonographic, operative, postoperative, and pathological data and were included in the final analysis. No additional patients were excluded from the final analysis because of missing core exposure or outcome data. The mean age of the study population was 46.06 ± 13.31 years, with a median age of 45 years and an age range of 16 to 65 years. The mean body mass index was 27.15 ± 4.20 kg/m², with a

median BMI of 27 kg/m² and a range of 16 to 44 kg/m². The mean operative time for the whole cohort was 53.55 ± 14.71 minutes, with a median operative duration of 50 minutes and a range of 30 to 120 minutes.

Most patients were female. Of the 180 included patients, 147 patients, 81.7%, were women and 33 patients, 18.3%, were men. Regarding ethnicity, the largest groups were Fars and Turk patients, including 76 patients, 42.2%, and 66 patients, 36.7%, respectively. Other ethnic groups included Kurd patients (20, 11.1%), Lor patients (15, 8.3%), and Afghan patients (3, 1.7%). Smoking was reported in 23 patients, 12.8%, and alcohol use in 13 patients, 7.2%. A positive family history was reported in 85 patients, 47.2% (Table 1).

Table 1
Baseline demographic characteristics of the study population

Variable	Category	n	%
Sex	Female	147	81.7
	Male	33	18.3
Skin color	Darker skin tone	35	19.4
	Intermediate skin tone	83	46.1
	Lighter skin tone	62	34.4
Ethnicity	Afghan	3	1.7
	Fars	76	42.2
	Kurd	20	11.1
	Lor	15	8.3
	Turk	66	36.7
Smoking status	Yes	23	12.8
	No	157	87.2
Alcohol use	Yes	13	7.2
	No	167	92.8
Family history	Positive	85	47.2
	Negative	95	52.8

Gallbladder wall thickness was assessed by both preoperative ultrasonography and postoperative pathology. The mean gallbladder wall thickness measured by ultrasonography was 3.20 ± 1.99 mm, with

a median of 2 mm and a range of 1 to 9 mm. The mean pathological gallbladder wall thickness was 3.03 ± 1.61 mm, with a median of 3 mm and a range of 1 to 10 mm. Agreement between ultrasonographic and pathological measurements was strong, with an intraclass correlation coefficient of 0.885 ($p < 0.001$), supporting the reliability of preoperative ultrasonography as a measure of gallbladder wall thickness (Table 2).

Table 2
Summary of continuous study variables

Variable	Mean	SD	Median	Range
Age, years	46.06	13.31	45	16–65
BMI, kg/m²	27.15	4.20	27	16–44
Gallbladder wall thickness by ultrasonography, mm	3.20	1.99	2	1–9
Gallbladder wall thickness by pathology, mm	3.03	1.61	3	1–10
Operative time, minutes	53.55	14.71	50	30–120

Based on ultrasonographic wall thickness, 117 patients, 65.0%, had normal gallbladder wall thickness, 46 patients, 25.6%, had mildly increased wall thickness, and 17 patients, 9.4%, had increased wall thickness. This classification was used for the main comparisons of operative time, intraoperative complications, hospital stay, and postoperative complications (Table 3).

Table 3
Gallbladder wall thickness measurements and ultrasonographic classification

Ultrasonographic wall-thickness group	Definition	n	%
Normal thickness	< 3 mm	117	65.0
Mildly increased thickness	3–5 mm	46	25.6
Increased thickness	> 5 mm	17	9.4
Total	—	**180**	**100.0**

3.2. Gallbladder Wall Thickness and Operative Outcomes

Gallbladder wall thickness was significantly associated with operative duration. Spearman correlation analysis showed a moderate positive relationship between ultrasonographic wall thickness and operative time ($r = 0.482$, $p < 0.001$). As wall thickness increased, operative time also increased, suggesting that thickened gallbladder walls were associated with greater technical difficulty during

laparoscopic cholecystectomy. When operative time was compared across wall-thickness groups, a clear stepwise increase was observed. The mean operative time was 48.92 minutes in patients with normal wall thickness, 59.35 minutes in those with mildly increased wall thickness, and 69.41 minutes in those with increased wall thickness (Table 4 and Fig. 1).

Table 4
Operative time according to ultrasonographic gallbladder wall-thickness group

Wall-thickness group	n	Mean operative time, minutes
Normal thickness	117	48.92
Mildly increased thickness	46	59.35
Increased thickness	17	69.41
Overall comparison	—	**p < 0.001**

Correlation analysis: Spearman's r = **0.482**, **p < 0.001**.

The difference between groups was statistically significant (p < 0.001). Post-hoc analysis showed significant pairwise differences between the normal, mildly increased, and increased wall-thickness groups, indicating that each rise in wall-thickness category was associated with a meaningful increase in operative duration.In practical terms, patients with increased gallbladder wall thickness had operations lasting approximately 20 minutes longer than patients with normal wall thickness. This difference is clinically relevant because longer operative duration may reflect more difficult dissection, inflammation, fibrosis, poor exposure of Calot's triangle, and greater likelihood of additional intraoperative maneuvers. Hospital stay also increased with gallbladder wall thickness. The mean ultrasonographic gallbladder wall thickness was 2.34 ± 1.41 mm among patients hospitalized for 1 day, 3.01 ± 1.76 mm among those hospitalized for 2 days, 4.95 ± 2.05 mm among those hospitalized for 3 days, and 5.72 ± 1.56 mm among those hospitalized for 4 days or more. This difference was statistically significant (p < 0.001). Post-hoc analysis showed that most pairwise comparisons were significant, except between the 1-day and 2-day groups (p = 0.148) and between the 3-day and ≥ 4-day groups (p = 0.524) (Table 5 and Fig. 2).

Table 5
Ultrasonographic gallbladder wall thickness according to length of hospital stay

Length of hospital stay	n	Mean ± SD wall thickness, mm	p-value
1 day	89	2.34 ± 1.41	
2 days	50	3.01 ± 1.76	
3 days	23	4.95 ± 2.05	
≥ 4 days	18	5.72 ± 1.56	**p < 0.001**

Post-hoc analysis: 1 day vs. 2 days, **p = 0.148**; 3 days vs. ≥4 days, **p = 0.524**. Other pairwise comparisons were statistically significant.

3.3. Intraoperative and Postoperative Complications

Overall, 84 of 180 patients, 46.7%, experienced at least one intraoperative complication. The most frequent intraoperative event was drain placement, which occurred in 84 patients, 46.7%. Major intraoperative bleeding occurred in 4 patients, 2.2%, gallbladder perforation in 1 patient, 0.6%, and conversion from laparoscopic to open surgery in 5 patients, 2.8%. The frequency of intraoperative complications increased substantially across gallbladder wall-thickness groups. Among patients with normal wall thickness, 32 of 117 patients, 27.4%, had at least one intraoperative complication. This increased to 37 of 46 patients, 80.4%, in the mildly increased wall-thickness group and 15 of 17 patients, 88.2%, in the increased wall-thickness group. The association between wall-thickness category and intraoperative complications was statistically significant ($p < 0.001$) (Table 6).

Table 6
Intraoperative complications according to ultrasonographic gallbladder wall-thickness group

Wall-thickness group	Total patients	Patients with ≥ 1 intraoperative complication	% within group	p-value
Normal thickness	117	32	27.4	
Mildly increased thickness	46	37	80.4	
Increased thickness	17	15	88.2	**p < 0.001**
Total	**180**	**84**	**46.7**	

Intraoperative event	n	%
Drain placement	84	46.7
Major intraoperative bleeding	4	2.2
Gallbladder perforation	1	0.6
Conversion to open surgery	5	2.8

Postoperative complications within 30 days occurred in 15 patients, 8.33%. Reported postoperative events included surgical site infection in 6 patients, 3.3%, biliary pancreatitis in 5 patients, 2.8%, wound dehiscence in 3 patients, 1.7%, urinary tract infection in 3 patients, 1.7%, biloma in 2 patients, 1.1%, postoperative bleeding in 2 patients, 1.1%, and rectus sheath hematoma in 2 patients, 1.1%. Patients who developed postoperative complications had significantly greater mean ultrasonographic gallbladder wall thickness than those without postoperative complications (5.20 ± 2.33 mm vs. 3.01 ± 1.87 mm, p <

0.001). Postoperative complications also increased stepwise across gallbladder wall-thickness groups. Complications occurred in 4 of 117 patients, 3.4%, with normal wall thickness, 6 of 46 patients, 13.0%, with mildly increased wall thickness, and 5 of 17 patients, 29.4%, with increased wall thickness. This association was statistically significant ($p < 0.001$) (Table 7 and Fig. 3).

Table 7. Postoperative complications according to ultrasonographic gallbladder wall-thickness group

Wall-thickness group	Total patients	Patients with ≥1 postoperative complication	% within group	p-value
Normal thickness	117	4	3.4	
Mildly increased thickness	46	6	13.0	
Increased thickness	17	5	29.4	**p < 0.001**
Total	**180**	**15**	**8.33**	

In multivariable analysis, gallbladder wall thickness remained significantly associated with both intraoperative and postoperative complications. Male sex ($p = 0.03$), higher BMI ($p = 0.004$), and increased gallbladder wall thickness ($p < 0.001$) were associated with intraoperative complications, while gallbladder wall thickness was the main significant predictor of postoperative complications ($p < 0.001$). (Table 8)

Table 8. Crude Logistic regression analysis for intraoperative and postoperative complications

Dependent outcome	Predictor	Reference group	OR	95% CI	p-value
Intraoperative complications	Mildly increased wall thickness	Normal wall thickness	10.92	4.74–25.15	< 0.001
	Increased wall thickness	Normal wall thickness	19.92	4.31–92.04	
Postoperative complications	Mildly increased wall thickness	Normal wall thickness	4.24	1.14–15.79	< 0.001
	Increased wall thickness	Normal wall thickness	11.77	2.78–49.84	

4. Discussion

In this study, increased gallbladder wall thickness was significantly associated with more difficult laparoscopic cholecystectomy, reflected by longer operative time, higher rates of intraoperative complications, longer hospital stay, and greater postoperative morbidity. These findings support the role of preoperative ultrasonographic gallbladder wall thickness as a practical marker for anticipating surgical complexity. Because ultrasonography is routinely performed before cholecystectomy, wall thickness can be incorporated into preoperative assessment without adding cost, radiation exposure, or invasive testing.

The relationship between wall thickness and operative time was one of the clearest findings of the present study. Patients with thicker gallbladder walls required longer operations, which likely reflects difficult dissection, dense adhesions, inflammation, and impaired visualization of Calot's triangle. Similar findings were reported by Alamiri, who showed that wall thickness greater than 3 mm was associated with more difficult laparoscopic dissection and a higher conversion rate to open surgery (10). Sharath Chandra et al. also found that increased wall thickness, particularly beyond 4 mm, was associated with longer operative duration and higher postoperative morbidity (11). These findings are consistent with our results and suggest that gallbladder wall thickness is not only a radiologic measurement, but also a clinically meaningful predictor of surgical difficulty.

The biological explanation for this association is plausible. Gallbladder wall thickening often reflects acute inflammation, chronic inflammatory change, edema, or fibrosis. These changes can distort normal tissue planes, increase tissue friability, and make safe identification of the cystic duct and cystic artery more challenging. In such cases, dissection around Calot's triangle may become prolonged and technically demanding, increasing the risk of bile spillage, bleeding, drain placement, or conversion to open surgery. This mechanism may explain why studies by Radunovic et al. and Kokoroskos et al. also found higher complication rates and longer operative times in patients with increased gallbladder wall thickness (9, 12).

Our findings also showed that postoperative complications were more frequent in patients with thicker gallbladder walls. This may be partly explained by greater operative difficulty, longer operative duration, more tissue manipulation, and a higher likelihood of inflammatory contamination or bile leakage. In clinical practice, these patients may require closer postoperative observation, more careful drain decisions, and more detailed counseling about recovery expectations. However, the absolute number of postoperative complications in this study was limited, so this finding should be interpreted with appropriate caution. The present results reinforce the value of preoperative ultrasonography beyond diagnosis alone. In patients scheduled for laparoscopic cholecystectomy, gallbladder wall thickness can help surgeons identify higher-risk cases before entering the operating room. This can support better operative planning, allocation of experienced surgeons, preparation for difficult dissection, and informed discussion with patients about the possibility of longer surgery, drain placement, conversion to open surgery, or extended hospitalization. This is especially useful in resource-limited settings, where a simple and accessible predictor may improve surgical planning without requiring advanced imaging.

Not all previous studies have found identical results. For example, Amirkanian reported no significant relationship between gallbladder wall thickness and conversion to open surgery, although wall thickening was still associated with longer operative time (13).These differences may be related to variation in study design, patient selection, ultrasonography thresholds, surgical expertise, definitions of difficult cholecystectomy, and the proportion of acute versus elective cases. In the present study, the strong agreement between ultrasonographic and pathological measurements supports the accuracy of ultrasonography assessment, but differences across studies highlight the need for standardized cutoff values and uniform outcome definitions.

In addition to gallbladder wall thickness, some patient-related factors may influence surgical outcomes. In our analysis, male sex and higher BMI were associated with intraoperative complications, while gallbladder wall thickness remained the most consistent predictor of both intraoperative and postoperative outcomes. This pattern is generally consistent with Yang et al., who reported that gallbladder wall thickening and acute inflammatory changes were stronger predictors of bile duct injury than several demographic or metabolic variables (14). These findings suggest that imaging-based inflammatory markers may be more useful than demographic factors alone when estimating operative difficulty.

This study has several limitations. First, it was conducted in a single center, which may limit the generalizability of the findings to other hospitals with different patient populations, imaging protocols, and surgical practices. Second, ultrasonographic wall-thickness measurement is operator-dependent; although measurements were obtained from clinical radiology reports, interobserver variability was not formally assessed. Third, the number of some specific complications, such as bile duct injury, gallbladder perforation, and postoperative biloma, was small, limiting the precision of event-specific estimates. Fourth, long-term postoperative outcomes, including chronic pain, biliary stricture, quality of life, and late readmission, were not evaluated.

Future studies should include larger, multicenter prospective cohorts to validate the predictive value of gallbladder wall thickness and determine the most clinically useful cutoff points. Combining wall thickness with other preoperative variables, such as inflammatory markers, symptom duration, acute cholecystitis status, pericholecystic fluid, impacted stones, and common bile duct diameter, may improve prediction models for difficult laparoscopic cholecystectomy. A standardized scoring system that integrates ultrasonography findings with clinical and laboratory parameters could help surgeons identify high-risk patients more accurately and plan safer operative strategies.

Conclusions

Overall, the present study supports gallbladder wall thickness as a simple, accessible, and clinically useful preoperative marker of surgical difficulty and postoperative risk in laparoscopic cholecystectomy. While it should not be used as the only determinant of operative strategy, it can meaningfully contribute to preoperative risk assessment, surgical planning, and patient counseling.

Abbreviations

ASA
American Society of Anesthesiologists
BMI
Body Mass Index
CI
Confidence Interval
ERCP
Endoscopic Retrograde Cholangiopancreatography
ICU
Intensive Care Unit
IRB
Institutional Review Board
LC
Laparoscopic Cholecystectomy
mm
Millimeter
OR
Odds Ratio
SD
Standard Deviation
SPSS
Statistical Package for the Social Sciences
US
Ultrasonography

Declarations

Ethics approval and consent to participate:

This study was approved by the Ethics Committee of Alborz University of Medical Sciences, Karaj, Iran, under the ethics code IR.ABZUMS.REC.1402.060. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before inclusion in the study.

Consent for publication:

Not applicable. No identifiable personal data, images, or individual clinical details are included in this manuscript.

Competing interests:

The authors declare that they have no competing interests.

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Author Contribution

MA contributed to study conception, supervision, data interpretation, and critical revision of the manuscript. KK contributed to methodology, statistical consultation, data interpretation, and critical revision of the manuscript. EN contributed to data collection, data entry, literature review, and drafting of the manuscript. AH contributed to conceptualization, data collection, literature review, and drafting of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials:

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Supplementary material is available in the online version of the article.

Clinical trial registration:

Not applicable. This was an observational study and did not involve an interventional clinical trial.

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Figures

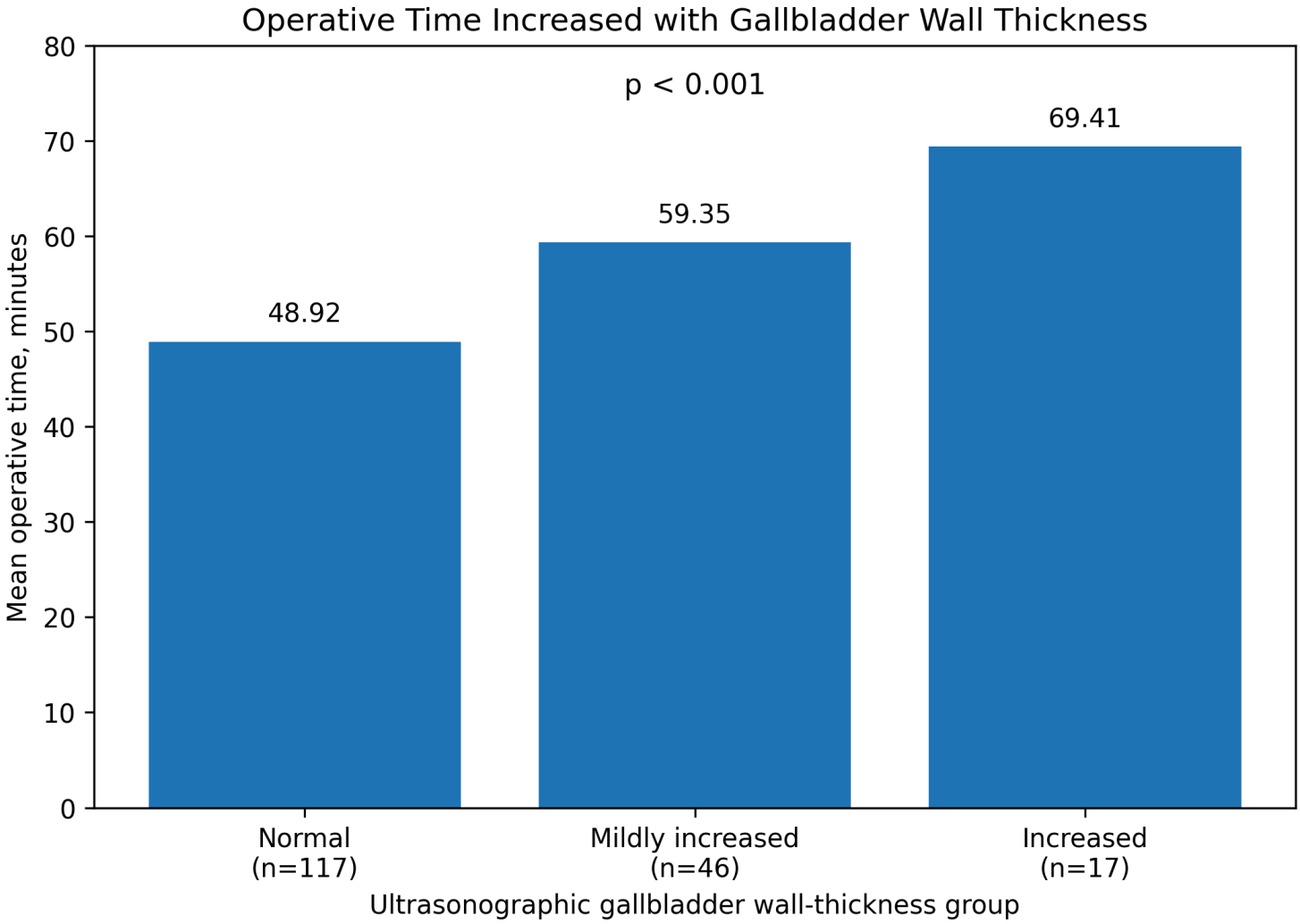


Figure 1

Operative time by gallbladder wall-thickness group

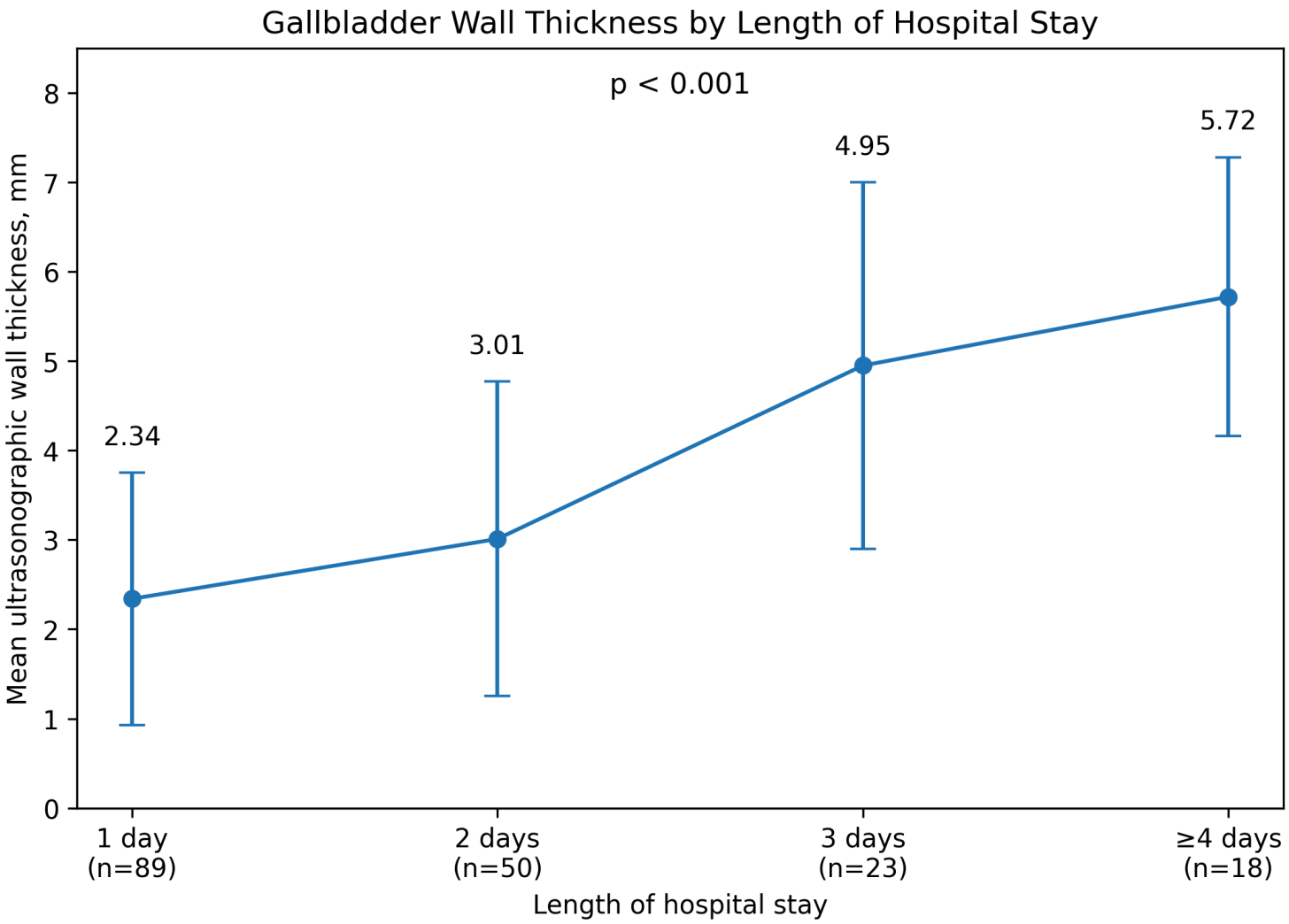


Figure 2

Gallbladder wall thickness by length of hospital stay.

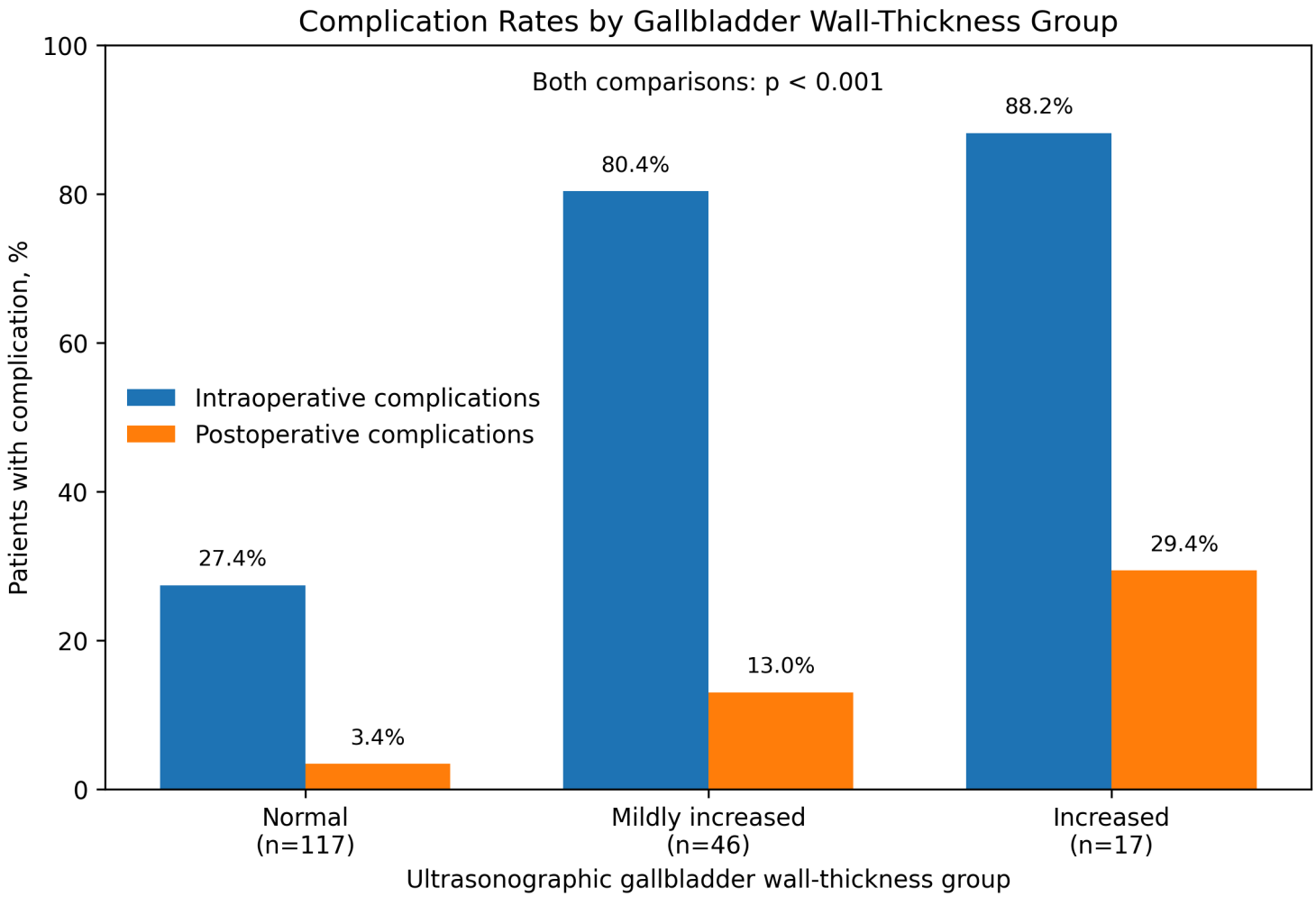


Figure 3

Intraoperative and postoperative complication rates by wall-thickness group