Could preoperative sonographic criteria predict the difficulty of laparoscopic cholecystectomy?

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Background: Although laparoscopic cholecystectomy (LC) is the gold standard approach for gallbladder diseases, this sometimes may face difficulties and require conversion to open surgery. The preoperative ultrasonographic study may provide information about the probability of difficult LC, but the data in this term are uncertain. We assessed the value of preoperative ultrasonographic findings for the prediction of LC's difficulty. **Materials and Methods:** The current prospective clinical trial was conducted on 150 patients who were candidates for LC due to symptomatic gallstone. All of the patients underwent ultrasonography study preoperatively, and then, LC was performed. The surgeon completed a checklist regarding the easy or difficult surgical criteria. Finally, the values of ultrasonographic findings for the prediction of LC difficulty were evaluated. **Results:** Among the 150 included patients, 80 had easy LC and 70 had difficult LC. Statistically significant differences were found between the two groups of easy and difficult LC regarding gallbladder wall thickness ($P = 0.008$), stone impaction ($P = 0.009$), and gallbladder flow ($P = 0.04$). The area under the curve (standard error [SE]) for the thickness of the gallbladder wall, flow in the gallbladder wall, and stone impaction was 0.598 ± 0.048, 0.543 ± 0.047, and 0.554 ± 0.047, respectively ($P < 0.05$). The highest specificity was for gallbladder wall flow (100%). Binary logistic regression showed that stone impaction had predictive value for determining difficult LC (odds ratio = 3.10; 95% confidence interval: 1.03–9.30; $P = 0.04$). **Conclusion:** Although a significant difference was observed between two groups in terms of impacted stone, flow in the gallbladder wall, and thickness of the gallbladder wall, only stone impaction had predictive value for determining difficult LC.

Key words: Cholecystectomy, gallbladder disease, laparoscopy, predictive value, ultrasonography

INTRODUCTION

Gallstone is among the prevalent complaints of patients referring to outpatient clinics. Neurovegetative-related abdominal pain, mostly in the right upper quadrant, or epigastric pain is the most common symptom contributing to a gallstone. Approximately 35% of the patients develop gallstone-related complications or recurrence of the symptoms; therefore, this disease is the most common medical problem leading to surgical interventions.[1-3]

Varieties of risk factors, including diabetes mellitus, estrogen hormone, pregnancy, obesity, liver cirrhosis, and hemolytic disorders, have been mentioned for the formation of gallstones.[3]

Universal principles of the gallstone management have not changed dramatically during recent years; however, surgical techniques have altered, and to date, laparoscopic cholecystectomy (LC) is the standard technique for the treatment of gallbladder-related complications requiring surgical intervention.[3,4] LC has remarkable advantages in contrast to conventional open cholecystectomy, including the decreased time of recovery, reduced hospital stay, less postoperative pain, and earlier initiation of daily activities.[5,6] On the other hand, LC may accompany with a significant injury to nearby structures such as vessels, bile duct, or bowel.[7] Moreover, 2%–15% of LCs converts to open procedures because of complications such as difficulties in the dissection of Calot's triangle and instrument failure.[8-10]

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Identification of factors in association with the difficulty of LC and its conversion to open surgery has significant advantages such as increased safety of patients, reduction in the overall costs of treatment, helping the surgeon consider the appropriate type of surgery, and eventually reduction in the surgical-related complications, morbidity, and mortality.[11]

Therefore, theories have been raised that ultrasonographic screening can be used for the identification of the patients who are not suitable for LC. In other words, it has been estimated that preoperative screening ultrasonography can be an appropriate means for the prediction of the possibility of LC conversion to open surgery.[12,13]

Studies in this regard are in progress and presented some factors such as a history of previous abdominal surgery, gallbladder thickness of ≥4 mm, multiple stones, and liver fibrosis as the factors associated with the conversion of LC to open surgery.[14,15] Although some studies investigated the predictive value of ultrasound in LC,[12-15] none of them evaluated the flow in the gallbladder wall which may affect the difficulty of this procedure.

Considering the high prevalence of LC and the significance of identifying factors related to the LC difficulties and failure, we evaluated the preoperative ultrasonographic criteria for the prediction of ease of LC.

MATERIALS AND METHODS

The prospective nonrandomized clinical trial has been conducted on 150 patients who were candidates for elective LC referred to the clinics of our hospitals affiliated to Isfahan University of Medical Sciences from Aril 2017 to July 2018.

The Ethics Committee of Isfahan University of Medical Sciences (Code: 396734) approved the study protocol. Furthermore, the study protocol was entirely explained for the patients, and written consent for the participation in the study was obtained from all of the study population.

Symptomatic patients older than 18 (neurovegetative abdominal pain at the right upper quadrant or epigastric pain) with the documented diagnosis of gallbladder stone based on the ultrasonographic study have entered the study. Besides, patients with abnormal liver enzymes, jaundice, and common bile duct (CBD) stone and those who were not eligible for general anesthesia were excluded from the study.

The study population was entered into the study through convenient sampling until achieving the required number of patients.

The patients' age, weight, body mass index (BMI), and history of abdominal surgery were entered into the study checklist.

Ultrasonography was performed for all of the patients by an expert radiologist using the curvilinear probe of Mindray ultrasound equipment.

The ultrasonographic assessments included gallbladder wall thickness, length, and width; presence of contracted gallbladder and collection around it; and stone impaction. In addition, Doppler sonography was performed to assess the presence of flow in the gallbladder wall.[16] Hepatic fibrosis was assessed through diagnostic values including hepatic length at the level of right kidney and the midclavicular line, hepatic surface integrity and left lobe of the liver nodularity using a linear high-frequency transducer (7.5 MHz), presence of any abnormal shunt (i.e., splenorenal shunt) or collateral circulation (i.e., patent umbilical vein >3 mm diameter or a left gastric vein >5 mm diameter), and additional findings as splenomegaly, high portal vein diameter, and decrease in velocity of portal vein.[17]

Then, all of the patients underwent LC by one of two surgeons who participated in this study, and the procedures were classified into two subgroups of easy or difficult according to surgeons' opinion. The procedures that met at least one of the manifestations below were considered as difficult:
1. Over 90-min elongation for the removal of the gallbladder following the insertion of the trocar needle
2. Over 20-min elongation for the gallbladder dissection from its bed
3. Spillage of the gallbladder content in the abdomen
4. Over 20-min elongation for the dissection of Calot's triangle
5. Conversion of LC to open surgery.[12]

Eventually, the interpretations of the ultrasonographic study were compared between the two assessed groups.

Statistical analysis
Data were entered into the Statistical Package for the Social Sciences version 19 (IBM, New York, United States). Descriptive information was presented in mean, standard deviation, percentages, and absolute numbers. For analytics, independent *t*-test and receiver operating characteristic curve were used. To present the data, specificity, sensitivity, positive predictive value, negative predictive value, and the area under the curve (AUC) were measured. $P < 0.05$ was considered statistically significant. To find the important variables of ultrasonography for prediction of different type of laparoscopy (easy or difficult), binary logistic regression was performed.

RESULTS

Data regarding of 150 patients who were candidates for LC were as follows: mean age of 47.7 ± 15.5 years (range: 18–81 years), mean body weight of 68.7 ± 10.2 kg (range: 49–100 kg), and mean BMI of 22.6 ± 3.2 kg/m² (range: 16.9–37.5 kg/m²).

The frequency distribution of reasons for considering the LC as a difficult one is demonstrated. The most prevalent one was spillage of the gallbladder content and stone in the abdomen during emptying the gallbladder. None of the procedures was converted to open surgery (0%).

The detailed information about the distribution of etiologies of difficult LC is shown in Table 1.

The mean age, weight, and BMI of the two groups were 46.96 ± 15.7 years, 69.95 ± 10.45 kg, and 22.9 ± 3.4 kg/m² in those with easy LC, respectively, and 48.52 ± 15.2 years, 57.30 ± 9.88 kg, and 22.2 ± 3.1 kg/m² in those with the difficult procedure, respectively. The insignificant difference was observed between the two groups (*P* values, 0.53 for age, 0.11 for weight, and 0.21 for BMI).

The comparison of ultrasonographic findings of those who underwent difficult versus easy LC is demonstrated in Table 2. The thickness of the gallbladder wall was higher among those with difficult surgery (*P* = 0.008).

Furthermore, significant differences between the two groups in terms of flow in the gallbladder (*P* = 0.009) and stone impaction (*P* = 0.04) were observed. Other entities including the presence of liver fibrosis, previous abdominal surgery, contraction of the gallbladder, presence of collection nearby the gallbladder, and detection of over 4 mm of gallbladder wall thickness were not statistically different between the two assessed groups (*P* > 0.05) [Table 2].

The AUC was determined for the value of gallbladder wall thickness, flow in gallbladder wall, and stone impaction for prediction of difficulty LC [Table 3].

Binary logistic regression showed that stone impaction had predictive value for determining difficult LC (odds ratio = 3.10; 95% confidence interval: 1.03–9.30; *P* = 0.04).

DISCUSSION

LC has made a positive revolutionary change in the surgical management of gallbladder stone disease.[12,18] This procedure can be performed with minimal surgical-related complications. In this term, the advantages of LC to open surgery have been well-established in the literature.[5,10] Despite all of the advantages, there are cases

Table 1: Distribution of etiologies contributing the laparoscopic cholecystectomy to a difficult procedure

The criterion contributing the procedure as difficult	Frequency (%)
No	80 (53.3)
1	2 (1.3)
2	26 (17.3)
3	3 (2)
4	0 (0)
5	0 (0)
1 and 2	3 (2)
1 and 3	3 (2)
1 and 4	11 (7.3)
2 and 4	3 (2)
3 and 4	3 (2)
1, 2 and 4	6 (4)
1, 3 and 4	4 (2.7)
2, 3 and 4	3 (2)
1, 2, 3 and 4	3 (2)

1: Over 90-min elongation for the removal of gallbladder following the insertion of trocar needle, 2: Spillage of the gallbladder content in the abdomen, 3: Over 20-min elongation for the gallbladder dissection from its bed, 4: Over 20-min elongation for the dissection of Calot's triangle 5: Conversion of LC to open surgery. LC=Laparoscopic cholecystectomy

whose procedure would not proceed in the desired trend accompanying complications or requiring turning into the open surgery.[19] Therefore, it has been assumed that preoperative assessments such as ultrasonography may provide information for the prediction of LC difficulty, thus deciding to use the best surgical approach.[12,13,20]

In the current study, we assessed the values of preoperative ultrasonographic findings for the prediction of LC difficulty. Eventually, we observed a significant thicker gallbladder wall, a higher rate of flow in the gallbladder, and a higher rate of stone impaction among those who met the criteria of difficult LC versus cases who underwent easy procedures. Other parameters including the length and width of the gallbladder, the presence of liver fibrosis, contracted gallbladder, collection around the gallbladder, over 4 mm of the gallbladder wall thickness, and previous history of abdominal surgery were similar between the two assessed groups. Further evaluations revealed that none of the preoperative ultrasonographic parameters were valuable for the prediction of LC difficulty (*P* > 0.05 for the flow in the gallbladder and stone impaction and AUC of 0.598 for the gallbladder thickness).

Varieties of ultrasonographic factors in the literature have been considered for the prediction of LC difficulty, but unified outcomes have not been achieved yet. Gallbladder thickness is one of the parameters extensively assessed in this regard. Contrary to the findings of our study, some reports are representing the predicting value of gallbladder wall thickness for the difficulty of LC and the probability of its conversion to open surgery.[8,13,21] The gallbladder

Table 2: Comparison the gallbladder ultrasonographic parameters in the two groups

Variable	Easy surgery	Difficult surgery	P
The thickness of the gallbladder wall, mean±SD	3.02±0.7	3.5±1.3	0.008
The length of the gallbladder, mean±SD	78.7±14.9	79.7±20.4	0.73
The width of the gallbladder, mean±SD	26.3±7.5	27.8±9.7	0.28
Liver fibrosis, n (%)	0	0	N/A
Previous abdominal surgery, n (%)	15 (18.8)	13 (18.6)	0.98
Contracted gallbladder, n (%)	25 (31.2)	19 (27.1)	0.58
Collection around the gallbladder, n (%)	0	0	N/A
Flow in the gallbladder wall, n (%)	0	6 (8.6)	0.009
Gallbladder wall thickness >4 mm, n (%)	11 (13.8)	15 (21.4)	0.21
Stone impaction, n (%)	5 (6.2)	12 (17.1)	0.04

N/A=Not available; SD=Standard deviation

Table 3: Comparison of the area under the curve for different variables of ultrasonographic criteria in laparoscopic cholecystectomy difficulty

Variable	AUC	SE	P	95% CI for AUC	95% CI		PPV	NPV
					Sensitivity (%)	Specificity (%)		
Wall thickness	0.598	0.048	0.008	0.496-0.682	61.4 (50.4-72.4)	60 (50.6-69.4)	57.3	64
Flow in gallbladder wall	0.543	0.047	0.009	0.450-0.636	6 (5.3-6.7)	100 (100)	100	0
Stone impaction	0.554	0.047	0.04	0.462-0.647	17.1 (14.3-19.7)	98.8 (97.1-98.9)	70.6	56.4

AUC=Area under the curve; CI=Confidence interval; SE=Standard error; PPV=Positive predictive value; NPV=Negative predictive value

wall thickness may be associated with the difficulty of the gallbladder dissection from its bed as it can impact the grasping and manipulation of the gallbladder in a negative manner.[8,22]

The other remarkably different parameter between the easy and difficult LC procedures was impacted stone that was not found to be a statistically valuable predictive factor for the difficulty of LC. Chand et al. conducted a study on fifty patients and assessed the ultrasonographic parameters among which impacted stone had 100% of predictive value for the prediction of difficult LC.[19] Lal et al. represented similar outcomes in favor of the gallbladder neck impaction value for the prediction of LC difficulty.[12] Arumugam and Pandurengan declared similar results as well, but with moderate, not excellent correlation.[23]

Flow in the gallbladder was the significant rate difference of difficult versus easy LC that similar to the previous parameters found not to be a predictive factor for the ease of LC. To the best of our knowledge, the current parameter has not been studied previously, and the current study is the first one assessing the decrease in the flow of the gallbladder as a predictive factor for the difficulty or conversion to open surgery of LC. Therefore, further studies in this term are strongly recommended.

Other clinical and ultrasonographic parameters have been stated as the predictive factors for the conversion of LC to open surgery, making LC complicated and difficult. Sharma et al. other than the gallbladder wall thickness presented the size of gallbladder and stones and the hepatoduodenal

ligament to Hartmann's pouch distance as the factors affecting the ease of LC.[13] The contraction of the gallbladder in addition to the diameter of the CBD has been presented as the other ultrasonographic manifestation for the conversion of LC to open surgery.[19] Contrary to our study, Arumugam and Pandurengan[23] and Hu et al.[24] presented the significant role of the previous history of abdominal wall manipulation on the both LC difficulty and its conversion to open surgery. It seems that the adhesions formed due to the previous abdominal surgeries may cause injury or bleeding by the placement of laparoscopic umbilical port.[25]

In the current study, bile/stone spillage was found as the most frequent complaint of surgeons in difficult LCs (29.3%). Spillage of gallbladder contents during LC has been extensively explained as a factor for the conversion of LC to open surgery and difficult LCs.[26-28] Even, Rice et al. have presented an increased risk of postlaparoscopic intra-abdominal abscess formation.[29]

We did not evaluate some demographic and clinical and paraclinical parameters including gender, white blood cells count, serum albumin, preoperative serum alkaline phosphatase, total bilirubin, diabetes mellitus, hypertension, chronic cholecystitis, history of pancreatitis, and choledocholithiasis which may be limitations of our study.[23,24,26,30]

The remarkable differences between our study and other reports in the literature may be attributed to further clinical or ultrasonographic considerations by them or maybe the type and different quality of equipment. Therefore, further

evaluations considering more demographic, laboratory, and clinical variables are recommended.

CONCLUSION

Based on the findings of the current study, although a significant difference was observed between two groups in terms of impacted stone, flow in the gallbladder, and thickness of the gallbladder wall, preoperative ultrasonographic parameters were not found to be valuable for predicting difficult LC and converting to open technique. It seems that the role of other risk factors, including biochemical parameters, should be considered in future studies.

Conflicts of interest
There are no conflicts of interest.

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