

Role of Preoperative Ultrasonography Findings in Predicting Difficult Laparoscopic Cholecystectomy

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ABSTRACT

Aim: Most of the complications in a laparoscopic cholecystectomy are due to the difficulties faced during the surgery. In this research, the attempt was made to determine the factors that can predict a difficult laparoscopic cholecystectomy preoperatively based on ultrasound findings.

Materials and methods: One hundred patients who are satisfied with our inclusion criteria were included in our study. Preoperative ultrasonography (USG) findings like thickness and size of the gallbladder (GB) wall, the diameter of the common bile duct (CBD), GB stone size and numbers, and the existence of fluid collection around the GB were given a grade of 1 or 0 based on findings being affirmative or dissent. The sums of the grade were taken and were interrelated with the difficult laparoscopic cholecystectomy. Intraoperative findings, namely, injury and damages made to the bile duct, CBD or artery, the existence of thick adhesions on the GB sides, region of the Calot's being frozen, ripped up GB and spillage of bile and stones, unusual and atypical anatomy, bleeding that hampers and obstructs the visual field, and time taken of 60–120 minutes were considered as difficult laparoscopic cholecystectomy.

Results: Four preoperative findings, namely, the thickness of GB, GB stone impacted at the neck, GB stone size, and the existence of fluid collection around the GB had statistical significance in anticipating a difficult laparoscopic cholecystectomy. An elevated preoperative ultrasonography score had shown higher chances of a difficult laparoscopic cholecystectomy.

Conclusion: Preoperative ultrasonography findings have a role in predicting a difficult laparoscopic cholecystectomy.

Clinical significance: Laparoscopic cholecystectomy will be useful to have some authentic factors (USG findings) to prognosticate difficulty, conversion, or complications in laparoscopic cholecystectomy.

Keywords: Difficult laparoscopy, Gallbladder, Laparoscopic cholecystectomy, Prospective observational study, Ultrasonography.

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INTRODUCTION

Cholecystectomy is one of the most frequently performed surgical procedures and in many developed countries they are performed laparoscopically.¹ The rapid acceptance of this new technique by the medical profession and the public was related to the obvious advantages of reduced cost, decreased hospital length of stay, reduced morbidity, better cosmetic scar, and increased patient satisfaction.² For these reasons, laparoscopic cholecystectomy is now considered the gold standard surgical treatment of choice for cholelithiasis.³ For cholecystitis and cholelithiasis, ultrasonography screening is proven to be highly accurate, safe, and non-invasive.

Those patients who had a well-established disease and previous events of cholecystitis or pancreatitis are at increased risk of experiencing a difficult laparoscopic cholecystectomy. The overall conversion rate, as reported in numerous series on laparoscopic cholecystectomy, varies from 3.2% to 5.3%. Laparoscopic cholecystectomy conversion rate increases from 15% to 20% in patients having acute cholecystitis. Presently, GB cancer and uncorrectable coagulopathy are the absolute contraindications for laparoscopic cholecystectomy.⁴

It will be useful to have some authentic factors to prognosticate difficulty, conversion, or complications in laparoscopic cholecystectomy. Patients who are anticipated to have difficulty, conversion, or complications can then be counseled about open surgery, complication, and prolonged hospital stay. In this way, the patients and their attendees will be prepared for the adverse consequences.

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A difficult laparoscopic cholecystectomy⁵ is defined as when we address a difficult GB during the surgery. When a cholecystectomy causes an increased risk and complication when compared to the standard cholecystectomy then it is known as a difficult GB. It can be due to GB inflammation due to infection and other reasons or due to difficult exposure. Inflammation includes severe chronic cholecystitis and acute cholecystitis. Acute cholecystitis is the most common cause of a difficult GB. It includes gangrenous cholecystitis, emphysematous cholecystitis, and perforated GB. Difficulty in exposure includes previous upper abdominal surgery and obesity. Other conditions are liver cirrhosis and Mirizzi's syndrome.

In this study, we determine the factors which can predict a difficult laparoscopic cholecystectomy preoperatively based on ultrasound findings. This is done by validating the cut-off score from ultrasonography formulated scoring and finding the most

commonly associated factor in the USG findings that correlates with a difficult laparoscopic cholecystectomy.

MATERIALS AND METHODS

The prospective observational study was conducted at the Department of General Surgery at Apollo Hospitals, Chennai, Tamil Nadu, India, from November 2019 to April 2021. Male and female patients above 18 of age who are ready to participate were included after explaining potential advantages, and risks. Patients were also informed about the possibility of on-table conversion to open cholecystectomy. Written informed consent for laparoscopy and if required open cholecystectomy was taken for surgery from the patient. Permission was obtained from the ethics committee and scientific advisory committee of the institution.

Inclusion Criteria

- Cholelithiasis
- Acute cholecystitis
- Empyema GB
- Symptomatic polyps
- Non-functioning GB
- Gallstone pancreatitis with or without previous upper abdomen surgery

Exclusion Criteria

- Gallbladder cancer
- Cardiac failure
- Portal hypertension
- Coagulopathies, uncorrectable coagulopathy
- Chronic obstructive pulmonary disease
- Biliary enteric fistula
- Pregnancy
- Hepatic and renal diseases

Methodology

All patients who presented to the outpatient department with symptoms suggestive of GB disease were evaluated on the following factors:

- Detailed history collection
- Systemic examinations
- Investigations with particular reference to biliary pathology
- Detailed ultrasound findings⁶

Preoperative USG findings such as thickness and size of the GB wall, the diameter of the CBD, GB stone size and numbers, and the existence of fluid collection around the GB were given a grade of 1 or 0 based on findings being affirmative or dissent.

After explaining the diagnosis to the patients and their attendees, they consented to surgery. Preanesthetic assessment and relevant investigation will be done. After relevant investigations and preanesthetic evaluation, the patients will be subjected to laparoscopic cholecystectomy, under general anesthesia. All relevant intraoperative findings will be noted.⁷ Intraoperative findings, namely, injury and damages made to the bile duct, CBD or artery, the existence of thick adhesions on the GB sides, region of the Calot's being frozen, ripped up GB and spillage of bile and stones, unusual and atypical anatomy, bleeding that hamper and obstruct the visual field and time taken of 60–120 minutes were considered as difficult laparoscopic cholecystectomy.

Statistical Methods^{8–10}

All the continuous variables will be represented by mean \pm standard deviation if they are normally distributed. All categorical variables will be represented by percentages. Comparison of categorical variables will be done by either the Chi-squared test or Fisher's exact test. Comparison of normally distributed continuous variables if any will be done by independent sample *t*-test. Comparison of non-normally distributed continuous variables if any will be done by Mann–Whitney *U* test. A receiver operating characteristic (ROC) curve is drawn to see if there is a cut-off that distinguishes between simple and difficult laparoscopic cholecystectomy instances. Data analysis will be carried out by SPSS, v.25.0; $p < 0.05$ will be considered statistically significant.

OBSERVATION AND RESULTS

Among the 100 patients who were enrolled in the study, the mean age (standard deviation) is 48.04 (± 14.23) and the median is 49. The highest number of patients lies in the 51–60 years age-group. Out of the 100 cases studied, the number of male and female patients was 48 and 52, respectively.

In these 100 patients, 26 patients had diabetes mellitus, 28 patients had hypertension, 10 patients had coronary artery disease, 6 patients had pulmonary disorder, 3 patients had renal disorder, and 1 patient had liver problem.

Pain was presented as a complaint in 90 patients on admission. A total of 73 patients had complaint of nausea and vomiting. Only two patients had complaints of a change of color of urine and stools.

Among the 100 patients 10 patients were asymptomatic and based on duration 38 patients were having acute disease and 52 patients were having chronic pathology. On examination, pallor, cyanosis, clubbing, and edema were found to be absent. Only two patients had icterus. Murphy's sign was positive in 41 patients and among these 100 patients, 18 of them had a previous history of abdominal surgery.

The ultrasonography findings of the 100 patients are as listed below. Among the 100 patients, 36 of them were found to have a GB wall thickness of more than 4 mm, 90 of them were found to have a distended GB and 15 of them had a CBD caliber size of more than or equal to 6 mm.

A total of 35 patients out of 100 had their stone size more than or equal to 1 cm and 20 of them had their stone impacted at the neck. Among these 100 patients, 39 patients had a pericholecystic fluid collection.

As depicted in Table 1, preoperative ultrasonography findings such as the thickness of the GB wall of more than 4 mm, stone at the neck of the GB, with the company of pericholecystic fluid and GB stone size of more than or 1 cm were significant in predicting a difficult laparoscopic cholecystectomy.

As seen in Table 2, the existence of wall thickness of the GB greater than 4 mm was the most precise vaticinator for a difficult laparoscopic cholecystectomy followed by gallstone impacted at the neck of the GB, the existence of pericholecystic fluid and GB stone size of more than or equal to 1 cm.

The preoperative ultrasonography score showed statistical significance in predicting a difficult laparoscopy cholecystectomy. As in Tables 3 and 4, it has been validated that when we observe

Table 1: Preoperative ultrasonographic findings with their incidence of easy and difficult laparoscopic cholecystectomy

Ultrasonography findings	Findings	Level		Total	p-value
		Easy	Difficult		
GB wall thickness	≤4 mm	51 (79.7%)	13 (20.3%)	64	0.000
	>4 mm	9 (25.0%)	27 (75.0%)	36	
GB size	<5 cm	8 (80.0%)	2 (20.0%)	10	0.308
	≥5 cm	52 (57.8%)	38 (42.2%)	90	
CBD size	<6 mm	53 (62.4%)	32 (37.6%)	85	0.253
	≥6 mm	7 (46.7%)	8 (53.3%)	15	
Size of calculus	<1 cm	46 (70.8%)	19 (29.2%)	65	0.003
	≥1 cm	14 (40.0%)	21 (60.0%)	35	
GB stone motility	Mobile	55 (68.8%)	25 (31.3%)	80	0.000
	Impacted	5 (25.0%)	15 (75.0%)	20	
Pericholecystic fluid collection	No	44 (72.1%)	17 (27.9%)	61	0.002
	Yes	16 (41.0%)	23 (59.0%)	39	

GB, gallbladder

Table 2: Diagnostic accuracy of preoperative ultrasonographic findings for predicting the difficult laparoscopic cholecystectomy.

Ultrasonography findings	Diagnostic accuracy				
	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
GB wall thickness (>4 mm)	67.5	85.0	75.0	79.7	78
GB size (≥5 cm)	95.0	13.3	42.2	80.0	70
CBD size (≥6 mm)	20.0	88.3	53.3	62.4	46
Size of calculus (≥1 cm)	52.5	76.7	60.0	70.8	61
GB stone motility (impacted)	37.5	91.7	75.0	68.8	67
Pericholecystic fluid collection (yes)	57.5	73.3	59.0	72.1	67

GB, gallbladder; PPV, positive predictive value; NPV, negative predictive value

a rise in preoperative USG score, the percentage of difficult laparoscopic cholecystectomies done is higher.

Among the 100 patients, 60 patients had an easy laparoscopic cholecystectomy and 40 patients had a difficult cholecystectomy.

DISCUSSION

Determining the factors that can predict a difficult laparoscopic cholecystectomy preoperatively based on ultrasound findings was the aim of our study. Our primary objective was to validate a cut-off score from the score formulated by preoperative ultrasonography findings that are specific to the GB and thereby predicting a difficult laparoscopic cholecystectomy. In our study, we also tried to find the most commonly associated finding that is specific to the GB that correlates with a difficult laparoscopic cholecystectomy.

There are many Western works of literature available that studied the relationship between preoperative ultrasonography findings and intraoperative surgical outcomes. In India, there are not that many studies available to correlate preoperative ultrasonography findings and intraoperative surgical outcomes.

In this study, we took a total of six parameters that are significant in predicting GB pathology. They were of the thickness of more than 4 mm of the wall of the GB, size of distension of the GB of more than or equal to 5 cm, the CBD caliber size of more than or equal to 6 mm, GB stone impacted at the neck, GB stone size

Table 3: Preoperative ultrasonography score with their incidence of easy and difficult laparoscopic cholecystectomy

Preoperative USG score	Laparoscopic cholecystectomy			
	Easy	Difficult	Total	p-value
0–1	20 (87.0%)	3 (13.0%)	23	0.000
2–3	40 (65.6%)	21 (34.4%)	61	0.000
≥4	0	16 (100.0%)	16	0.000

Table 4: Diagnostic accuracy of preoperative ultrasonography score for predicting the difficult laparoscopic cholecystectomy

Preoperative USG score	Diagnostic accuracy				
	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
0–1	13.0	51.95	7.5	66.67	43.0
2–3	34.4	51.28	52.5	33.33	41.0
≥4	100.0	71.43	40.0	100.0	76.0

PPV, positive predictive value; NPV, negative predictive value

more than or equal to 1 cm, and the existence of fluid collection around the GB. The surgical outcomes were divided into easy difficult and very difficult based on the intraoperative findings

which were discussed earlier. In our study, we had no conversions to open cholecystectomy. All 100 patients have had a standard laparoscopic cholecystectomy.

In this study, we had a remarkable association with the thickness of the GB wall. A total of 36 patients had an increased breadth. When we had a breadth of more than 4 mm, 27 (75%) of them had a difficult laparoscopic cholecystectomy and the rest 9 (25%) had an easy laparoscopic cholecystectomy. Daradkeh et al.,¹¹ Lal et al.,¹² Carmody et al.,¹³ Kreimer et al.,¹⁴ and Corr et al.¹⁵ also reported in their respective studies that the GB wall thickness was the best ultrasonic parameter to predict a difficult laparoscopic cholecystectomy.

Chindarkar et al.⁶ and Dinkel et al.¹⁶ reported the sensitivity of 65 and 66.7%, specificity of 97 and 94.1%, positive predictive value (PPV) of 92.9 and 84.2%, negative predictive value (NPV) of 84.8, and 85.3% for escalating in the breadth of the wall of the GB of more than 4 mm as a criterion for operative difficulty. Whereas in this study, we had a sensitivity of 67.5%, specificity of 85.0%, PPV of 75.0%, NPV of 79.7%, and an accuracy of 78.0% for escalating in the breadth of the wall of the GB of greater than 4 mm as a criterion to anticipate a difficult laparoscopic cholecystectomy, respectively, with $p = 0.000$.

Next to increased thickness, the further notable statistically significant criterion was the GB stone impacted at the neck. Out of 20 cases that had stone impacted and adhered at the GB neck, 15 cases were found to be difficult. Daradkeh et al.,¹¹ Santambrogio et al.,¹⁷ and Randhawa and Pujahari⁷ have reported that when we had a case where the stone is firmly attached to the neck of the GB there are more chances that the case will be having a difficulty in dissection during surgery. Chindarkar et al.⁶ and Akhter et al.¹⁸ have reported that there is a firm association with the impaction of the stone at the neck of the GB to anticipate a difficult laparoscopic cholecystectomy. Chindarkar et al.⁶ reported a sensitivity of 40%, specificity of 100%, PPV of 100%, NPV of 76.9%, and 80% accuracy for the stone impaction at the GB neck.

The chief difficulty observed during the surgery is when the calculi get adhered to the neck and making it difficult to hold and grasp with laparoscopic instruments. It slows down and restricts retraction and the dissection of the Calot's triangle. There is also mucocoele formation due to mucus collection with in turn makes the GB to be distended and tense. In our study, we found a sensitivity of 37.5%, specificity of 91.7%, PPV of 75.0%, NPV of 68.8%, and 67% accuracy with $p = 0.000$.

Our study also discovered that there is an appreciable interconnection between the existence of pericholecystic collection in anticipating a difficult laparoscopic cholecystectomy. In our study, out of 100 patients, 39 of them had the presence of pericholecystic fluid collection in their preoperative ultrasound. Among those 39 of them, 23 patients had a difficult laparoscopic cholecystectomy. In the study done by Chindarkar et al.⁶ and Nidoni et al.,¹⁹ they have reported that presence of pericholecystic collection have a significant correlation with a difficult laparoscopic cholecystectomy. They also reported a sensitivity of 50.0 and 70%, specificity of 97.5 and 91.76%, PPV of 90.9 and 33.33%, NPV of 79.6 and 98.11%, and accuracy of 81.7 and 73.33%, respectively. In our study, we had a result of 57.5% of sensitivity, specificity of 73.3%, PPV of 59.0%, NPV of 72.1%, and accuracy of 67% with the $p = 0.002$.

Few studies have reported that there is a statistical significance between the sizes of the GB calculus with the difficult laparoscopy cholecystectomy. In this study, 35 patients had their calculus size more than or equal to 1 cm. Among those 35 patients, 21 patients (60%) had a difficult laparoscopic cholecystectomy. Chindarkar

et al.,⁶ Corr et al.,¹⁵ Lein and Huang,²⁰ and Kama et al.²¹ have reported in their studies that there is an appreciable interconnection in anticipating a difficult laparoscopic cholecystectomy if the stone in the GB measures more than or equal to 1 cm in diameter. Chindarkar et al.⁶ reported 40.0% of sensitivity, specificity of 92.5%, 72.7% of PPV, NPV of 75.5%, and 75% accuracy with $p = 0.004$. Our study had a 52.5% of sensitivity, specificity of 76.7%, and PPV of 60.0%, NPV of 70.8%, and 61% accuracy with $p = 0.003$ for the criterion if GB calculus measurement in length is more than or equal to 1 cm.

Other two criterion in preoperative ultrasound, namely, the size of distension of the GB of more than or equal to 5 cm and the CBD caliber size of more than or equal to 6 mm was found to have no statistical significance in predicting a difficult laparoscopic cholecystectomy. This is a contrast discovery we found to the study made by Chindarkar et al., Lal et al., Corr et al., and Daradkeh et al. They have published that they noticed a moderate interrelation in anticipating a difficult laparoscopic cholecystectomy.

Several studies have attempted to form a scoring to predict a difficult laparoscopic cholecystectomy preoperatively. However, most of these studies are complex and use large number of determining factors. These studies are difficult to adapt and use in regular day-to-day practice.²²⁻²⁵ In our studies, the scoring method was made in such a way that it is easy to follow and to use on regular day-to-day practice. In the study reported by Chindarkar et al., they had a 92.86% of sensitivity, 97.5% of specificity, PPV of 65.0%, NPV of 97.5%, and accuracy of 86.66% for the preoperative ultrasound score of more than or equal to 4. Whereas in this study, the sensitivity was 100.0%, specificity was 71.43%, PPV of 40.0%, NPV of 100.0%, and 76.0% accuracy for preoperative ultrasound scores more than or equal to 4 as a criterion to predict a difficult laparoscopic cholecystectomy with $p = 0.000$.

The difficulties we faced in our study intraoperatively are the presence of dense peri GB adhesions and frozen Calot's triangle. There was a minimal tear in the GB during dissection which accounted for bile and stone spillage. In our study, there was no injury made to the hepatic duct, CBD, and hepatic artery. We did not have bleeding that hindered the visual field, buried or intrahepatic GB. In this study, there were no conversions to open cholecystectomy. All 100 patients have had a standard laparoscopic cholecystectomy. Our observation made from the study agrees with other studies by Corr et al.,¹⁵ Fried et al.,²⁶ Chindarkar et al.,⁶ Santambrogio et al.,¹⁷ and Daradkeh et al.,¹¹ that the preoperative ultrasonography finding can help in predicting a difficult laparoscopic cholecystectomy.

CONCLUSION

Overall critical complication rates seen in a standard laparoscopic cholecystectomy are more and seen frequently when compared to traditional open cholecystectomy. Most of these complications are made due to the difficulty faced during the surgery. Therefore, it would be helpful to have some tools to recognize a difficult laparoscopic cholecystectomy preoperatively. Determining the factors that can predict a difficult laparoscopic cholecystectomy preoperatively based on ultrasound findings was the aim of our study. The primary objective of our study is to validate a cut-off score from the ultrasonography formulated scoring method in identifying a difficult laparoscopic cholecystectomy. Finding the most notable and remarkable criterion in ultrasonography which is interrelated with a difficult laparoscopic cholecystectomy was our secondary objective.

A total of 100 patients who are satisfied to our inclusion criteria who were admitted for laparoscopic cholecystectomy were included

in our study. Preoperative ultrasound findings such as thickness of more than 4 mm of the wall of the GB, size of distension of the GB of more than or equal to 5 cm, the CBD caliber size of more than or equal to 6 mm, GB stone impacted at the neck, GB stone size more than or equal to 1 cm and the existence of fluid collection around the GB were given a grade of 1 or 0 based on findings being affirmative or dissent. The sums of the grade were taken and were interrelated with the difficult laparoscopic cholecystectomy. Intraoperative findings, namely, injury and damages made to the bile duct, CBD or artery, the existence of thick adhesions on the GB sides, region of the Calot's being frozen, ripped up GB and spillage of bile and stones, unusual and atypical anatomy, bleeding that hamper and obstruct the visual field and time taken of 60–120 minutes were considered as difficult laparoscopic cholecystectomy.

Four preoperative findings, namely, the thickness of more than 4 mm of the wall of the GB, GB stone impacted at the neck, GB stone size more than or equal to 1 cm, and the existence of fluid collection around the GB had statistical significance in anticipating a difficult laparoscopic cholecystectomy. An elevated preoperative ultrasonography score had shown higher chances of a difficult laparoscopic cholecystectomy. Our study also discovered that the preoperative grade of more than or equal to 4 had the highest statistical significance in anticipating a difficult laparoscopic cholecystectomy.

Preoperative ultrasound findings such as the thickness of greater than 4 mm of the wall of the GB, measurement in the length of distension of the GB of greater than or equal to 5 cm, the CBD caliber size greater than or equal to 6 mm, GB stone impacted at the neck, GB stone size more than or equal to 1 cm and the existence of fluid collection around the GB can predict a difficult laparoscopic cholecystectomy preoperatively. A cut-off score of more than or equal to 4 from the ultrasonography formulated grading method can prognosticate a difficult laparoscopic cholecystectomy. The thickness of more than 4 mm of the wall of the GB is the most statistically significant criterion in predicting a difficult laparoscopic cholecystectomy. From these observations, we conclude that preoperative ultrasonography findings have a role in predicting a difficult laparoscopic cholecystectomy.

RECOMMENDATION

Our study only compared the correlation of ultrasonography findings with the intraoperative prediction of difficult laparoscopic cholecystectomy. Our study was conducted on a limited patient population. Having a larger population will make our result more statistically significant. Also, there are very few literatures available that compared difficult laparoscopic cholecystectomy with other investigation modalities such as a contrast-enhanced computed tomography scan and magnetic resonance imaging. Hence, we would recommend a good larger population and use computed tomography scans, and magnetic resonance imaging scans to get more statistically significant results.

LIMITATIONS

The study was conducted on a limited patient population of 100. Even though the gold standard investigation of choice is ultrasound for diagnosing GB stones, it is purely an operated depended on one. A highly skilled and experienced sonologist with the latest ultrasound device can provide the best quality image and make a precise diagnosis. Hence, some degree of variation in the values

of ultrasonography findings was anticipated. Laparoscopy surgery compared to open surgery needs extra time to become an expert in it and as the surgery itself a skill-based technique it differs from surgeon to surgeon. To make it to have some standard, all radiologists and surgeons with a minimum of more than 10 years of experience in their respective field were performing the investigation and the surgery.

CLINICAL SIGNIFICANCE

Compared with open cholecystectomy, laparoscopic cholecystectomy has obvious advantages of reduced cost, decreased hospital length of stay, reduced morbidity, better cosmetic scar, and increased patient satisfaction. For these reasons, the laparoscopic cholecystectomy is now considered as the gold standard surgical treatment of choice for cholelithiasis. It will be useful to have some authentic factors (USG findings) to prognosticate difficulty, conversion, or complications in laparoscopic cholecystectomy.

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