

Original Research Article

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Prediction of difficult laparoscopic cholecystectomy on the basis of preoperative ultrasonography assessment

Saurabh Chhaparia^{1,2}, Komal Prasad Dewangan^{1,3*}, Srinivasa Rao Geddam^{1,4}

¹Department of General Surgery, The Calcutta Research Institute, Kolkata, West Bengal, India

²Department of General Surgery, Acharya Shree Bhikshu Hospital, Moti Nagar, New Delhi, India

³Department of General Surgery, Chhattisgarh Institute of Medical Sciences (CIMS), Bilaspur, Chhattisgarh, India

⁴Department of General Surgery, Visakha Institute of Medical Sciences, Visakhapatnam, Andhra Pradesh, India

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***Correspondence:**

Dr. Komal Prasad Dewangan,

E-mail: drkomaldewangan1986@gmail.com

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is widely used for cholezystolithiasis. Abdominal ultrasonography (USG) is the investigation of choice for diagnosis of gall stone and often done before cholecystectomy. It also helps to predict possible complications during peri-operative period. Till now, there is no established definition of difficult LC.

Method: Patients diagnosed as cholezystolithiasis confirmed by USG were studied. Nine parameters of abdominal USG had been assessed. Each parameter was divided into two groups, group A and group B based on finding of USG. Total number of USG finding of each group was calculated. Each surgery was assessed and categorise as easy or difficult and co related with total number of USG finding of each group.

Results: For difficult LC-group B USG criteria ≥ 4 with group A USG criterion ≤ 5 having sensitivity 84.09%, specificity 80.43% and diagnostic accuracy 82.22%. For easy LC-group A USG criterion ≥ 6 with group B USG criteria ≤ 3 having sensitivity 80.43%, specificity 84.09% and diagnostic accuracy 82.22%. For easy LC, the mean post-operative stay was 1.57 days and for difficult LC, the mean post operative stay was 2.52 days.

Conclusions: Preoperative USG assessment is a good predictor of difficult LC. Thick-walled gall bladder (GB), presence of pericholecystic fluid collection, impacted stone at neck or proximal to neck of GB and contracted GB are good predictors of difficult LC. Gender is not an independent risk factor for difficult LC.

Keywords: LC, Cholezystolithiasis, Abdominal USG, Preoperative USG, GB

INTRODUCTION

Cholezystolithiasis is presence of gall stone while choledocholithiasis means presence of stone inside bile duct. Cholezystolithiasis is the most commonly known biliary pathology. Generally, gallstones are present in 10 to 15% of the general population and out of these, asymptomatic cases are in the majority ($>80\%$).¹ The prevalence of cholezystolithiasis varies widely in different parts of the world. In India, it is estimated approximately to be around 4%. LC is one of the most common procedures done for biliary pathology.

Cholezystolithiasis first described in 1420 by Florentine pathologist; Antinio Benivenius.² Carl Langenbuch on July 15th 1882, performed the first open cholecystectomy (OC) for treatment of cholezystolithiasis.³ Erich Muhe in 1986, performed LC for the first time, which quickly became the standard of care for symptomatic cholezystolithiasis because of early recovery.⁴ It has a very good therapeutic outcome which results in improvement of symptoms in about 90% of patients.

Investigation of choice is abdominal USG for diagnosing cholezystolithiasis and it is the most common non-

invasive procedure, safe even in pregnancy and highly accurate screening test for cholecystolithiasis and cholecystitis. USG can also helpful for surgeons to get an idea of potential difficulty to be faced during surgery in a particular patient as suggested by different studies. The advantages of LC over OC are earlier return of enteral feeding, decrease postoperative pain, better cosmetic outcome, duration of hospital stay is less, earlier return of patient's physical activity.

In advancing age, selection criteria for LC have become more liberal. Like, previously morbid obesity and upper abdominal surgery were considered as absolute contraindication for doing LC, but now these are not considered as absolute contraindications. Now, numbers of contraindications are coming down significantly. However, Sometimes LC becomes difficult and few difficult cases require conversion of LC to OC for various reasons. So, for surgeons it would be helpful to establish criteria that will assess the predictability of become difficult LC and risk of conversion to open preoperatively and managing a more experienced surgical team which includes surgeons and nursing staff. This would also be useful for informing patients for increase length of hospital stay, increase financial burden when LC become difficult and risk for conversion appears significant.³

Some studies shows that clinical factor which includes patient factor (e.g., age, sex, obesity, previous upper abdominal surgeries co morbidities like diabetes mellitus, COPD etc.) and disease factor (e.g., recurrent attack of acute cholecystitis, derange LFT, serum amylase), radiological factor which includes different USG finding of GB, intraoperative factor (e.g., adhesions, frozen calot's etc.) should be considered before doing LC. So that, a prediction can be made whether surgery is becoming easy or difficult.⁵ But considering all criteria become very difficult and complex also, so a definition of difficult LC cannot be made till now.

Some previous studies show different USG criteria can predict a difficult LC. But results are variable and they suggest further need for study. Some studies suggest, certain USG findings can predict the chances of conversion to the open procedure and risk of certain complications so that the Surgeon and the patient can be well prepare. On the basis of USG findings, Surgeons can select the easy or difficult cases, appropriate for their skills aiming at reducing operative and post operative complications and minimizing the operative time. This study had been done in our hospital, CMRI Kolkata to look for certain preoperative USG findings to develop criteria which can predict difficult LC preoperatively.

METHODS

Study design

The study was an observational prospective study.

Study setting

This study was conducted in the department of general surgery in collaboration with department of radio diagnosis at the Calcutta medical research institute, Kolkata.

Study period

This study was conducted for a period of 6 months from 1st Jan 2020 to 1st July 2020.

Study sample

The study had been done on 90 patients of cholecystolithiasis, requiring elective LC, attending surgical OPD in CMRI, Kolkata.

Inclusion criteria

All patients with cholecystolithiasis of age more than 18 years were included in this study.

Exclusion criteria

Patients with CBD stones, patients with jaundice, patients with acute pancreatitis, patients with known carcinoma gallbladder, patients with cholangitis, biliary-enteric fistula, portal hypertension, patients with history of previous upper abdominal surgeries were excluded.

A detailed clinical history with special reference to abdominal pain, jaundice, co-morbidities, history of prior hospitalization, history of previous abdominal surgery was taken. The information was recorded in proforma.

Patients who fulfilled the inclusion criteria were recruited in this study after obtaining informed consent.

Intervention

Since it was prospective observational study, so intervention was not required for study and not be done.

Data collection

Study population

The source of data for study was 90 patients, 18 years and above, requiring LC admitted during the period of 6 months commencing from 1st Jan 2020 to 1st July 2020, in the department of general surgery at the Calcutta medical research institute, Kolkata.

Assessment for easy and difficult LC

All ultrasonogram were done on ACUSON Juniper 100V/115V/230V WW ultrasound machine in department of radiodiagnosis, CMRI, KOLKATA.

All ultrasonograms were done or reviewed by single senior radiologist of the institute.

USG findings of 90 patients who underwent LC are assessed prospectively.

Table 1: USG parameters used in this study.

Deciding parameters	Group A	Group B
Number of stones²⁴	Single stone	Multiple stone
Approximate stone sizes or size of largest calculus⁸	<10 mm size	≥10 mm size score
Stone mobility²⁴	Mobile in GB	Impacted at neck or proximal to neck
Biliary sludge²⁹	Absent	Present
Pericholecystic fluid²⁴	Absent	Present
GB wall thickness²⁴	<4 mm	≥4 mm
GB size²⁷	GB distended (transverse diameter >5 cm)	GB contracted (transverse diameter equal or <5 cm)
Diameter of common bile duct²⁴	<6 mm	≥6 mm
Liver size²⁴	Liver span <15.5 cm	liver span ≥15.5 cm

Perioperative factors used in study

Following nine parameters were taken to assess easy and difficult LC:

Time taken in minutes: Easy <60 minutes, difficult ≥ 60 minutes.²⁴ Surgeon having experience of more than 5 years or done 250 laparoscopic cholecystectomies independently. Time was taken from insertion of varies needle or trocar in open method to GB removal from port.

GB bed dissection:¹⁴ Operating surgeon was describe as easy or difficult LC depending upon difficulty in grasping/retracting GB, obscure anatomy of Calot's, adhesions, anatomical variation.

Difficult extraction:¹⁴ Extension of incision for extraction.

Rupture of GB with spillage of bile or stone.²⁴ Cystic duct or cystic arterial injury.⁴ Conversion to OC.²⁴ Need additional help or requiring opinion of other surgeon during intraoperative period. Need for blood transfusion due to LC. Significant amount of drainage in terms of quantity and quality (Drain had to kept for >24 hour).

These criteria were suggested in prior studies and also being agreed upon by senior surgeons of general surgery department of CMRI, Kolkata.

Assessment was done after preoperative USG and correlate with easy or difficult LC.

After clinical assessment, investigations and documented consent of patient, preoperative USG assessment was done and categories each USG finding into 2 groups of USG parameter, group A and group B. Then patient was taken to OT. Operative assessment and post-operative assessment were done. This perioperative assessment was classified whether it was easy or difficult LC based on negative or positive findings of above criteria. If all parameter were negative, then only LC considered to be easy. If one or more parameter was/were present, then LC was considered to be difficult. Each LC whether difficult or easy, was correlate with each preoperative USG finding for their significance, for significance of total number of group A and group B criteria.

Procedure for LC: The procedure was follow the sequence of creation of pneumoperitoneum using veers needle or by open method, 4 standard port placement, separation of all adhesions from GB and the surrounding liver with the exposure of calot's triangle, attaining critical view of safety, peritoneal fold dissection in which cystic artery and duct situated, skeletonization of cystic duct and cystic artery, occlusion and division of these structures, dissection of GB from the GB fossa of liver and extraction of GB from the infraumbilical/supraumbilical/epigastric port site under vision using a 10 mm 30 degree/0 degree telescope during specimen extraction. In case of need, intraperitoneal wash given.

Outcome

Primary: Primarily, to validate a USG based criteria which can predict difficult LC.

Secondary: To find individual USG parameter as a risk factor for difficult LC. Whether USG based criteria to predict increase hospital stay in case of difficult LC based on USG.

Sample size: The sample size for this study was 90 patients. Assuming p<0.05 to be significant.

n (sample size) = $z_{\alpha/2}^2 p (1-p)/e^2$ where p is proportion, e is precision

Here, $\alpha=5\%$ hence $z_{\alpha/2}=1.96$ p (prevalence of gallstone) =4% $e=5\%$. Using these values in above formula, n is coming as 60. Hence minimum 60 patients should be included in study. But for study, sample size was 90.

Statistical methods

Continuous variables are expressed as mean, median and standard deviation and compared across the groups using Mann-Whitney U test. Categorical variables are expressed as Number of patients and percentage of patients and compared across the groups using Pearson's Chi Square test for independence of attributes/ Fisher's exact test as appropriate. Sensitivity, specificity, PPV, NPV and diagnostic accuracy calculated for specified cut offs. Statistical software SPSS version 20 has been used for the analysis. An alpha level of 5% has been taken, i.e., if any $p<0.05$ it has been considered as significant.

Ethical considerations

There was no risk as such involved in the study because I was collected data from a procedure that was a scheduled part of treatment protocol of patient. There was no any additional cost involved in the study. Study may help in economic counseling and mental preparation of patient and their relatives for prolong hospital stay in case of difficult LC. Study result may help to surgeons for explaining about morbidity and OT preparation in case of difficult LC.

RESULTS

This study was an observational prospective study carried out on 90 patients who visited to CMRI (Kolkata) surgical OPD and underwent cholecystectomy (Laparoscopic/laparoscopic proceed to open procedure) after being diagnosed as case of cholezystolithiasis.

The analysis of results revealed that: Total number of cases included in this study-90, total number of easy LC-46 and total number of difficult LC-44.

Criteria taken for decide for difficult LC, if any one criterion was present then LC was considered as difficult: In case of OT time (≥ 60 minutes) study, it was found that out of total 90 cases, 30 i.e., 33.33% cases took time ≥ 60 minutes and 60 cases i.e., 66.67% cases took time < 60 minutes. Also, out of 44 difficult cases, OT time was less than 60 minutes in 14 cases i.e., 31.82% and OT time was ≥ 60 minutes for 30 cases, i.e., 68.18%. Hence, $p<0.001$ which was found significant (Table 2).

In case of difficult GB bed dissection study, it was found that out of total 90 cases, 33 i.e., 36.67% cases had difficult GB bed dissection and 57 cases i.e., 63.33% cases had no difficulty in GB bed dissection. Also, out of total 44 difficult cases, 33 cases i.e., 75% had difficulty in dissection of GB bed, while 11 cases i.e., 25% cases had no difficulty in GB bed dissection. Hence, $p<0.001$ which was found significant (Table 3).

It was found that in GB rupture with spillage of bile and stone, out of total 90 cases, 24 cases i.e., 26.67% had GB rupture with spillage while 66 cases i.e., 73.33% had not

GB rupture with spillage. Also, out of total 44 difficult cases, 24 cases i.e., 54.55% had GB rupture with spillage while 20 cases i.e., 45.45% cases had not GB rupture. Hence, $p<0.001$ which was found significant (Table 4).

Different USG parameters

It was found that the number of stones out of total 90 cases, 28 cases i.e., 31.11% had single stone placed in group A and 62 cases i.e., 68.89% had multiple stone placed in group B. And, out of total 46 cases which were found to be easy, 17 cases i.e., 36.96% had single stone i.e., from group A and 29 cases i.e., 63.04% had multiple stone i.e., from group B. Also, out of total 44 cases which were found to be difficult, 11 cases i.e., 25% had single stone i.e., from group A and 33 cases i.e., 75% had multiple stone i.e., from group B. Hence, $p=0.221$ which was found not significant (Figure 1).

Approximate stone sizes or size of largest calculus was found out of total 90 cases, 44 cases i.e., 48.89% had < 10 mm GB stone size placed in group A and 46 cases i.e., 51.11% had ≥ 10 mm GB stone size placed in group B. And, out of total 46 cases which was found to be easy, 27 cases i.e., 58.7% had < 10 mm stone size i.e., from group A and 19 cases i.e., 41.3% had ≥ 10 mm stone size i.e., from group B. Also, out of total of 44 cases which was found be difficult, 17 cases i.e., 38.64% had < 10 mm stone size i.e., from group A and 27 cases i.e., 61.36% had ≥ 10 mm stone size i.e., from group B. Hence, $p=0.057$, which was found not significant (Figure 2).

In case of stone mobility study, it was found that out of total 90 cases, 72 cases i.e., 80% had stone mobile in GB lumen placed in group A and 18 cases i.e., 20% cases had stone impacted at neck or proximal to neck of GB placed in group B. And, out of total 46 cases which found to be easy, 42 cases i.e., 91.3% had stone mobile in GB lumen i.e., from group A and 4 cases i.e., 8.7% had stone at neck or proximal to neck of GB i.e., from group B. Also, out of total 44 cases which found to be difficult, 30 cases i.e., 68.18% had stone mobile in GB lumen i.e., from group A and 14 cases i.e., 31.82% had stone impacted at neck or proximal to neck of GB i.e., from group B. Hence, $p=0.006$ which was found significant (Figure 3).

Pericholecystic fluid collection was found in out of total 90 cases, 60 cases i.e., 66.67% had not pericholecystic fluid placed in group A and 30 cases i.e., 33.33% cases had pericholecystic fluid placed in group B. And, out of total 46 cases which found to be easy, 40 cases i.e., 80.96% had not pericholecystic fluid i.e., from group A and 6 cases i.e., 13.04% had pericholecystic fluid i.e., from group B. Also, out of total 44 cases which found to be difficult, 20 cases i.e., 45.45% had not pericholecystic fluid i.e., from group A and 24 cases i.e., 54.55% had pericholecystic fluid i.e., from group B. Hence, $p<0.001$ which was found significant (Figure 4).

The GB wall thickness was found out of total 90 cases, 51 cases i.e., 56.67% had GB wall <4 mm placed in group A and 39 cases i.e., 43.33% had GB wall thickness ≥ 4 mm placed in group B. And, out of total 46 cases which were found to be easy, 36 cases i.e., 78.26% had GB wall thickness <4 mm i.e., from group A and 10 cases i.e., 21.74% had GB wall thickness ≥ 4 mm i.e., from group B. Also, out of total 44 cases which were found to be difficult, 15 cases i.e., 34.09% had GB wall thickness <4 mm i.e., from group A and 29 cases i.e., 65.91% had GB wall thickness ≥ 4 mm i.e., from group B. Hence, $p<0.001$ which was found significant (Figure 5).

The liver size in this study was found out of total 90 cases, 73 cases i.e., 81.11% had liver span <15.5 cm placed in group A and 17 cases i.e., 18.89% had liver span ≥ 15 cm placed in group B. And, out of total 46 cases which were found to be easy, 38 cases i.e., 82.61% had liver span <15.5 cm i.e., from group A and 8 cases i.e., 17.39% had liver span ≥ 15.5 cm i.e., from group B. Also, out of total 44 cases which were found to be difficult, 35 cases i.e., 79.55% had liver span <15.5 cm i.e., from group A and 9 cases i.e., 20.45% had liver span ≥ 15.5 cm i.e., from group B. Hence, $p=0.711$ which was found not significant (Figure 6).

In central tendency for group A and group B study, for easy LC, the mean, median and SD of group A criteria

was found 6.93, 7.0 and 0.77 respectively whereas, for group B criteria, it was found 2.07, 2.0, 0.77 respectively. For difficult LC, the mean, median and SD of group A criteria was found 4.68, 5.0 and 0.98 respectively whereas, for group B criteria, it was found 4.32, 4.0 and 0.98 respectively. Hence, p value for both group A and group B criteria calculated <0.001 (Significant) (Table 5).

The USG criteria for difficult LC was found for group B ≥ 4 criteria and for group A ≤ 5 criteria, sensitivity was found 84.09%, specificity was found 80.43%, PPV was found 80.43, NPV was found 84.09 and diagnostic accuracy was found 82.22% (Table 6).

In this study, it was found that mean and median age was 42.22 years and 36.00 years respectively for easy LC with SD=15.45. Whereas, for difficult LC, mean and median age-47. 45 years and 46 respectively with SD=11.91. Hence, $p=0.020$ which found significant (Figure 7).

Also, for easy LC, mean, median and SD post-op stay in days was found 1.57, 2.0 and 0.50 respectively. Whereas, for difficult LC, mean, median and S.D. post-operative stay in days was found 2.52, 2.0 and 1.37 respectively. Hence, $p<0.001$ which was found significant (Figure 8).

Table 2: OT time (≥ 60 minutes).

Variables	Result, n (%)		Total, n (%)	P value	Significance
	Easy	Difficult			
OT time (≥ 60 min)	No	46 (100)	14 (31.82)	<0.001	Significant
	Yes	0 (0)	30 (68.18)		
Total		46 (100)	44 (100)	90 (100)	

Table 3: Difficult GB bed dissection.

Variables	Result, n (%)		Total, n (%)	P value	Significance
	Easy	Difficult			
Difficult GB bed dissection	No	46 (100)	11 (25)	<0.001	Significant
	Yes	0 (0)	33 (75)		
Total		46 (100)	44 (100)	90 (100)	

Table 4: GB rupture with spillage of bile and stone.

Variables	Result, n (%)		Total, n (%)	P value	Significance
	Easy	Difficult			
Gb rupture with spillage	No	46 (100)	20 (45.45)	<0.001	Significant
	Yes	0 (0)	24 (54.55)		
Total		46 (100)	44 (100)	90 (100)	

Table 5: Central tendency for group A and group B.

Results	Age (In years)		
	Mean	Median	SD
Easy	42.22	36.00	15.45

Continued.

Results		Age (In years)
Difficult	Mean	47.45
	Median	46.00
	SD	11.91
	P value	0.020
	Significance	Significant

Table 6: USG criteria for difficult LC.

Parameters	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
Group A ≤ 5	37	37	9	7	84.09	80.43	80.43	84.09	82.22
Group B ≥ 4	37	37	9	7	84.09	80.43	80.43	84.09	82.22

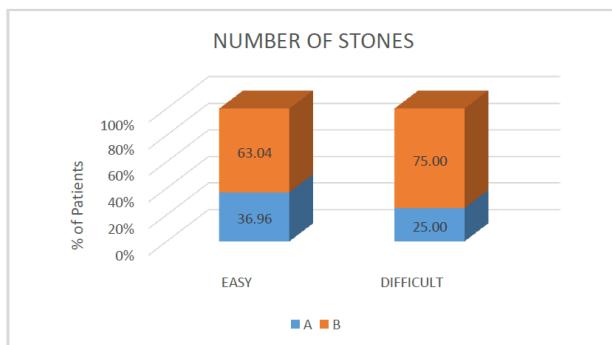


Figure 1: Number of stones.

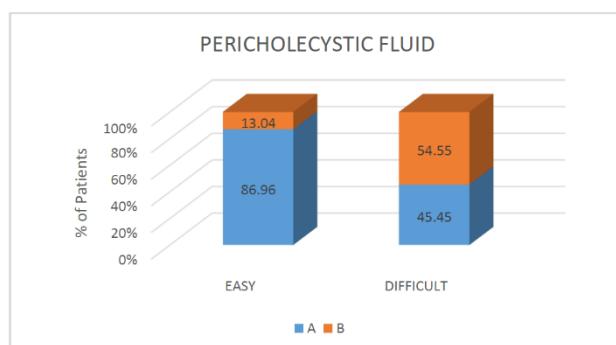


Figure 4: Pericholecystic fluid collection.

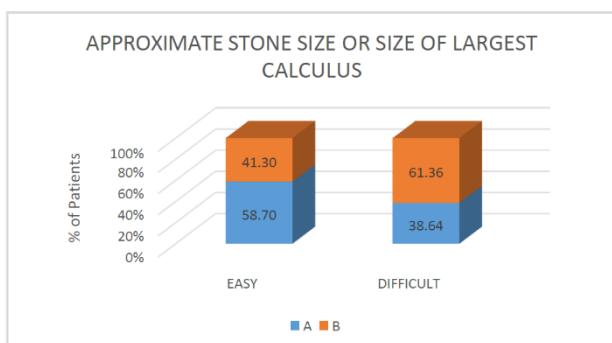


Figure 2: Approximate stone sizes or size of largest calculus.

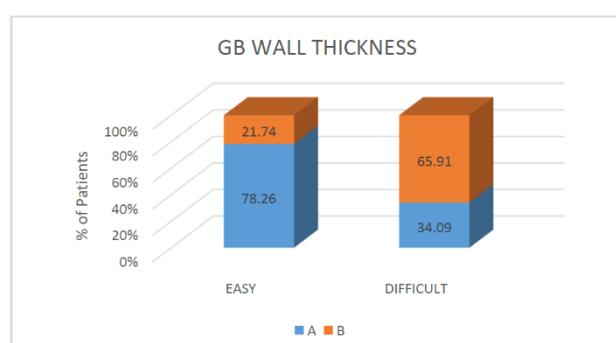


Figure 5: GB wall thickness.

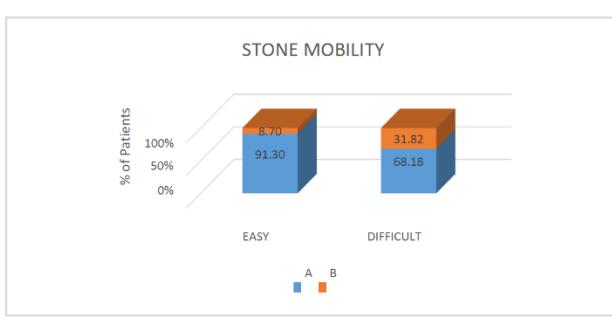


Figure 3: Stone mobility.

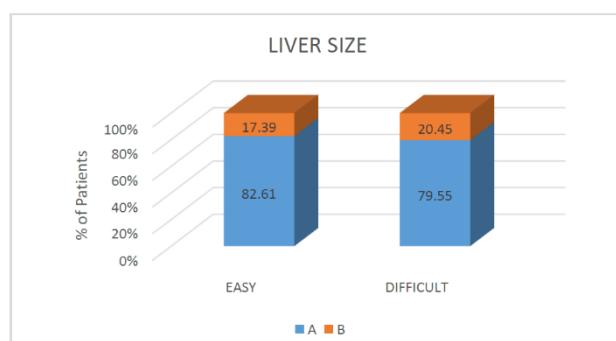


Figure 6: Liver size.



Figure 7: Mean age with difficulty of laparoscopic cholecystectomy.

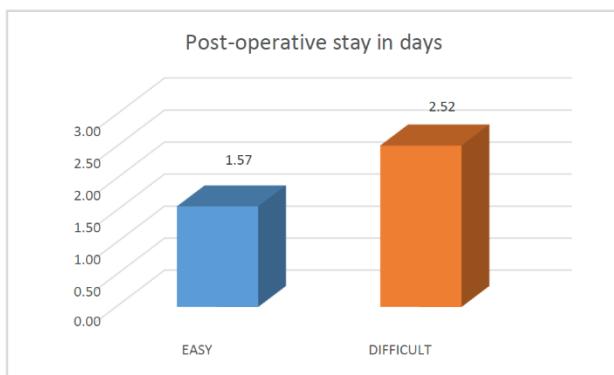


Figure 8: Post operative stay in hospital in days for easy and difficult laparoscopic cholecystectomy.

DISCUSSION

There were 128 patients admitted for LC from CMRI OPD, 38 patients were in exclusion criteria i.e., 18 CBD stone, 28 raised LFT, 13 pancreatitis, 16 cholangitis, 10 previous upper abdomen surgery. Exclusion criteria were overlapping to each other in patients. In this study, 90 patients were taken, who attended CMRI, Kolkata surgical OPD followed by diagnose as a cholezystolithiasis on USG and underwent LC in same institute. The purpose of the study was to find a parameter for prediction of difficult LC on the basis of preoperative USG assessment.

Preoperative USG parameters of the study were - stone mobility ($p=0.006$), pericholecystic fluid ($p<0.001$), GB wall thickness ($p<0.001$) was significant while approximate stone size or size of largest calculus ($p=0.057$), number of stone ($p=0.221$), liver span ($p=0.711$) were not significant. Each USG criteria divided into group A USG finding and group B USG finding.

Perioperatively, 9 parameters were used to identifying difficult LC (presence of any one or more parameter considered LC as difficult)- OT time ≥ 60 min ($p<0.001$), difficult GB bed dissection ($p<0.001$), intraoperative

rupture of GB with spillage of bile or stone ($p<0.001$) were found to be significant.

In our study, it was found that LC was difficult if group B USG criteria was ≥ 4 with group A USG criterion ≤ 5 had sensitivity 84.09%, specificity 80.43% and diagnostic accuracy 82.22%. LC was easy if group A USG criterion was ≥ 6 with group B USG criteria ≤ 3 had sensitivity 80.43%, specificity 84.09% and diagnostic accuracy 82.22%.

Siddiqui et al on 300 patients, studied 7 USG findings- GB thickness, distended GB, impacted stones, dilated CBD were statistically significant and pericholecystic collection, multiple stone, liver size were not statistically significant for prediction of difficult LC.²⁴ They assigned score 2 for each significant finding and score 1 for each non-significant finding, so 11 was total score. They reported for difficult LC USG score >5 out 11, had sensitivity 80.7% and specificity 91.7%.

In our study, we had taken 9 USG parameters divided into group A and group B. USG criteria - stone mobility, biliary sludge, pericholecystic fluid, GB wall thickness, GB size were significant while number of stone, approximate stone size or size of largest calculus, diameter of CBD, liver span were not significant. In our study, ≥ 4 out of 9 group B USG criteria with ≤ 5 out of 9 group A were significant for prediction of difficult LC and had sensitivity 84.09% and specificity 80.43%. So, our study is matched with Siddiqui et al study, in terms of sensitivity as well as specificity for the predicting difficult LC.

Chindarkar et al on 60 patients, studied preoperative 6 USG parameters-gallbladder wall thickness (≥ 4 mm), GB size (≥ 5 cm), gallstone mobility (impacted), common bile duct diameter (≥ 6 cm), size of calculi (≥ 1 cm) and presence of pericholecystic fluid collection which were found significant.²⁵ Total score was 6 and it was correlated to difficulty of surgery. Operative findings, considered for difficult LC were presence of dense pericholecystic adhesions, difficult dissection of Calot's triangle, rupture of gallbladder, bleeding that leads to non-visualization of GB, anomalies of biliary tree and intrahepatic or buried GB. Higher the preoperative USG score, higher was the number of difficult LC cases. 0-1 score 2 out of 60, 5 out of 60, 13 out of 60 become difficult LC.

In our study, 90 patients were taken for study, 9 USG parameters were taken for finding difficulty in LC, additional were number of stone, biliary sludge, liver span in comparison to Chindarkar et al study.²⁵ Operative findings for consider difficult LC were also more in number(9)-OT time ≥ 60 minute, difficult GB bed dissection, difficult GB extraction, intraoperative rupture of GB with spillage of bile or stone, conversion to OC, cystic duct or cystic artery injury, need additional help or requiring opinion of other surgeon during intraoperative

period, need for blood transfusion due to LC, significant amount of drainage in term of quantity and quality post-operatively were considered for difficult LC.

Perioperative findings

In our study, we had taken of ≥ 60 minutes for operative procedure for difficult LC. It was seen that dense adhesions, low lying cystic duct that need to suture, cleaning of peritoneal cavity due to spillage of bile and stone, impacted stones at neck were most common cause of increase time of surgery. Gupta et al studied on 50 patients and parameter was >45 minutes for difficult LC. Prashant et al studied on 99 patients and parameter was >60 minutes for difficult LC procedure.^{27,30}

In our study, GB bed dissection and dissection of calot's triangle were difficult in cases of dense pericholecystic adhesions, pericholecystic fluid collection, ductal anomaly, non-visualization of GB due to bleeding or dense adhesion. Difficulty in grasping of GB due to tendency to slip if it was filled with stones and/or distended. This was also seen that inflamed GB wall become oedematous and friable, make it difficult to grasp. In our study, sometimes non visualization of GB on introduction of scope inside peritoneal cavity was seen, it was mostly due to dense adhesion around GB and presence of pericholecystic fluid. Adhesion was due to recurrent attacks leads to inflammatory process and fibrosis which caused difficulty during LC. Singh et al and Gabriel et al also studied similar findings.^{17,31} Suryawanshi et al also taken adhesion of GB to omentum and viscus as a parameter to consider as a difficult LC. Nachnani et al, also used this criterion for considered as difficult LC.^{14,32} Singh et al had also found grasping GB is difficult in cases of distended GB and pericholecystic inflammation.¹⁷

In our study, presence of rupture of GB with spillage of stone or bile was considered as difficult LC because rupture of GB is due to difficult grasping or friable GB wall. Rupture of GB caused different manoeuvre to stop spillage of bile and falling of stone inside abdominal cavity and peritoneal wash given to patient which was additional step of LC. Siddique et al were also considered this for prediction of difficult LC.²⁴ Suryawanshi et al also taken perforation of GB as a parameter to consider as a difficult LC.³²

USG findings

In our study, number of stone was found not significant USG parameter for predicting difficult LC ($p=0.221$). It was seen that multiple stones did not cause any difficulty during LC until they were large, causing grasping difficulty of GB or need to extension of incision for extraction of specimen. Siddiqui et al studied on 300 patients and also found number of stone was not a significant parameter ($p=0.74$).²⁴

In our study, stone size was not significant statistically but its $p=0.057$ which was near 0.05. It was seen that sometimes multiple small stone caused grasping difficulty, risk to slip inside peritoneal cavity while large stone did not cause any difficulty until they were hard, very large i.e. more than 15mm, multiple or associated with other small stones. While some times single large stone caused difficulty due to its shape, hardness, very large i.e. more than 15 mm in size etc. or impaction at neck of GB. Chindarkar et al studied on 60 patients found stone size >10 mm is significant for difficult LC ($p=0.004$).²⁵

In our study, impacted stone was a significant parameter for predicting difficult LC. Most of that study also reported that impaction of stone causes difficulty during LC. Most of the time, when impacted stone was small, it did not cause any difficulty during LC but when impacted stone became large it caused significant difficulty. Patil et al studied on 50 patients and found impacted stone was not a significant criterion for difficult LC ($p>0.3$).⁷ Suryawanshi et al (600 patients) reported that this was a significant criterion.³² Siddiqui et al studied on 300 patients and also found presence of impacted stone was significant ($p<0.05$).²⁴ Chindarkar et al studied on 60 patients also found gall stone mobility (impacted stone) was significant for difficult LC ($p=0.001$).²⁵

In our study, pericholecystic fluid collection was a significant risk factor for difficult LC. Pericholecystic fluid collection occurs when there is inflammation around GB. Most of the study also reported that it is a significant risk factor for difficult LC. Patil et al studied on 50 patients and found pericholecystic fluid collection was not a significant criteria for difficult LC ($p>0.2$).⁷ Nidoni et al studied on 180 patients and found pericholecystic fluid collection was a significant criteria for difficult LC ($p<0.01$).³³ Siddiqui et al studied on 300 patient and found pericholecystic fluid collection was not significant ($p=0.54$).²⁴ Chindarkar et al studied on the 60 patients found also pericholecystic fluid was significant for difficult LC ($p=0.001$).²⁵ Suryawanshi et al (600 patients) also reported that this was the significant USG parameter.³²

In our study, GB wall thickness ≥ 4 mm was a significant criterion for predict difficult LC ($p<0.001$). All most, all studies favour that wall thickness is a significant criterion. Siddiqui et al studied on 300 patient and found GB wall thickness ≥ 4 mm was significant for predicting difficult LC.²⁴ Patil et al studied on 50 patients and found wall thickness was a significant criterion for difficult LC ($p<0.01$).⁷ Suryawanshi et al (600 patients) also reported that thick-walled GB (≥ 3 mm) was a significant criterion.³² Chindarkar et al studied on 60 patients found GB wall thickness >4 mm was significant for difficult LC ($p=0.001$).²⁵ Jethwani et al studied on 200 patients found that thick-walled GB was a risk factor for difficult LC.⁸ Lee et al studied on 346 patients found that thick-walled GB was a risk factor for the difficult LC. Nidoni et al

studied on the 180 patients and found that thick GB wall was a significant criterion for the difficult LC ($p<0.01$).^{33,34}

In our study liver span was not a significant USG criterion to decide difficult LC. Vivek et al.¹² studied on 323 patients and found cirrhotic liver was statistically significant ($p<0.01$) for difficult LC. Cirrhotic liver had decrease liver size, had fibrosis, distortion of normal liver anatomy and neovascularisation caused difficulty in grasping and increased bleeding at GB bed during dissection. Siddiqui et al studied on 300 patient and found liver size was not significant.²⁴

In our study, mean age of easy LC was found to be 42.22 years and for difficult LC 47.45 years which was found to be significant ($p=0.020$).

Post-operative stay

For easy LC, the mean post operative stay was 1.57 days and for difficult LC, the mean post operative stay was 2.52 days which was found to be significant ($p<0.001$).

Chong et al studied in 2016 on 336 patient who underwent LC, studied on two groups of patients.⁴⁰ One group was for ≤ 2 post operative hospital stay (POHS) had average operative time, 45 minutes. While the other group was for >2 post operative hospital stay had average operative time 77 minutes ($p<0.001$).

Above study findings are similar with our study. We considered operative time ≥ 60 minutes as difficult which was found significant ($p<0.001$) and these patients had mean 2.52 POHS. While the easy LC, operative time <60 minutes had mean 1.57 POHS.

Strength

Our study has revealed some important USG factors which can predict difficult LC and can predict longer hospital stay in case of difficult LC.

Bias of the study

Surgery is done by multiple surgeons. Operative difficulty can be different for different surgeons. To reduce bias as much as possible, the surgeons in this study who have done the surgeries have been matched with their experience in years and number of cases done.

Limitations

Association of insignificant USG factor with clinical factor had not been done because this was beyond the scope of this study. Since, USG is operator dependent it does not throw light on multi radiologist at multicenter consideration. So, multicenter studies need to be done.

CONCLUSION

LC is treatment of choice for both acute and chronic calculus cholecystitis. Abdominal USG is the investigation of choice for gall stone disease and done before LC. It also helps in to predict possible complication in perioperative period. Now, there is no established definition for difficult LC. The study was done to find a USG based criteria to predict difficult LC. Prior to surgery, a good prediction for difficult LC can help to patient and treating surgeon for better management of operative procedure. We found that LC would become difficult if, group B USG criteria ≥ 4 with group A USG criterion ≤ 5 . This had sensitivity 84.09%, specificity 80.43% and diagnostic accuracy 82.22%. Also, LC would become easy if Group A USG criterion ≥ 6 with group B USG criteria ≤ 3 having sensitivity 80.43%, specificity 84.09% and diagnostic accuracy 82.22%. GB wall thickness ($p<0.001$), pericholecystic fluid ($p<0.001$), stone mobility ($p=0.006$), GB size ($p=0.037$) was good predictor for risk assessment of difficult LC which were statistically significant. Mean hospital stay in case of difficult LC is 2.52 days which was significant ($p<0.001$). Assessment of other non-sonological parameters like clinical factor which include both patient factor and disease factor and other advance imaging modalities may improve prediction for difficult LC and require further studies. USG is operator dependent modality, different centers have different radiologist, so there is also need to reduce the operator dependent bias by need of further study. There is also scope of further study for validation of this USG assessment for predicting difficult LC.

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APPENDIX I

Study proforma

I) Patient particulars:

a) Name:

b) Age:

c) Sex:

d) PANA No:

e) Bed No.:

f) Occupation:

g) Address:

II) Date of admission:

III) Date of discharge:

IV) Preoperative data:

V) Past history: DM/Hypertension/Hypothyroidism/ Bronchial asthma

(a) Any other Medical history:

(b) Past surgical history: with special reference to upper abdomen surgery

VI) History of any drug intake/ Drug allergy:

VII) General physical examination:

a) Facies

b) Decubitus

c) Temperature

d) Blood pressure

e) Pulse

f) Pallor, icterus, cyanosis, clubbing, oedema, neck nodes, neck veins.

VIII) Systemic Examination:

a) Per abdomen findings: Inspection, palpation, percussion, auscultation

b) Other systems: respiratory system, cardiovascular system, central nervous system, musculoskeletal system

IX) Provisional Diagnosis:

X) Laboratory investigations:

a) Complete hemogram:

b) Blood sugar:

c) Blood Urea, S. Creatinine:

d) LFT:

e) Serology (HIV 1 and 2, anti HCV, HBsAg):

f) PT/INR

XI) Radiological investigations

a) USG (W/A):

Table 1: Preoperative USG parameters.

Deciding parameters	Group A	Group B
Number of stones	single stone	multiple stone
Approximate stone sizes or size of largest calculus	<10 mm size	≥10 mm size score
Stone mobility	Mobile in GB	Impacted at neck or proximal to neck
Biliary sludge	Absent	Present
Pericholecystitic fluid	Absent	Present
GB wall thickness	<4 mm	≥4 mm
GB size	GB distended (transverse diameter >5 cm)	GB contracted (transverse diameter ≤5 cm)
Diameter of common bile duct	<6 mm	≥6 mm
Liver size	Liver span <15.5 cm	Liver span ≥15.5 cm

Number of Group A USG parameter/s -----

Number of Group B USG parameter/s -----

b) Chest x ray PA View

c) 12 lead ECG

XII) Any other significant investigation-

XIII) Perioperative assessment (Easy or difficult LC) -----

Perioperative parameters:

1. Time taken in minutes (≥ 60 minutes)- Yes/No
2. GB bed dissection difficult- Yes/No
3. Difficult extraction (extension of incision for extraction)- Yes/No
4. Rupture of GB with spillage of bile or stone- Yes/No
5. Cystic duct or cystic arterial injury- Yes/No
6. Conversion to OC- Yes/No
7. Need additional help/requiring opinion of other surgeon during intraoperative period-Yes/No
8. Need for blood transfusion due to LC- Yes/No
9. Significant amount of drainage in terms of quantity and quality- Yes/No

XIV) Duration of post-operative hospital stay:

XV) Reason for delay in discharge (if any)