Preoperative predictive risk factors of difficult laparoscopic cholecystectomy

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Background
Laparoscopic cholecystectomy (LC) is the preferred approach for treatment of gallbladder (GB) diseases. LC is relatively an easy procedure and can be done quickly, but in some cases, LC may be difficult, takes longer time, and needs special instrument and a well-trained surgeon. Moreover, in specific situations, conversion from laparoscopic to open approach is still required. However, identification of those cases at high risk for conversion is not easy.

Aim
This article was conducted to detect the preoperative parameters that make LC difficult and elevate the rate of conversion from LC to open approach.

Patients and methods
During the period from September 2019 to December 2020, 100 LC cases were performed in the Surgical Department, Al Azhar University Hospitals, Assiut. Examined preoperative parameters were age, sex, BMI, previous attacks of acute cholecystitis, obstructive jaundice with or without endoscopic retrograde cholangiopancreatography, previous abdominal surgery, the thickness of wall of GB, size and number of GB calculi, abnormal liver functions, and leukocytosis, which were used for determination of those variables that predict conversion of LC. The term 'difficult' cholecystectomy is mainly based on operative findings and is highly dependent on the skills of surgeon in handling a thickened GB wall (difficulties in grasping and retraction of the GB, limited identification of the anatomy, and difficulty in dissection), adhesions, and presence of common bile duct stones or Mirizzi's syndrome.

Results
Difficult LC was found in 28 (28%) patients. A total of four (4%) patients had been converted to open cholecystectomy. Parameters like BMI more than 30, empyema of GB, thick-walled GB, large size stones, multiple GB calculi, recurrent acute attack, and previous endoscopic retrograde cholangiopancreatography are found of statistical significance and can be used as criteria for predicting difficult LC.

Conclusion
Many preoperative parameters can expect the possibilities of conversion from LC to open technique and the drawbacks throughout LC.

Keywords:
conversion, laparoscopic cholecystectomy, preoperative parameters, risk factors

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Introduction

Laparoscopic cholecystectomy (LC) is a widespread technique for management of patients with gallbladder (GB) calculi [1]. LC has great advantages including short hospital stay, decreased morbidity, rapid recovery, and better cosmesis [2]. However, the prevalence of injury to the biliary tree is more in LC than in open cholecystectomy. LC procedure may be easy and take shorter time, but in many cases, it may be difficult and need conversion to open cholecystectomy [3]. Although the experience with LC has improved, there are certain limitations to LC for symptomatic GB calculi. So, ~2–15% of the cases need conversion to open procedure for numerous reasons [4]. Since the first LC have done by Mouret in 1987, the average duration of LC has constantly reduced in parallel with the growing experience of surgeons [5–10]. It is important to have reliable predictive factors for predicting difficult or complicated LC cases. Preoperative prediction of these factors enables surgeons to evaluate their choice of procedure, for acceleration of the decision to convert to open procedure, to provide well-timed information to patients for better psychological preparation, and to acquire approval to convert to open procedure [11]. LC is considered difficult in certain situations such as prolonged operative time, difficult grasping of GB,

dense adhesions [12], obscure anatomy of cystohepatic triangle (calots triangle), injury to cystic artery, oozing around cystic artery or injury to cystic duct, or GB with stones and bile spillage [13]. According to previous factors, LC can be classified into easy or difficult cases. The warning signs for conversion consist of failure of demonstration of the 'critical view of safety' [4], or the occurrence of intraoperative complications, which include intestinal injury, bleeding, or biliary injury. Multiple factors elevate the risk of conversion to open procedure, which include age, male sex [14], obesity [15], acute cholecystitis [7,16], and previous endoscopic cholangiopancreatography [17]. Conversion to open surgical procedure commonly suggests a difficult technique, not a failure or a complication, and taking into consideration the decision of conversion should seem as a sign of proper judgment in the presence of unfavorable situations. Preoperatively, there are numerous benefits from prediction of patient with elevated chance of conversion from LC to open procedure. Patients with reduced risk might be recognized and accurately scheduled in an ambulatory care facility and selected as easy cases for education for surgical trainees [18], whereas patients with increased risk need to be accurately counseled and operated with skilled surgeons [19]. Most of the research studies that discuss the risk factors of conversion of LC to open procedure are small retrospective series or population based [20]. Many research studies have evolved risk scores, but their scientific applications are restricted by retrospective data, reduced sample sizes, and/or loss of validation [21].

Difficult cholecystectomy

The term 'difficult cholecystectomy' is frequently subjective, owing to the fact that it is able to be mounted by the operator in an arbitrary manner. Instead, it is important to set up and employ a set of intraoperative parameters. Recorded data from the previous year's document markedly decrease the rate of conversions [22]. These statistics are essential because they display that the laparoscopic technique has a great margin of safety, and it is not bound by technical skill of the surgeon. LC for difficult cases does not increase complications, but it simplifies the postoperative route by acceleration of the early return to ordinary activities [23].

Patients and methods

This prospective study was carried out at the Department of General Surgery, Al Azhar University Hospital, Assiut, after approval from local ethical committee, and an informed written consent was taken from all patients who accepted for participation in the study. Full history was taken, physical examination and radiological investigations were reported, and this study was conducted from September 2019 to December 2020 with 1-month period for follow-up. A total of 100 cases with cholecystitis (acute and chronic) participated in this study. Patients with problems that are contraindicated with laparoscopy such as major pulmonary pathology or coagulopathy were excluded from this study.

Clinical, imaging, and laboratory data were recorded such as age, sex, BMI, number of previous acute attacks, history of pancreatitis or jaundice, preceding endoscopic retrograde cholangiopancreatography (ERCP), number and size of gall stones, distended GB, and its wall thickness. Other data such as diabetes mellitus and previous abdominal operations were also recorded.

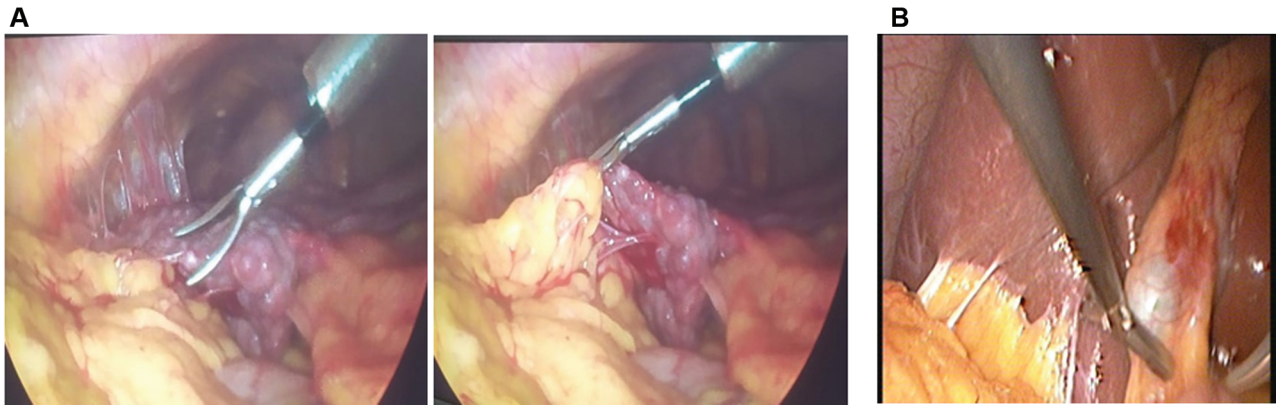
Evaluation of preoperative ultrasound findings such as GB calculi, thickness of GB wall, presence of pericholecystic fluid collection, or concomitant common bile duct (CBD) stones was done. Evaluation of effect of preoperative removal of stone via ERCP on the rate of conversion was assessed. The operative difficulties such as prolonged operative time, difficult grasping of GB, unclear anatomy, dense adhesions (Fig. 1), obscure anatomy of cystohepatic triangle, injury to cystic artery (Fig. 2), oozing around cystic artery (Fig. 3), or injury to cystic duct or GB with stones, and bile spillage (Fig. 4) were evaluated.

Postoperative data included duration of hospitalization, complications, pathologic diagnosis, pathologic wall thickness, and occurrence of CBD stones. Age was taken into consideration as a continuous variable. Classifications of indication of surgery were as elective surgery (asymptomatic GB calculi, biliary colic, and chronic cholecystitis) for patients' evaluation in an office setting. Nonelective surgery (acute cholecystitis, gallstone pancreatitis, and empyema) has been categorized on the basis of an emergency room visit followed by cholecystectomy.

Obesity was described as a BMI 30 kg/m^2 and morbid obesity as a BMI 40 kg/m^2.

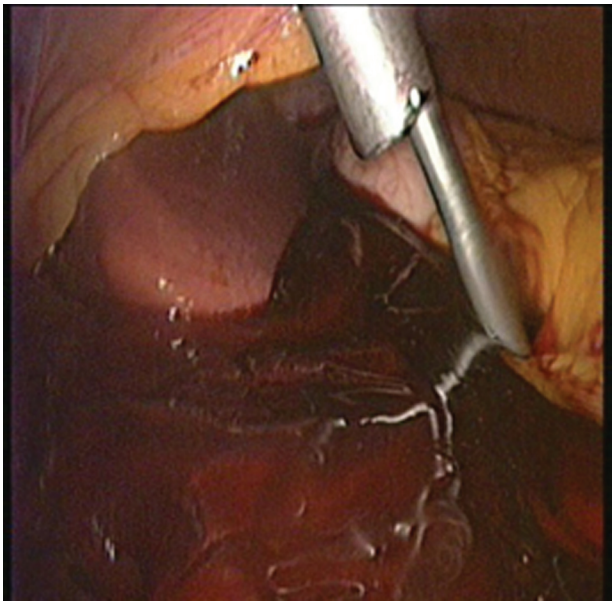
The incidence of conversion of LC to open cholecystectomy was analyzed. The rates of conversion remained tremendously stable all through the duration of study. The indicators of conversion to open procedures were analyzed in Table 1.

Figure 1



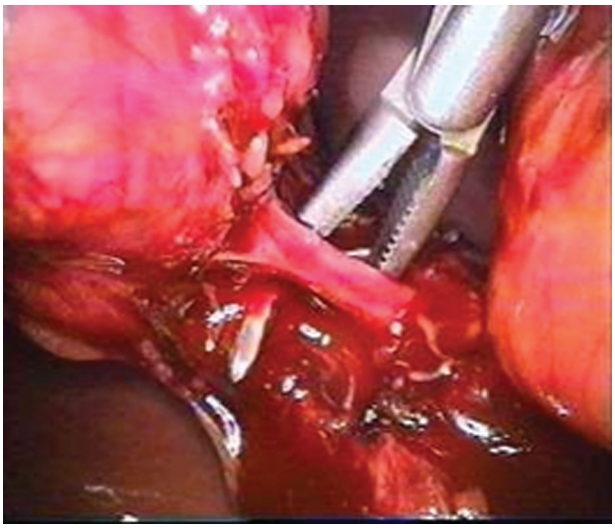
(a) Adhesion's around GB, omentum, colon, and liver associated with liver cirrhosis. (b). Adhesion's around GB and liver. GB, gallbladder.

Figure 2



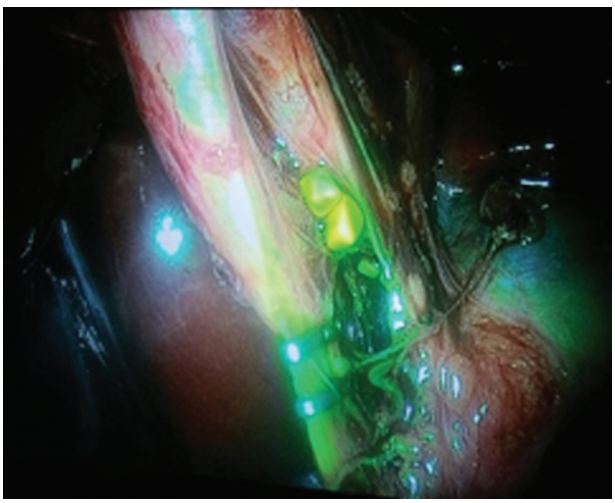
Bleeding from injured cystic artery.

Figure 3



Oozing around cystic artery.

Figure 4



Spillage of stones and bile from perforated GB. GB, gallbladder.

All patients were operated with the standard technique for LC. All patients were instructed at the discharge time to contact us if any abnormal complaints occurred such as vomiting, distention, constipation, or fever. All cases have been instructed for follow-up in the outpatient clinic after first and second weeks and first month to rule out any problems for proper managements.

Statistical analysis

Categorical variables had been expressed as a number (percentage). Percent of categorical variables had been compared using the Pearson's χ^2 test. All tests were two sided. *P* value less than 0.05 was considered statistically significant. Analysis of all recorded data was done using Statistical Package for Social Science for Windows, version 18.0 (SPSS Inc., Chicago, Illinois, USA).

Results

A total of 100 patients were treated by standard technique of LC. Tables 2–7 entail the preoperative gathered information for all cases and its relation to degree of difficulty of the procedure.

Table 2 shows that age more than 40 years is considered as a predictor for difficulty. Moreover, males were more difficult than females in LC (Table 3).

Regarding obesity, mean BMI was 29.9±5.3. Table 4 declares that BMI and difficulty increase with increases in BMI and obesity.

Distribution according to ultrasound measurement was noted. Table 6 shows the ultrasound imaging data and its effect on difficulty. Distended GB, thick wall (>5 mm), big stones (>1 cm), infundibular stones, multiple stones, and pericholecystic fluid collection were found to positively correlate with difficulty. However, GB wall calcification showed border line correlation.

Table 6 (a, b) shows patients' ultrasound measurement.

Table 1 Causes of conversion in our study

Causes of conversion	Number of patients [*n* (%)]
Mirizzi syndrome	1 (1)
Bleeding from the cystic artery	1 (1)
Adhesions	1 (1)
Inflamed GB (acute cholecystitis)	1 (1)

GB, gallbladder.

Table 2 Distribution of age the of patients

Distribution of age the of patients	Number of the patients [*n* (%)]
<30	15 (15)
30–40	26 (26)
41–50	37 (37)
51–60	12 (12)
>60	10 (10)

Table 3 The patient sex

Sex	Number of the patients [*n* (%)]
Female	73 (73)
Male	27 (27)

Table 4 Patients' BMI distribution

BMI (kg/m^2)	Number of the patients [*n* (%)]
Normal <25	4 (4)
Preobese 25–29.9	42 (42)
Obese 30–34.5	43 (43)
Morbid obese >35	11 (11)

Table 7 shows preoperative laboratory findings. Abnormal liver functions and leukocytosis correlated with difficult LC.

Table 8 shows some associated disorders that are found to be correlate positively with difficult procedure, such as diabetes mellitus, previous upper abdominal surgery, previous obstructive jaundice, and ERCP.

Difficult cholecystectomy was seen in 30.3% of patients older than 45 years, especially in male patients (27%).

There were four (4%) cases that underwent conversions: one female and three males. These

Table 5 Patient difficult Operative data

Difficult operative data	Number of cases [*n* (%)]
Difficult to access to abdominal cavity	5 (5)
Difficult dissection in Calot's triangle	20 (20)
Difficult GB bed dissection	12 (12)
Difficult GB extraction	17 (17)
Perforation of GB and spillage of stones and bile	14 (14)
Bleeding	3 (3)
Conversion to open surgery	4 (4)

GB, gallbladder.

Table 6 XXXX

(a) GB wall thickness, size of stone, and CBD diameter

Patient us measurement	Minimum	Maximum	Mean±SD
GB wall thickness (mm)	2.00	5.8	3.5±2.01
Size of stone (mm)	2.5	26.7	9.9±6.3
CBD diameter (mm)	2.00	6.5	3.94±1.01

(b) Number of stone, size of GB, and pericholecystic collection

Stones number [*n* (%)]	
Multiple	74 (74)
Solitary	26 (26)
Distended GB	
Yes	7 (7)
No	93 (93)
Pericholecystic fluid collection	
Yes	6 (6)
No	94 (94)

CBD, common bile duct; GB, gallbladder.

Table 7 Patient laboratory findings

Laboratory findings	Minimum	Maximum	Mean±SD
TLC	4040	13 600	7196.23±1886.20
Bilirubin	0.20	1.20	0.52±0.17
ALK Ps	22.70	241.00	93.74±31.12
SGOT	6.00	66.0	23.75±11.22
SGPT	7.20	113.00	33.75±14.18
GGT	21.5	45.6	31.23±25.45

ALK Ps, alkaline phosphate; GGT, gamma-glutamyl transferase; TLC, total leukocyte count.

conversions were owing to massive adhesions at Calot's triangle (one cases), Mirizzi syndrome (one cases), inflamed GB (acute cholecystitis) (one cases), and uncontrolled bleeding (one cases).

Table 8 Patient history of jaundice, acute attacks, abdominal surgery, and endoscopic retrograde cholangiopancreatography

History	Jaundice	Acute attacks	Abdominal surgery	ERCP	DM
Yes	6	16	14	2	28
No	94	84	84	98	72

ERCP, endoscopic retrograde cholangiopancreatography; DM, diabetes mellitus.

The numerous preoperative and operative difficulties correlating with conversion have been analyzed in Table 9. No considerable relation was discovered between the probability of conversion and any of the subsequent variables: previous history of abdominal surgery, jaundice, pancreatitis, alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, amylase, presence of GB calculi and CBD stones on ultrasound, ERCP, intraoperative cholangiogram, or laparoscopic CBD exploration. Considerable predictors of conversion based on univariate analysis were increasing age, obesity, male sex, history of fever, tenderness or a palpable mass in the right upper quadrant on physical examination, leukocytosis,

Table 9 The following table shows the relation between the preoperative factors and operative difficulty

	Easy LC (*N*=72) [*n* (%)]	Difficult LC (*N*=28) [*n* (%)]	χ^2	*P* value
Sex				
Male	17 (23.6)	10 (35.7)	1.49	0.220
Female	55 (76.4)	18 (64.3)		
Age				
<45	39 (54.2)	17 (60.7)	0.35	0.553
>45	33 (45.8)	11 (39.3)		
BMI				
>30	42 (58.3)	20 (71.4)	1.46	0.225
<30	30 (41.7)	8 (28.6)		
Previous abdominal surgery				
No	63 (87.5)	23 (82.1)	0.48	0.488
Yes	9 (12.5)	5 (17.9)		
History of jaundice				
No	67 (93.1)	27 (96.4)	0.4	0.523
Yes	5 (6.9)	1 (3.6)		
Previous ERCP				
No	71 (98.6)	27 (96.4)	0.48	0.483
Yes	1 (1.4)	1 (3.6)		
Previous acute attack				
No	68 (94.4)	16 (57.1)	**20.8**	**<0.001**
Yes	4 (5.6)	12 (42.9)		
Murphy's sign				
Negative	60 (83.3)	24 (85.7)	0.085	0.770
Positive	12 (16.7)	4 (14.3)		
Palpable GB				
No	70 (97.2)	24 (85.7)	**4.73**	**0.029**
Yes	2 (2.8)	4 (14.3)		
Distended GB				
No	70 (97.2)	23 (82.1)	**7.07**	**0.007**
Yes	2 (2.8)	5 (17.9)		
Stone number				
Multiple	58 (80.6)	16 (57.1)	**5.7**	**0.016**
Solitary	14 (19.4)	12 (42.9)		
Stone size (cm)				
>1	16 (22.2)	16 (57.1)	**11.3**	**<0.001**
<1	56 (77.8)	12 (42.9)		
Pericholecystic collection				
No	70 (97.2)	24 (85.7)	**4.7**	**0.029**
Yes	2 (2.8)	4 (14.3)		

ERCP, endoscopic retrograde cholangiopancreatography; GB, gallbladder; LC, laparoscopic cholecystectomy. The bold values are statistical significance is present when ($P<0.05$).

hyperbilirubinemia, presence of pericholecystic fluid collection or a thickened wall on ultrasound, a preoperative diagnosis of acute attack, and a thickened GB wall on pathologic examination. Multivariate analysis with a multiple logistic regression model confirmed that the considerable independent predictive factors for conversion were acute cholecystitis, growing age, obesity, and pathologic GB wall thickness.

Discussion

LC is the preferred procedure for management of all cases presented with GB calculi [24]. It offers a minimally invasive technique with much less morbidity and better postoperative recovery. Moreover, it provides a good exposure of the operative field for GB surgery. On the contrary, lacking of tactile sensation and bidimensional vision are considered as obstacles, especially with difficult cases. Open surgical procedure has numerous advantages over laparoscopic technique, especially in difficult cases, as it allowed surgeons to apply manual compression, experience better tactile feedback, have a wide range of exposure and movements, and also there is no restricted number of instruments in the operative field. Preoperative identification of patient with considerable difficulties that lead to conversion could decrease the drastic outcomes of prolonged surgical procedure through decreasing the period of the trial of laparoscopic dissection [25].

This study tried to find a reliable predictor for difficult cases of LC for better preoperative planning and early decision to convert to open procedure. Difficult cholecystectomies were seen at 30.3% of cases older than 45 years, especially in male patients (27%). As age above 45 years predicted prolonged dissection time at Calot's triangle due inflammation and fibrosis, which is more extensive in male than females. These results are similar to what stated by Ercan *et al*. [26] that the rate of difficult LC with possible conversion is 52% in male above 60 years.

This current study declares that BMI of 30 kg/m^2 or more predicted prolonged GB bed dissection time owing to inflammation or fibrosis and unclear anatomy owing to presence of excessive intraperitoneal fat and insufficient retraction of the liver, and difficulty increase with increases in BMI and obesity. However, other studies included BMI more than 27.5 kg/m^2 as a measure rather than the usual standard definition of obesity, that is, BMI of more than 30 kg/m^2, to be included in their model. This study showed that cholecystectomy in acute cholecystitis is quite difficult (75%), and also, the time of surgery in acute cholecystitis is very important [16]. Acute cholecystitis is a severe inflammation associated with increased vascularity and extensive adhesions which lead to improper visualization, as the thick-walled GB became shrunken and contracted. So, the cystic duct becomes shortened and GB adherents to the CBD, making grasping and retraction of GB difficult and its dissection from the CBD unsafe. Difficult LC cases (87.5%) with possible conversion to open cholecystectomy are encountered if cholecystectomy is performed after 3 days from the onset of pain. These data are similar to the results obtained by Madan *et al*. [27]. They stated that the surgical procedure needs to be performed among 48–72 h as the appearance of the first symptoms and conversion rate was less than 1% (four cases out of 24 cases) if performed more than 3 days.

Patients with uncontrolled diabetes mellitus had a significant difficulty during LC with possible early necrosis or gangrene of GB due to autonomic and peripheral neuropathy, which lead to delayed clinical presentations. Results are similar to Lau *et al*. [28] (72%).

The number of previous attacks of acute cholecystitis is found to be directly proportional to difficult LC, especially, if more than five attacks of acute cholecystitis (75%). Moreover, Sanabria *et al*. [29] in a study that include 628 cases stated that cases that had more than 10 (84%) attacks of severe pain had considerably more difficulties when GB bed is dissected.

The repeated episodes of acute cholecystitis are associated with excessive fibrosis in GB bed that fix GB to the surroundings, making Calot's triangle frozen with difficult dissection. This explains the difficult procedure. However, in the early phase of acute attack, pericholecystic edema facilitates the GB dissection from GB bed and the anatomy of the Calot's triangle is not affected by fibrosis [30].

In this study, we found that thickness of GB walls (>5 mm) leads to difficult grasping of the GB with dense adhesions, and this added to the difficulty of procedure with higher incidence of conversion to the open cholecystectomy. The cause of conversion was the dense adhesions between GB and adjacent structures such as omentum, duodenum, or colon, leading to dense Calot's triangle.

This agreed with what was mentioned by Daradkeh *et al*. [31] and Alponat *et al*. [32]. They stated that GB thickness increases the difficulty (84 and 83%, respectively). In another study, Carmody *et al*. [33] reported that wall thickness did not increase difficulty, representing two cases out of 31 (6.4%) cases.

We found that impacted stone at the neck of GB is associated with difficult LC (50%) and conversion to the open procedure. Mirizzi syndrome was recorded in 0.3–3% of all LC; for successful diagnosis of Mirizzi syndrome, a high index of suspicion is needed, and it might be suspected in any patient with empyema, mucocele, or impacted stone in the infundibulum. Mirizzi syndrome was considered as a contraindication for LC, owing to high conversion rate of up to 74% for type I and up to 100% for type II [33]. Stone impacted in the neck of GB hinders grasping the GB neck during dissection; moreover, the GB is usually mucocele with difficult grasping. In these cases, the GB was evacuated from its contents by aspirating the contents making the GB more manageable. We also recorded that distended GB to be significantly associated with difficult LC, which agreed with what was mentioned by Cho *et al.* [34], who also reported that distension of GB lumen was associated with a technically difficult [35].

The results of this study show that stones larger than 1 cm were found to be related to difficult LC (50%). Moreover, Nachnani and Supe [36] documented similar data (88%). are larger than 1 cm are usually impacted in neck of GB with difficult grasping of Hartman's pouch as well as difficult extraction of GB with large stone from the abdominal cavity.

On preoperative evaluation, the number of cases that were difficult/very difficult was 28 (28%) patients, and 72 (72%) of them were easy on surgery.

In this study, injury of the cystic artery appears only in three patients, but two of them not converted, and bleeding was stopped via application of clip; one patient was converted to open cholecystectomy owing uncontrolled bleeding from cystic artery.

Perforation of GB and spillage of bile and stones as a reason of conversion to open procedure were recorded by Frazee *et al*. [37]. Although in our study perforation of GB and spillage of bile and stones were recorded in 14 patients, conversions were not performed in any cases owing to these complications. The average operative time was 1 h. Categorization of these 14 patients as difficult cases was owing to bile and stone spillage. All cases were treated by irrigation and suction, and conversions were not performed in any one of them.

In our study, four (4%) patients were converted to open cholecystectomy from 28 (28%) patients found to be difficult/very difficult on preoperative evaluation. So, in our study, there were four (4%) conversions, seen in one female and three males. These conversions were owing to dense adhesions at Calot's triangle (one cases), Mirizzi syndrome (one cases), inflamed GB (acute cholecystitis) (one cases), and uncontrolled bleeding (one cases).However, for sure, experience of surgeon is an important parameter that should be taken in consideration for conversion, as the conversion rate reduced in the cases operated by well-trained surgeons.

Conclusion

The conversion of LC to an open approach seems to be multifactorial, to be affected by factors related to the patient, GB pathology, and the surgeon [38]. Preoperative factors can help to detects a difficult LC. These recorded data may be beneficial to both the patient and the surgeon.

In this study, the preoperative factors that significantly predicted difficult LC were male sex, age above 45 years, and BMI of 30 kg/m^2 or more. Palpable GB predicted prolonged operative time, prolonged GB bed dissection time, and prolonged GB extraction time. Moreover, distended GB in ultrasound predicted prolonged operative time [34,35]. Single stone, large stone size larger than 1 cm in diameter, and presence of pericholecystic fluid collection increase the risk for conversion to open surgery.

Prediction of a difficult technique might permit the surgeon to discuss the probability of conversion with the cases and prepare them psychologically in addition to making plans for suitable technique. Another advantage might be to allow more efficient scheduling of the operating lists and ensuring the availability of a more skilled laparoscopic surgeon for surgical procedure.

A high-predicted risk of conversion can also allow the surgeon to take an early decision to convert to open procedure when difficulty is encountered throughout dissection; this can also additionally decrease the time of operation and reduce the related morbidity [39].

An experienced surgeon can complete the difficult cases successfully in high-risk patient using the

subtotal LC. The need for conversion to open procedure should be considered as neither a failure nor a complication, but as an attempt for avoidance of complications either intraoperatively or postoperatively [40].

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Conflicts of interest
There are no conflicts of interest.

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