Preoperative Clinical and Radiological Variables for Prediction of Difficult Laparoscopic Cholecystectomy

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ABSTRACT

Introduction: Laparoscopic cholecystectomy (LC) has replaced open technique as the main surgical intervention in the treatment of gall bladder stones. There are different clinical and radiological predictors that are indicators for technically difficult LC.

Aim of the work: The aim of this study was to identify the clinical and radiological variables associated with difficult LC.

Methods: During the period from March 2018 to March 2021, 452 adult patients who presented with symptomatic gall bladder stones underwent LC. Different clinical and radiological data were collected as: abdominal scar, palpable gall bladder, previous hospitalization, history of ERCP, total leucocyte count, thickness of the gall bladder wall, peri-cholecystic collection, solitary or multiple gall bladder stones, impacted stone and diameter of the CBD.

Results: Age of 50 years or over (P value 0.001), male gender (P value 0.001), previous hospital admission (P value 0.001), impacted stones (P value 0.003), and leukocytosis (P value 0.031) were found statistically significant with area under ROC curve is 0.814 with 95 % confidence interval.

Conclusion: These preoperative risk factors; old age, male gender, previous hospitalization for biliary problem, impacted stone, and leukocytosis could potentially predict difficult LC, and give surgeons and their assistants the chance to predict the risk of complications intra-operatively and the possibility to convert the maneuver to a bail-out one.

Key words: laparoscopic cholecystectomy, difficult, prediction, technically difficult, conversion

INTRODUCTION

Gall bladder stone is the most common disease affecting biliary system. (1) Ten to fifteen percent of the population presents with cholelithiasis with eighty percent of these being asymptomatic. (2) About 1-2% of asymptomatic patients will present with symptoms requiring surgical intervention annually that makes cholecystectomy the most common intervention performed by general surgeons (3). Considering its safety, reliability, short hospital stay, cost-effectiveness, better cosmesis, neglected mortality, minimal complications of the wound, and lower percentage of paralytic ileus, (4) laparoscopic cholecystectomy (LC) has become

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the main therapeutic modality in the treatment of symptomatic cholelithiasis (5).

There are many challenges faced by surgeons during LC such as access to the peritoneal cavity difficulties, pneumoperitoneum creation, Calot's triangle dissection, and excised gall bladder extraction (6). In 2015, Nidoni et al. reported that factors like morbid obesity and previous upper abdominal surgery were no longer considered as absolute contraindication for LC and the number of these contraindications has decreased over time (7). Gadacz reported in 2000 that with advances in technology and the increase in the experience of surgeons, the rate of complication reached very low levels that only represented 2-6 % (8). In 2004, Khan and his colleagues reported the conversion rate from LC to open cholecystectomy (OC) as 7% to 35% (9).

In literature, about thirty-four parameters have been studied to predict their effect on LC and the possibility to convert it to OC. These parameters include age, gender, and previous hospitalization during acute attack, supra and infra umbilical scars, palpable gall-bladder, and the BMI of the patient (10). Prediction of possibility of difficult LC or conversion to OC is a serious challenge in laparoscopic surgery. With these predictive factors for high-risk patients, these patients can be informed about their potential difficult intervention and give a chance to senior surgeons to prepare the best time and team for this surgery as junior surgeons may hesitate to take an early decision to convert to open intervention/ bail-out procedure, increasing the likelihood of intraoperative complications (5). In addition, the prediction of difficult LC would give nursing staff a chance from the start to be ready for conversion by preparing open surgery setup nearby (11), or give the medical team a chance to send these patients to a tertiary hospital to be managed properly by experienced surgeons.

Aim of the work

The aim of this study was to identify the clinical and radiological variables associated with difficult laparoscopic cholecystectomies.

PATIENTS AND METHODS

This was a non-randomized prospective study conducted on 452 eligible patients presenting with symptomatic gall bladder stone disease and scheduled for elective LC from March 2018 to March 2021 in the General Surgery Department, Tanta University.

After explanation of the details of this surgery in a simple manner with benefits that would be achieved from laparoscopic intervention and risk of conversion to open surgery, fully informed consent was obtained from these patients.

Inclusion criteria:

Symptomatic gall bladder stone disease, which was scheduled for elective LC.

Exclusion criteria:

1. Patients with mass formation after an attack of acute cholecystitis.
2. Absolute contraindication for LC such as cardiovascular disease, end stage liver disease, and coagulopathies.
3. LC with common bile duct (CBD) exploration.
4. Pregnant patients.
5. Lap to open conversion due to equipment failure or emergency surgery.
6. Age under 18 years.

Preoperative variables:

Included demographic data, previous abdominal surgery, palpable gall bladder, previous hospitalization because of acute attack, history of ERCP or biliary pancreatitis, total leucocyte count (TLC) with C – Reactive Protein and Bilirubin (total and direct).

Radiological variables:

These data were obtained by using abdominal ultrasound such as: thickness of the gall bladder wall (normal < 4 mm vs. thick $\geq$ 4 mm), peri-cholecystic collection, solitary versus multiple gall bladder stone, impacted stone, diameter of the CBD (normal < 6 mm vs. dilated $\geq$ 6 mm); and liver size (normal < 15.5 cm vs. large $\geq$ 15.5 cm).

A preoperative score of Randhawa that was published in 2009 was used to evaluate every patient based on history, clinical examination, and sonographic findings (12) (table 1).

Operative outcome:

Operative outcomes were divided into three categories: easy, difficult, and very difficult (table 2) according to operative parameters that were recorded for all patients:

- Operative time.
- Duct or arterial injury.
- Spillage of the bile or stone.
- Conversion to open technique.

Table 1 - Randhawa and Pujahari scoring system

		Score	Max score
Age	≤ 50 yrs.	0	1
	>50 yrs.	1	
Sex	Male	1	1
	Female	0	
History of hospitalization for acute cholecystitis	Yes	4	4
	No	0	
Clinical parameters			
BMI	< 25	0	2
	25 – 27.5	1	
	> 27.5	2	
Abdominal scar	No	0	2
	Infra-umbilical	1	
	Supra-umbilical	2	
Palpable gallbladder	Yes	1	1
	No	0	
Sonography			
Wall thickness	Thin < 4 mm	0	2
	Thick ≥ 4 mm	2	
Pericholecystic collection	No	0	1
	Yes	1	
Impacted stone	No	0	1
	Yes	1	

Score 0-5 easy, 6-10 difficult, 11-15 very difficult

Operative techniques

Prophylactic antibiotic in the form of third generation cephalosporin and metronidazole were administered on the induction of anesthesia. Pneumoperitoneum with CO₂ was used with pressure ranging from 12 to 15 mmHg with standard four-port technique. A 10 mm telescope through the umbilical port with a 30-degree camera. Another 10 mm trocar was used in the epigastric region, which is the main working surgeon's port. A 5 mm trocar in the right lumbar region was used for traction of gallbladder fundus and another 5 mm trocar in the right hypochondrium was used as left-hand working port for the surgeon.

Monopolar electrocautery was used as the hemostatic modality except in some difficult cases when bipolar electrocautery was used in addition to monopolar one. Surgery time was calculated from first port insertion to closure of the last wound.

Statistical analysis

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0 Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

1. Independent-samples t-test of significance was

Table 2 - Level of difficulty criteria

Parameters	Score	Grading
Time taken < 60 min & No bile spillage & No injury to duct	0-5	Easy
Time taken 60 – 120 min and / or Bile or stone spillage and / or Injury to duct	6-10	Difficult
Time taken > 120 min or conversion	11-15	Very difficult

used when comparing between two means.

2. Chi-square (χ^2) test of significance was used in order to compare proportions between two qualitative parameters.
3. Receiver operating characteristic (ROC curve) analysis was used to find out the overall predictivity of parameter in and to find out the best cut-off value with detection of sensitivity and specificity at this cut-off value.
4. Univariate and multi-variate analysis of potential risk factors.

RESULTS

A total of 452 cholecystectomies were performed between March 2018 and March 2021. Age ranged from 18 years to 85 years with a mean of 39.54 years (SD ±13.97). Of these, 376 (83.2 %) were females, and 76 (16.8 %) were males. Two hundred and sixty-eight procedures (62 %) were considered as easy intervention while the rest of procedures (184; 38 %) were difficult (152 patients), and very difficult (32 patients) (*table 3*).

In our study, BMI of our patients ranged from 22 to 47 kg/m². Nearly half, that is 49.6 %, had abdominal scars. Two hundred and twelve cases were with previous infra-umbilical scar, previous cesarean section in 112 patients, and the remaining 100 patients had Macberny's scar of open appendectomy. Only twelve cases presented with supra-umbilical scar, eight of them were due to laparoscopic sleeve gastrectomy and the remaining four were due to open splenectomy (*table 3*).

Sixty patients (13.3 %) had previous history of hospital admission; 44 for acute cholecystitis and 16 for biliary pancreatitis. Gall bladder was palpable only in four (0.9 %) cases. Endoscopic retrograde cholangiopancreatography (ERCP) was performed in 20 (4.4 %) cases. Abnormal thickness of the GB wall (more than 4 mm) was present in 192 (42.5 %) patients, and 72 (15.9%) patients presented with impacted stones in the Hartmann pouch (*table 3*).

Of the 452 patients, 116 (25.7 %) had positive CRP. Total leucocyte count ranged from 3800 to 13300, Total

Table 3 - Pre-operative clinical and radiological parameters studied for easy and difficult laparoscopic cholecystectomies

			Easy	Difficult	Total	χ^2	P-value	Randhawa p value
Age	< 50	N	216	108	324	25.780	0.001*	0.937
		%	80.6%	58.7%	71.7%			
	≥ 50	N	52	76	128			
		%	19.4%	41.3%	28.3%			
Sex	Male	N	24	52	76	29.071	0.001*	0.736
		%	9.0%	28.3%	16.8%			
	Female	N	244	132	376			
		%	91.0%	71.7%	83.2%			
BMI	< 27.5	N	128	64	192	7.521	0.006*	
		%	47.8%	34.8%	42.5%			
	> 27.5	N	140	120	260			
		%	52.2%	65.2%	57.5%			
Abdominal Scars	No	N	124	104	228	4.588	0.032*	0.882
		%	46.3%	56.5%	50.4%			
	Yes	N	144	80	224			
		%	53.7%	43.5%	49.6%			
Palpable GB	No	N	268	180	448	5.878	0.015*	0.022*
		%	100%	97.8%	99.1%			
	Yes	N	0	4	4			
		%	.0%	2.2%	.9%			
Previous Hospital Admission	No	N	264	128	392	79.381	0.001*	0.001*
		%	98.5%	69.6%	86.7%			
	Yes	N	4	56	60			
		%	1.5%	30.4%	13.3%			
ERCP	No	N	268	164	432	30.479	0.001*	
		%	100%	89.1%	95.6%			
	Yes	N	0	20	20			
		%	.0%	10.9%	4.4%			
Biliary Pancreatitis	No	N	264	172	436	8.081	0.0004*	
		%	98.5%	93.5%	96.5%			
	Yes	N	4	12	16			
		%	1.5%	6.5%	3.5%			
CRP	-ve	N	212	124	336	7.846	0.005*	
		%	79.1%	67.4%	74.3%			
	+ve	N	56	60	116			
		%	20.9%	32.6%	25.7%			
Thickness of GB	< 4 mm	N	168	92	260	7.186	0.007*	0.038*
		%	62.7%	50.0%	57.5%			
	> 4 mm	N	100	92	192			
		%	37.3%	50.0%	42.5%			
Impacted Stones	No	N	244	136	380	23.910	0.001*	0.190
		%	91.0%	73.9%	84.1%			
	Yes	N	24	48	72			
		%	9.0%	26.1%	15.9%			
Number of Stones	Single	N	80	52	132	0.133	0.715	
		%	29.9%	28.3%	29.2%			
	Multiple	N	188	132	320			
		%	70.1%	71.7%	70.8%			
Liver Size >15.5 cm	No	N	228	156	384	0.007	0.932	
		%	85.1%	84.8%	85.0%			
	Yes	N	40	28	68			
		%	14.9%	15.2%	15.0%			

bilirubin ranged from 0.23 to 8.3 and the range of direct bilirubin from 0.02 to 4.7. The diameter of the CBD ranged from 2 mm to 9 mm and 320 patients had multiple stones (320; 70.8 %). Only 68 (15 %) patients presented with liver size more than 15.5 cm (*table 3*).

On univariate analysis, we found the following

variables to be significant: age of 50 years or over (P value 0.001), male gender (P value 0.001), BMI 29 Kg/M² (P value 0.032), previous supra or infra abdominal scars (P value 0.032), palpable GB (P value 0.015), previous hospitalization for biliary problem (P value 0.001), history of ERCP (P value 0.001), history of biliary

pancreatitis (P value 0.004), positive CRP (P value 0.005), thickness of gall than 4 mm (P value 0.007), impacted stone (P value 0.001), TLC of $12800 \times 10^9/L$ or more (P value 0.001), total bilirubin of 0.9 mg/dl (15.3 Mmol/L) or more (P value 0.008), and direct bilirubin of 0.3 mg/dl (5.1 Mmol/L) or more (P value 0.034) (table 4).

On integrating them on multivariate analysis, we found age equal to or over 50 years (P value 0.001), male gender (P value 0.001), previous hospital admission (P value 0.001), impacted stones (P value 0.003), and TLC more than 12800 (P value 0.031) statistically significant with area under ROC curve is 0.814 with 95 % confidence interval. The positive predictive value of the operative outcome was 81.2 % (254/313) and 89.9 % (125/139) for easy and difficult, respectively. At score five, sensitivity and specificity were 70% and 82%, respectively (table 5).

DISCUSSION

The key to health care advancement is to understand the outcomes. It is essential to know the factors that lead to conversion to an open procedure (11). In addition, conversion is not a failure of laparoscopic approach, but it is considered a step toward safe maneuver especially in difficult situations (13). Many scores are used preoperatively to assess difficult LC in a hope to give the chance for surgeons and the rest of the staff to expect any unpleasant events that may occur and reduce the risk of postoperative complications. In addition, prediction of difficult LC may help the staff to refer patients with high possibility of difficult cholecystectomy to a tertiary hospital that can manage these situations properly (11).

In our study, we initially used the scoring system of Randhawa and Pujahari to predict difficult LC. At score 5 for prediction of easy or difficult maneuver, sensitivity and specificity were 70 and 82 respectively. For the easy and difficult LC, prediction came true in 81.2 % and 89.9 % subsequently, and the area under ROC was 0.814. In 2009, a study performed by Randhawa and his colleagues proved that their scoring method sensitivity and specificity were 75% and 90.2%, at the same score with the area under ROC curve being 0.82, and the positive predictive values were 88.8% for easy cases, and 92.2% for difficult ones (12).

Gupta et al. found that sensitivity and specificity for prediction of easy or difficult LC were 95.74% and 73.68% respectively, and prediction was true in about 90% in easy cases, and 88% for difficult ones with the area under ROC curve being 0.86 (10). In 2020, Boraii et al. reported that sensitivity was 88.9 % and specificity

Table 4 - Univariate analysis of intraoperative outcome with risk factors

	Univariate	
	B (95% CI)	P value
Age	2.923 (1.917 – 4.456)	0.001*
Sex	0.250 (0.147 – 0.423)	0.001*
BMI	1.714 (1.165 – 2.523)	0.006*
Abdominal Scars	0.662 (0.454 – 0.966)	0.032*
Palpable GB	0.402 (0.359 – 0.450)	0.015*
Previous Hospital Admission	28.875 (10.246 – 81.376)	0.001*
ERCP	0.380 (0.337 – 0.428)	0.001*
Biliary Pancreatitis	4.605 (1.461 – 14.510)	0.004*
CRP	1.832 (1.196 – 2.806)	0.005*
Thickness of GB	1.680 (1.148 – 2.458)	0.007*
Impacted Stones	3.588 (2.106 – 6.114)	0.001*
Number of Stones	1.080 (0.714 – 1.634)	0.715
Liver Size >15.5 cm	1.023 (0.606 – 1.728)	0.932
TLC	0.617 (0.167 – 0.862)	0.001*
Total bilirubin	0.715 (0.369 – 0.956)	0.015*
Direct bilirubin	0.548 (0.334 – 0.861)	0.029*
CBD Diameter > 6 mm	0.514 (0.065 – 2.650)	0.267

was 68.8 % at score 5 with a comparable value of the area under ROC curve (0.9) with prediction coming true in 97.2 % in easy cases, and very low percentage in difficult cases (37.5%) (11). Comparable to the results confirmed by the other three studies, we proved that this scoring system could be considered more sensitive in the prediction of difficult LC more than its prediction for the easy cases (10-12). Our study also showed that this scoring system was found to be less sensitive (only 70%) than the previous studies which means there are other risk factors which should be added to the original scoring system.

Table 5 - Multivariate analysis of intraoperative outcome with risk factors

	Multivariate	
	B (95% CI)	P value
Age	3.524 (2.116 – 5.870)	0.001*
Sex	0.263 (0.132 – 0.523)	0.001*
BMI	1.137 (0.691 – 1.871)	0.614
Abdominal Scars	0.786 (0.473 – 1.304)	0.351
Palpable GB	1.372 (0.023 – 5.324)	0.824
Previous Hospital Admission	16.789 (5.371 – 52.484)	0.001*
ERCP	2.299 (0.034 – 14.364)	0.817
Biliary Pancreatitis	2.526 (0.531 – 12.007)	0.244
CRP	1.377 (0.787 – 2.408)	0.262
Thickness of GB	1.043 (0.650 – 1.673)	0.763
Impacted Stones	2.976 (1.454 – 6.090)	0.003*
TLC	0.518 (0.309 – 0.754)	0.027*
Total bilirubin	0.597 (0.315 – 2.361)	0.109
Direct bilirubin	0.754 (0.268 – 3.605)	0.234

Figure 1 - ROC curve and its area under curve for predicting the operative outcome based on preoperative scores

As symptomatic GB stones which need LC is a middle age disease, 324/452 (71.7%) of patients were under the age of 50 with a mean age 39.54 ± 13.97 years. Chand et al. mentioned that 75% of their patients were between 31 and 60 years with the mean age 43.44 ± 1.13 years (4). On analyzing our data in relation to age, we found that age of 50 years or over had significance for difficult LC with P value = 0.001. We think it is due to a long duration of gall stone disease with increasing number of attacks of cholecystitis. Identical to our study, a series performed by an Indian group in 2019 observed that age over 65 correlated significantly with difficult maneuver (P=0.004) (4). Another series by a group in Virginia in 2012 found a high risk of conversion to OC with mean age 58.9 ± 14.3 (P value= 0.0002) (14).

Also, in 2002 Kannan et al. performed a study on risk factors with conversion from laparoscopic to open technique in acute and chronic cholecystitis and they found that patients older than 50 years had high risk of conversion (P value > 0.05) (15).

Opposite to our result, Egyptian series on 60 patients observed increasing rate of conversion in cases over 50 years. However, they found this result was not statistically significant as a predictor of difficult LC (P=0.292) (11). In addition, another study on 180 patients performed by Nidoni et al. stated that the age was not a considerable predictor for difficult maneuver (P=0.22), although the age of both groups, converted and non-converted, was 44.1 and 62.33 (7). They predict that it was attributed to long experience in the field of laparoscopic surgery that may exceed 20 years.

Because GB stone disease is more common in females, (4) our study showed that 376/ 452 (83.2%) of the cases were female. Also, there was a high risk of

having difficult LC in males as the dissection of Calot's triangle may be difficult due to dense adhesion and fibrosis as males were reluctant to seek medical advice which leads to increase the duration and the number of attacks of inflammation (14). In our study, male gender was found to be a statistically significant index for difficult LC (P value =0.001) and this is supported by the result stated by Yol et al. in 2006 that males with GB stones are susceptible to recurrent attacks of inflammation that healed by fibrosis making dissection very difficult (16). Similar to the current study, Nidoni found that male sex was a risk factor for conversion from laparoscopic to open maneuver (P value = 0.034), and Lee in 2012 stated high risk of conversion in males 19/39 with a P value 0.003 (7). Contrary to our result, Gupta et al. reported that male gender was a non-significant factor (P=0.265) (10). In addition, another study in 2020 proved that males were not considered as a significant factor for conversion from laparoscopic to open technique (P=0.599) (11).

As for the history of previous admission, 13.3% of our patients were admitted for acute cholecystitis and biliary pancreatitis (44 and 16 respectively). Our study proved that previous hospitalization in both univariate and multivariate analysis had a risk of difficult LC with the same P value=0.001 and this is often due to intensive adhesion in the Calot's triangle and fossa of the GB that need a lot of time for dissection. Consistent with our result, Gupta et al. in 2013, Khetan et al. in 2017 found that repeated acute attacks of cholecystitis that need hospital admission represented a risk factor for difficult LC with P value 0.031 and 0.0419 respectively. (10,17).

Impacted stone in the GB neck was found to be a significant risk for difficult LC in univariate and multivariate analysis with p value 0.001 and 0.003 respectively. Concerning this problem, it prevents grasping the GB neck to have the chance to clarify Calot's triangle and its very thick wall due to mucocoele formation that makes it very difficult to hold. In agreement with our result, a paper published in 2002 showed that impacted stone in Hartman's pouch had a risk of conversion to open procedure with p = 0.0004 (18). In addition, Saleem et al. in 2018 found that impacted stone in the GB neck was a statistically significant factor for difficult laparoscopic maneuver with p = 0.003 (19).

Contrasting with our result, a study performed in 1998 by a Jordanian group on 160 consecutive patients with symptomatic GB disease to assess the significance of the preoperative ultrasound variables as GB size, number of stones, size of stones, location, wall thick-

ness, diameter of CBD, and liver size. They only found that GB thickness and CBD diameter were predictors of difficult LC without any risk factor for stone location (P value= 0.2575) (20).

In our work, we noticed there was significant risk of difficult LC with P value=0.031 when TLC was $12800 \times 10^9/L$ or more. Compatible with our result, Nidoni et al. found high risk of conversion from laparoscopic to open procedure in patients with TLC $12933 \times 10^9/L$ with P value = 0.037. (7) Another series published in 2006 by a Singaporean group that reported high risk of conversion with TLC 13.2 ± 1.6 with significant P value 0.05 (21).

CONCLUSION

There are some preoperative factors such as old age, male sex, previous hospitalization for biliary problem, impacted stone, and leukocytosis that could help to predict difficult LC and give surgeons and their assistants the chance to predict the risk of complications intraoperatively and the possibility to convert it into a bail-out procedure.

Limitations of this study

As limitations of this study we could list the small number of patients, this study was not a multi-centric one as it was limited to our department and potentially more parameters could be analyzed.

Authors' contribution

All authors had equal role in design, work, statistical analysis, and manuscript writing.

Conflict of interest

No conflict of interest has been declared.

Financial disclosure statement

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