

## The Value of Preoperative Ultrasound In Predicting Technical Difficulties During Laparoscopic Cholecystectomy

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### ABSTRACT

**Background:** In spite of advances made in laparoscopy with the development of higher technical skills, there is still a reported significant incidence of serious complications during laparoscopic cholecystectomy which may necessitates conversion to open surgery and in turn; may affect the post operative outcome. **Aim of work:** Evaluation of preoperative sonography as a simple non-invasive method in predicting technical difficulties in laparoscopic cholecystectomy. **Patients and Methods:** Prospective clinical trial study included 100 patients with chronic calcular cholecystitis underwent laparoscopic cholecystectomy. Preoperative US was done for all of them measuring four parameters, namely, gall bladder size and wall thickness, stone size and mobility. Then detecting their relation with intraoperative technical difficulties. **Results:** Operation time was more with thickened gall bladder wall and with impacted stones. More technical difficulties were encountered with stone impaction and size of gall bladder while conversion to open was higher with thickened gall bladder wall. **Conclusion :** In spite of the importance in predicting operation time and technical difficulties, no single sonographic parameter was reliable in predicting risk of conversion to open surgery.

**Keywords:** Laparoscopic cholecystectomy, Technical difficulties, Preoperative sonography, Impacted stones, Gall bladder

### INTRODUCTION

Laparoscopic cholecystectomy is considered now the gold standard in management of calcular gall bladder disease with its advantages over open approach in being less traumatic, less operative time, faster recovery, shorter hospital stay, smaller wounds and better cosmetic results. In spite of that, laparoscopic cholecystectomy still has its technical challenges and a significant incidence of intra- and post-operative complications which may be life threatening or associated with prolonged disabling morbidities or even necessitates conversion to open surgery.<sup>[1-3]</sup>

Major frequently encountered complications are vascular injuries (the most lethal event), bile duct injury (the most serious complication), bowel injury, post operative bile leak and retained bile duct stones. Other complications are gall bladder perforation and stone or bile spillage, wound infection, ileus, port site hernia, foreign body inclusion and perihepatic collections.<sup>[3-7]</sup>

These complications may result due to the technical difficulties faced during the procedure leading to abortion of the procedure and conversion to open surgery which in turn may significantly changes the outcome because of prolonged hospitalization and the development of more postoperative complications.<sup>[2]</sup>

Ultrasound examination of the abdomen is a routinely performed investigation prior to cholecystectomy as it is the most important diagnostic tool. In addition, it may be of significance in measuring different parameters that help in predicting intra-operative technical difficulties that may be encountered during laparoscopic cholecystectomy. This can be of utmost importance in detecting the possible outcome, the risk of conversion to open surgery and also deciding the procedure of choice preoperatively or even intraoperatively.<sup>[8-10]</sup>

#### **Aim of work:**

Predicting technical difficulties, operation time and conversion to open surgery incidence during laparoscopic cholecystectomy based on preoperative sonographic detection of four

different parameters: Gall bladder size and wall thickness, stone size and mobility.

## PATIENTS AND METHODS

### Study design:

This was a prospective double blind cohort study conducted in Cairo University hospitals over a period of 24 months starting from January 2013 to January 2015 on 100 patients presented with chronic calculous cholecystitis who underwent laparoscopic cholecystectomy.

### Inclusion criteria:

Male and female patients with symptomatic chronic calculous cholecystitis.

### Exclusion criteria:

Gall bladder mass, distended gall bladder  $\geq 50$  ml., CBD stone, acute cholecystitis, liver cirrhosis, liver cell failure, renal failure, bleeding tendency or previous upper abdominal surgery.

### Methodology:

Preoperative patient data were collected. History taking and full clinical examination were done. Routine investigations prior to the surgery were done as CBC, coagulation profile, liver and kidney functions. Abdominal U/S was done for all of them as a diagnostic tool for the gall bladder disease and for detection of the following four parameters which may predict technical difficulties :

1. Gall bladder wall thickness; the gall bladder wall is considered thickened if more than 3mm
2. Gall bladder size; whether contracted (<30ml) or normal
3. Stone mobility; mobile stones or impacted at the neck (immobile stones as gall bladder being totally packed with stones is considered impacted)
4. Stone size; large stone is that more than 20mm

All patients received intravenous antibiotics in form of 3<sup>rd</sup> generation cephalosporin ceftriaxone. General anesthesia was administered then standard four ports laparoscopic cholecystectomy was done by the same well trained and

experienced surgeons to avoid bias of the learning curve. Also, surgical team were blinded to the ultrasonographic findings.

Operation time was measured starting from ports insertion till gall bladder extraction. The encountered technical difficulties were recorded (stone spillage, difficult dissection at Calot's triangle, presence of extensive adhesions, bleeding, conversion to open surgery and its causes).

Data were statistically described in terms of mean  $\pm$  standard deviation ( $\pm$  SD), median and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student *t* test for independent samples. For comparing categorical data, Chi square ( $\chi^2$ ) test was performed. Exact test was used instead when the expected frequency is less than 5. *p* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows (2006).

## RESULTS

This study included 100 patients with non-complicated chronic calculous cholecystitis, 90 females and 10 males, with the highest prevalence in age group 32 to 45 years old. Preoperative sonography was done for all of them measuring the four criteria; gall bladder wall thickness (more or less than 3mm), gall bladder size (normal or contracted), stone site (impacted or freely floating) and size (more or less than 20mm). Laparoscopic cholecystectomy procedure lasted less than 30 minutes in most of cases with conversion to open in 7% of them. The technical difficulties were encountered in 24% of cases in form of extensive adhesions, gall bladder perforation and stone spillage, bleeding or difficult dissection at triangle of Calot. (Table 1)

**Table 1:** Basic characteristics and distribution of sonographic findings, intra-operative findings and events among studied cases

	PARAMETERS	NUMBER (%)
<b>Sex distribution</b>	Male	10 (10%)
	Female	90 (90%)
<b>Age distribution</b>	<18	2 (2%)
	18-32	30 (30%)
	33-45	50 (50%)
	>45	18 (18%)
<b>U/S findings</b>	<b>GB wall thickness</b>	
	>3 mm	22 (22%)
	<3 mm	78 (78%)
	<b>GB size</b>	
	Normal	86 (86%)
	Contracted	14 (14%)
	<b>Stone mobility</b>	
Mobile	81 (81%)	
<b>Stone size</b>	Impacted	19 (19%)
	<2 cm	89 (89%)
	>2 cm	11 (11%)
<b>Technical difficulties</b>	Stone spillage	6 (6%)
	Difficult dissection of Calot's triangle	4 (4%)
	Adhesions	9 (9%)
	Bleeding	5 (5%)
<b>Operation time</b>	<30 min.	79 (79%)
	30 – 45 min.	17 (17%)
	>45 min.	4 (4%)
<b>Conversion to open</b>	Converted to open surgery	7 (7%)
	Completed laparoscopically	93 (93%)

As shown in table 2, operation time was significantly affected in cases with thickened bladder wall, impacted stones, contracted gall bladder and large sized stones with significant p values but only the first two criteria can be a predictor of the expected operation time. (Table 3)

**Table 2:** The relation between ultrasound parameters and the operation time

U/S parameters		Operation time						P value
		<30 min.		30-45 min.		>45 min.		
		N	%	N	%	N	%	
<b>Gall bladder wall thickness</b>	> 3mm (n=22)	8	36.4	11	50.0	3	13.6	<0.001 (S)
	< 3mm (n=78)	71	91.0	6	7.7	1	1.3	
<b>Gall bladder size</b>	Normal size (n=86)	74	86.0	11	12.8	1	1.2	<0.001 (S)
	Contracted (n=14)	5	35.7	6	42.9	3	21.4	
<b>Stone mobility</b>	Mobile (n=81)	69	85.2	11	13.6	1	1.2	0.001 (S)
	Impacted (n=19)	10	52.6	6	31.6	3	15.8	
<b>Stone size</b>	>20 mm (n=11)	4	36.4	6	54.5	1	9.1	0.001(S)
	<20 mm (n=89)	75	84.3	11	12.4	3	3.4	

S = significant (p< 0.05)

**Table 3:** Multi-variate analysis to predict the operation time

	P value	$\beta$	95% C.I. for $\beta$		
<b>GB wall thickness (&gt;3mm vs &lt;3mm)</b>	<0.001(S)	5.091	3.182	-	7.000
<b>GB size (Contracted vs normal)</b>	0.173(NS)	3.831	-1.707	-	9.369
<b>Stone mobility (Impact vs mobile)</b>	0.031(S)	4.735	0.454	-	9.017
<b>Stone size(&gt;20 mm vs &lt;20 mm)</b>	0.542(NS)	1.685	-3.776	-	7.147

$\beta$  = Beta coefficient, CI= Confidence interval, S=Significant, NS= Non significant

Table 4 shows that, there is a significant relation between the thickened gall bladder wall and the faced technical difficulties as stone spillage, difficult identification of cystic duct and the presence of adhesions. Also, impacted stones were associated with higher incidence of bleeding and difficulty in dissecting the Calot's triangle. Furthermore, most of the difficulties were encountered in cases associated with contracted gall bladder and/or large sized stones with the exception that there was no significant relation between presence of extensive adhesions and the stone size.

**Table 4:** The relation between ultrasound parameters and the intra-operative technical difficulties

U/S parameters		Technical difficulties							
		Stone spillage		Difficult dissection of Calot's triangle		Adhesions		Bleeding	
		N	%	N	%	N	%	N	%
<b>Gall bladder wall thickness</b>	> 3mm (n=22)	4	18.2	3	13.6	6	27.3	2	9.1
	< 3mm (n=78)	2	2.6	1	1.3	3	3.8	3	3.8
	P-value	0.02(S)		0.03(S)		0.003(S)		0.3(NS)	
<b>Gall bladder size</b>	Normal size (n=86)	2	2.3	2	2.3	4	4.7	2	2.3
	Contracted (n=14)	3	21.4	3	21.4	5	35.7	3	21.4
	P-value	0.02(S)		0.02(S)		0.002(S)		0.02(S)	
<b>Stone mobility</b>	Mobile (n=81)	3	3.7	0	0.0	6	7.4	2	2.5
	Impacted (n=19)	3	15.8	5	26.3	3	15.8	3	15.8
	P-value	0.1(NS)		<0.001(S)		0.4(NS)		0.046(S)	
<b>Stone size</b>	>20 mm (n=11)	3	27.3	3	27.3	1	9.1	4	36.4
	<20 mm (n=89)	3	3.4	2	2.2	8	9.0	1	1.1
	P-value	0.02(S)		0.01(S)		1.0(NS)		<0.001(S)	

S = significant ( $p < 0.05$ ) NS = Non significant

It was found that, the size of the gall bladder and the site of the stones can be of significant value in predicting technical difficulties that may be faced during laparoscopic cholecystectomy. (Table 5)

**Table 5:** Multi-variate analysis to predict difficulties

	P value	OR	95% C.I. for OR		
<b>GB wall thickness (&gt;3mm vs &lt;3mm)</b>	0.066(NS)	2.147	0.950	-	4.853
<b>GB size (Contracted vs normal)</b>	0.004(S)	13.659	2.361	-	79.029
<b>Stone mobility (Impact vs mobile)</b>	0.049(S)	5.502	1.005	-	30.105
<b>Stone size(&gt;20 mm vs &lt;20 mm)</b>	0.892(NS)	0.841	0.068	-	10.322

OR= odds ratio, CI= Confidence interval S=Significant, NS= Non significant

As shown in table 6, there is a significant relation between the thickness of the gall bladder wall and the incidence of conversion to open surgery. Extensive adhesions and thickened wall were the main causes of conversion (Table 7). In spite of that, there was no sonographic criteria that can be a reliable predictor of conversion to open. (Table 8)

**Table 6:** The relation between ultrasound parameters and conversion to open surgery

U/S parameters		Conversion to open		P value
		N	%	
Gall bladder wall thickness	> 3mm (n=22)	5	22.7	0.005(S)
	< 3mm (n=78)	2	2.6	
Gall bladder size	Normal size (n=86)	4	4.7	0.06(NS)
	Contracted (n=14)	3	21.4	
Stone mobility	Mobile (n=81)	5	6.2	0.6(NS)
	Impacted (n=19)	2	10.5	
Stone size	>20 mm (n=11)	2	18.2	0.2(NS)
	<20 mm (n=89)	5	5.6	

S = significant ( $p < 0.05$ ) NS = Non significant

**Table 7:** The relation between pre-operative U/S parameters and different causes of conversion to open surgery

Case No.	pre-operative U/S parameters	Cause of conversion to open surgery
1	>3mm, impacted stone, stone size >20mm	CBD injury
2	>3mm, contracted GB	Adhesions
3	>3mm, contracted GB	Adhesions
4	>3mm	Adhesions
5	>3mm, impacted stone, stone > 20mm	Adhesions, inability to identify cystic duct
6	<3mm	Adhesions, stone spillage
7	<3mm, contracted GB	Uncontrolled arterial bleeding

**Table 8:** Multi-variate analysis to predict Conversion

	P value	OR	95% C.I. for OR		
GB wall thickness (>3mm vs <3mm)	0.373(NS)	1.503	0.613	-	3.688
GB size (Contracted vs normal)	0.377(NS)	3.015	0.260	-	34.973
Stone mobility (Impact vs mobile)	0.514(NS)	0.436	0.036	-	5.282
Stone size(>20 mm vs <20 mm)	0.230(NS)	3.988	0.416	-	38.249

OR= odds ratio, CI= Confidence interval S=Significant, NS= Non significant

## DISCUSSION

After being the gold standard in management of calcular cholecystitis, laparoscopic cholecystectomy still has its specific intraoperative technical difficulties which may result in serious complications, unnecessary prolongation of surgery or conversion to open cholecystectomy.<sup>[11]</sup>

Preoperative ultrasound provides 95-98% sensitivity and specificity in the diagnosis of gallstones greater than 2 mm in diameter. In addition, its findings may be a guide for predicting the technical difficulties and conversion during laparoscopic cholecystectomy, so surgeons can properly arrange their operative

schedules, select cases appropriate for their skills, convert earlier the difficult cases with less time and effort consumption and also discuss potential difficulties of the procedure with patients prior to surgery.<sup>[12,13,14]</sup>

The aim of this study is to evaluate four, easily measured ultrasound parameters as preoperative predictors of technical difficulties that may be encountered during laparoscopic cholecystectomy which can be assessed by the prolongation of the operation time and the rate of conversion to open.

This study involved 100 patients with non complicated chronic calcular cholecystitis. Preoperative abdominal ultrasound was done for all of them measuring gall bladder wall thickness, gall bladder size, stone size and mobility.

Technical difficulties as stone spillage, difficult dissection of Calot's triangle, adhesions and bleeding as well as the operation time and conversion to open surgery were analyzed in relation to the four ultrasound parameters.

Many similar studies were done for the same purpose with creation of scoring systems by some of them. Single up to fifteen ultrasound parameters were measured but some of them were commonly used in most of the studies being simple and can be accurately measured.

Lal et al. conducted a study on 73 patients measuring four ultrasound criteria, namely gallbladder wall thickness >4-mm, gallstone mobility, gallbladder size and common bile duct diameter. The procedure was considered difficult according to these criteria: operation time more than 90 minutes, tear of the gallbladder during dissection with spillage of bile and stones, more than 20 minutes taken to dissect the gallbladder from the gallbladder bed, more than 20 minutes taken to dissect Calot's triangle, and any laparoscopic cholecystectomy converted to the open procedure.<sup>[15]</sup>

Sharma et al. conducted a study on 200 patients. Four sonographic parameters were measured : size of gall bladder, wall thickness, distance between hepaticoduodenal ligament and Hartmann's pouch and the size of stone. Difficulties in terms of adhesions around gall bladder, anatomy of calot's triangle, difficulty in peeling off gall bladder from the bed and retrieval and conversion to open were analyzed.<sup>[10]</sup>

Jitea et al. made a study on 100 cases. The sonographic features as size, volume, function, wall thickness, hydrops, number and size of stones, infundibular position of the stones, perivesicular liquid collections hepatic and pancreatic aspects, main bile duct caliber were registered. The difficulty in performing the procedure was measured using 10 different parameters including in them adhesions, difficult grasping of the gallbladder, bleeding and operative time.<sup>[16]</sup>

Kaya et al. conducted a study on 50 consecutive patients. 15 ultrasound parameters were measured including gall bladder stones number, site and size, gall bladder volume and wall thickness. Difficulty was assessed based on the following criteria : Entrance into peritoneal cavity and intraabdominal adhesions, dissection of gallbladder adhesions, dissection of Calot

triangle, dissection of gallbladder bed and extraction of the gall bladder from the abdominal cavity.<sup>[12]</sup>

Cho et al. conducted a study on 55 patients suffering from acute cholecystitis. Ultrasound was used to measure 14 parameters involving : volume of gallbladder (GB), thickness of GB wall, pattern of GB wall thickening, size of largest gallstone, gallstone mobility. Evaluation of difficulties was done on each of the five main operative steps.<sup>[17]</sup>

Stanisic et al. conducted their study on 369 cases. Sonographic parameters were measured in form of gall bladder diameter, wall thickness (> 4 mm vs < 4 mm), adhesion of the GB (yes vs no), size of stones (> 2 cm vs < 2 cm), number of stones (solitary vs multiple) and presence of free fluid in the lodge of the GB (yes vs no). Difficulty was assessed regarding difficult dissection, operation time for each step and total operative time.<sup>[18]</sup>

Haldeniya et al. conducted a study on 500 patients undergoing Laparoscopic cholecystectomy. Sonographic parameters like Gall Bladder wall thickness, antero posterior diameter of Gall Bladder in fasting state, impacted gall stone, CBD diameter were taken into consideration and difficulties in terms of time taken for surgery, cystic duct injury; cystic artery injury and lead to conversion were analyzed.<sup>[19]</sup>

In this study, it was found that, the operation time was significantly prolonged in cases associated with thickened bladder wall, large size stones, contracted gall bladder and/or with impacted stones.

Haji et al. and Ammori et al. found that there is a significant relation between gall bladder wall thickness and prolongation of operation time.<sup>[20,21]</sup>

Jitea et al. found that there is a strong relation between the time of the procedure and the following sonographic criteria: gall bladder volume and wall thickness, stones site, size and mobility.<sup>[16]</sup>

Haldeniya et al. reported a significant relation of the gall bladder diameter and wall thickness with the operation time.<sup>[19]</sup>

Stanisic et al. found that the duration of operation was prolonged in association with with difficulties as time of dissection of Callot's triangle, dissection of GB and on the time of extraction of GB from abdominal cavity. This was significantly related to impacted stones, large

stones, thickened gall bladder wall and contracted gall bladder.<sup>[18]</sup>

Cho et al. did not document any significant relation between operation time and sonographic parameters; gall bladder volume, wall thickness, stones size or mobility.<sup>[17]</sup>

In the present study, thickened gall bladder wall was significantly associated with difficult dissection at Calot's triangle, presence of extensive adhesions around the gall bladder and also with stone and bile spillage due to bladder injury. In spite of that, thickening of the gall bladder wall can not predict the possible technical difficulties.

Sharma et al., Cho et al., Stanisic et al. and Daradkeh et al. found that thickened gall bladder wall that was detected preoperatively by the ultrasound, is associated with more technical difficulties and can be used as a significant preoperative predictor.<sup>[10,17,18,22]</sup>

Also, Haldeniya et al. found that, thickened gall bladder wall was significantly associated with bleeding and adhesions that causes more technical difficulties during surgery.<sup>[19]</sup>

In this study, gall bladder size was related significantly to the presence of intra-operative technical difficulties. Contracted gall bladder was associated with difficult dissection at Calot's triangle, presence of extensive adhesions around the gall bladder, bleeding and stone or bile spillage due to bladder injury. Also, it was found that, the size of the gall bladder can be used as a predictor for technical difficulties.

Sharma et al., found that, contracted gall bladder was associated with dense adhesions around the gall bladder - which significantly increased the difficulty of the procedure – and with unclear Calot's triangle which was statistically non-significant. Also, it is used as a predictor of technical difficulties.<sup>[10]</sup>

Haldeniya et al. found that, contracted gall bladder was associated with adhesions, problems of exposure and difficulty in gall bladder separation from the bed. It can be used as a predictor of difficult laparoscopic cholecystectomy.<sup>[19]</sup>

Cho et al., found that only with increased GB volume  $\geq 50$ ml, there were increased difficulty of dissection of adhesions around gall bladder and Calot's triangle identification and dissection.<sup>[17]</sup>

Daradkeh et al., reported that, gall bladder size could not be used as a predictor of difficult cholecystectomy.<sup>[22]</sup>

In the current study, it was found that, impacted gall bladder stones were associated with higher incidence of bleeding and with the presence of more difficulties during dissection of cystic duct and artery and also it can be used as a predictor for the presence of intra-operative technical challenges.

Haldeniya et al., Jitea et al. found that, impacted stone was associated with difficulties in holding the gall bladder and is a good predictor of technical difficulties during laparoscopic cholecystectomy.<sup>[19,16]</sup>

Cho et al. and Daradkeh et al. did not find a significant relation between impacted gall bladder stone and the surgical difficulty.<sup>[17,22]</sup>

In this study, large sized stones  $>20$ mm were associated with more technical difficulties than small stones as there was higher incidence of bleeding, difficult dissection at triangle of Calot and stone spillage. But stone size can't be a reliable predictor for the presence of technical difficulties.

Haldeniya et al., Sharma et al. and Jitea et al. found that, stones  $>2$ cm is associated with difficult dissection of the gall bladder from its bed and difficult extraction of the specimen. So, it can be used significantly in detecting technical difficulties during laparoscopic cholecystectomy.<sup>[19,10,16]</sup>

In the present study, only thickened gall bladder wall was significantly associated with increased incidence of conversion from laparoscopic to open cholecystectomy but no single ultrasound parameter can be used to predict the possibility of conversion to open approach.

Haldeniya et al., Ercan et al., Nachnani and Supe, found that thickened gall bladder wall detected by preoperative ultrasonography was significantly associated with increased risk of conversion to open surgery<sup>[19,23,24]</sup> while Goonawardena et al. added to that the significance of impacted stone at the neck of the gall bladder as a predictor for conversion<sup>[25]</sup>.

Cwik et al. reported that thickened gall bladder wall  $> 5$ mm is associated with higher risk of conversion while thickness of 3-5mm is associated with stressful surgery. So, it can be used as a predictor for conversion.<sup>[26]</sup>

## CONCLUSION

Preoperative sonographic parameters were detected in order to predict operation time, technical difficulties and risk of conversion to open surgery. Gall bladder wall thickening and stone impaction can be used to predict the operation time. Gall bladder size and stone impaction are reliable predictors for technical difficulties while thickened gall bladder wall was associated with increased incidence of conversion to open surgery but no single parameter can be used to predict the possibility of conversion.

This study may go side with side in cooperative way with the previously done and future planned studies to facilitate creation of easy and reliable scoring system.

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