International Surgery Journal
Abou-Shady M. Int Surg J. 2016 Aug;3(3):1150-1155
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: http://dx.doi.org/10.18203/2349-2902.isj20162191

Research Article

The feasibility and accuracy of laparoscopic ultrasonography during laparoscopic cholecystectomy

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Received: 31 May 2016
Accepted: 02 July 2016

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ABSTRACT

Background: During laparoscopic cholecystectomy (LC), intraoperative cholangiography (IOC) is currently regarded as the gold standard in the detection of choledocholithiasis. When laparoscopic ultrasonography (LUS) emerged as a viable diagnostic adjunct, it was hypothesized that its routine use would facilitate dissection, detect occult choledocholithiasis, and prevent bile duct injury (BDI) during LC. The aim of this study was to evaluate the feasibility of LUS during LC, and to evaluate its routine use in reducing bile duct complications during LC.
Methods: Forty consecutive patients with gall stones disease scheduled for LC were included in this study. Initial abdominal ultrasound scan was done for all patients. LUS of the liver and the biliary system was done during LC. The success rate of the procedure, operative time, accuracy in the diagnosis of bile duct stones, and delineation of exact biliary anatomy were evaluated.
Results: Forty patients (30 females and 10 males) with a mean age of 43.5 years (range, 26 to 58). The mean time required to complete the LUS examination was 11.40 minutes (range, 5 to 20). Adequate LUS visualization of the common bile duct (CBD) occurred in 40 patients (100%) and of the common hepatic duct (CHD) in 38 patients (95%). It identified 37 patients with gall bladder stones. Thus in terms of the detection and exclusion of gall bladder and common bile duct stones, the sensitivity and specificity of LUS were 94.8 percent and 100 percent respectively. LUS excluded the presence of stones in 3 cases reported to have gall stones by abdominal ultrasound (sensitivity and specificity of abdomen ultrasound were 86.5% and 100% respectively). Bile leak occurred in one patient and was treated nonoperatively. No other major bile duct injury occurred during LC.
Conclusions: LUS gives better identification of vascular structures and anatomic relationship of bile duct to the portal vein and hepatic arteries. The routine use of LUS is safe and accurate and avoids biliary complications during LC.

Keywords: Laparoscopic ultrasound, Laparoscopic cholecystectomy, CBD

INTRODUCTION

Bile duct injury (BDI) is a dreaded complication of cholecystectomy, often caused by misinterpretation of biliary anatomy. To prevent BDI, techniques have been developed for intraoperative assessment of bile duct anatomy.[1]

During laparoscopic cholecystectomy (LC), intraoperative cholangiography (IOC) is currently regarded as the gold standard in the detection of choledocholithiasis.[2] About 10 years ago, when laparoscopic ultrasonography (LUS) was introduced during LC as a newer intraoperative imaging method, it was hypothesized that its routine use would facilitate dissection, detect occult choledocholithiasis, and prevent bile duct injury during LC.[3] The main advantages of LUS

are that it does not involve ionising radiation, is quicker to perform, has a lower failure rate and can be repeated during the procedure as required.[2]

The aim of this study is to evaluate the feasibility of LUS during LC and to evaluate the routine use of LUS in reducing bile duct complications during LC.

METHODS

Forty consecutive patients with gall stones disease scheduled for LC were included in this study from August 2011 to June 2012. In addition to careful history taking and clinical examination, all patients were entered prospectively into a database recording the patient age, sex, and the presenting symptoms and signs, together with routine laboratory and imaging investigations. The investigations included liver function tests (serum bilirubin, albumin, prothrombin time, alkaline phosphatase, alanine and aspartate transferase levels), renal function tests (blood urea and creatinine), complete blood count, bleeding and coagulation times, and blood sugar.

Abdominal ultrasound scan of the liver and biliary system was done initially prior to surgery. Routinely, LUS was performed to screen the bile duct for stones and to delineate the biliary anatomy for completion of the LC.

Laparoscopic ultrasound technique

Laparoscopic ultrasound system consists of a probe, and the scanning machine. The probe was inserted through the umbilical region or right flank port and under laparoscopic vision the probe was placed in direct contact with the capsule of segment IV of the liver (quadrate lobe) to examine the gall bladder and intra- hepatic portion of the biliary tree.[4]

The gall bladder was examined by applying the laparoscopic probe on the surface of segment IV of the liver and its wall thickness and the presence of calculi were determined. Early in the course of LC, before the triangle of calot was dissected, initial scanning was performed to screen the bile duct and to delineate biliary anatomy.[5] During surgery and after dissection of the cystic duct, scanning with colour Doppler ultrasound was done to identify aberrant ductal or vascular anatomy. All patients were followed up for 12 months postoperatively. All the data were collected and tabulated.

RESULTS

The study included 40 consecutive patients undergoing LC: 30 women (75%) and 10 men (25%) with a mean age of 43.5 years (range, 26 to 58). Of these patients, 32 (80%) had chronic cholecystitis and 8 (20%) had acute cholecystitis. The results were shown in Tables 1-5 and Figures 1-5. The commonest presenting symptom was fatty dyspepsia in 32 patients (80%), followed by right hypochondrial pain in 28 patients (70%). The mean time required to perform the laparoscopic ultrasound procedure was 11.40 minutes (range, 5-20) (Tables 3).

Table 1: Clinical presentations of the studied patients.

Patients complaints	Total (n=40)	
	N	%
Fatty dyspepsia	32	80
Right hypochondrial pain	28	70
Epigastric pain	10	25
Vomiting	8	20

Table 2: Demographics of the studied patients.

Age groups (Years)	Sex				Total (n=40)	
	Males (n=10)		Females (n=30)			
	N	%	N	%	N	%
<40	0	0	8	26.7	8	20
40-50	6	60	16	53.3	22	55
>50	4	40	6	20	10	25
Range	43-52		26-58		26-58	
Mean±SD	47.80±4.02		42.13±7.97		43.55±7.52	

Table 3: Distribution of patients regarding duration of the operation and the LUS.

Variable	Sex						Total (n=40)		
	Males (n=10)			Females (n=30)					
	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.
Duration of operation (hours)	1-1.67	1.47	0.28	1-4	1.8	0.70	1-4	1.72	0.64
Duration of LUS (minutes)	10-16	13.2	2.95	5-20	10.8	3.71	5-20	11.40	3.62
t	1.013			1.308					
P*	0.325			0.207					

LUS = laparoscopic ultrasonography, *Not significant.

Adequate intraoperative ultrasonographic visualization of the CBD occurred in 40 patients (100%) and of the CHD in 38 patients (95%) (Figure 4). The overall failure rate of CBD and CHD visualization was therefore 0% and 5% respectively. Among the forty patients included in the study, LUS correctly identified 37 patients with gall

bladder stones. No gall bladder or CBD stones were demonstrated in the remaining patients. Thus in terms of the detection and exclusion of gall bladder and CBD stones, the sensitivity and specificity of LUS were 94.8% and 100% respectively. There were 3 false positive cases reported to have gall bladder stones by preoperative abdominal ultrasound, the sensitivity and specificity of abdomen ultrasound were 86.6% and 100% respectively (Table 4).

Table 4: Sensitivity and specificity of abdominal US and LUS in detection of CBD and GB stones and biliary dilatation.

Parameter		Sensitivity	Specificity
Abdominal US	CBD stones	100%	100%
	GB stones	86.5%	100%
	Dilatation	100%	95%
LUS	CBD stones	100%	100%
	GB stones	94.8%	100%
	Dilatation	100%	100%

LUS = laparoscopic ultrasonography, US=ultrasonography, CBD=common bile duct, GB= gall bladder.

Table 5: Surgical complications of the studied patients.

Parameter	Sex				Total (n=40)		Fisher exact test*
	Males (n=10)		Females (n=30)				
	N	%	N	%	N	%	
Bleeding from gall bladder bed	0	0.0	2	6.7	2	5	1.000
Subcutaneous emphysema of anterior abdominal wall	0	0.0	2	6.7	2	5	1.000
Bile leak	0	0	1	2.5	1	2.5	1.000

*Not significant.

Two patients converted to open surgery to secure hemostasis from gall bladder bed and peritoneal washout due to perforated gall bladder and stone spillage, and another two patients developed subcutaneous emphysema. There was one biliary complication (2.5%). Bile leak from the liver bed (i.e., Strasberg's classification type A) was diagnosed 3 days after LC for acute cholecystitis.[6] This leak was treated nonoperatively by percutaneous drainage. There were no other abdominal complications and no major bile duct injuries (Table 5). Three patients had other extra abdominal complications including pneumonia, urinary tract infection and cardiac arrhythmia, which were treated medically. Neither signs nor symptoms of retained stones developed in any of these 40 patients during a follow-up period of 12 months.

Figure 1: LUS showing gall bladder with multiple stones inside and good delineation of both anterior and posterior gall bladder walls.

Figure 2: LUS showing gall bladder with biliary mud inside, no stones could be detected. This patient was reported to have multiple small gall stones by abdominal ultrasound.

Figure 3: LUS showing gall bladder with two impacted stones in Hartmann's pouch reported as single stone by abdominal ultrasound.

LUS excluded the presence of stones in 3 cases reported to have gall stones by abdominal ultrasound (Figure 2). It detected two stones in the Hartmann's pouch reported as a single stone by abdominal ultrasound (Figure 3). In addition, LUS gives better identification of vascular

structures and anatomic relationship of bile duct to the portal vein and hepatic arteries (Figure 5). No vascular anomalies of the hepatic arteries were detected in the studied patients.

Figure 4: LUS showing right and left hepatic ducts forming the CHD. The probe is placed on the surface of the liver at segment IV.

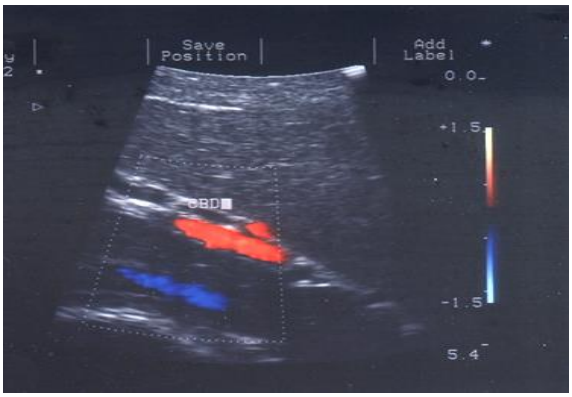

Figure 5: LUS showing portal vein and CBD with no stones or dilatations. The probe is placed at the porta hepatis.

DISCUSSION

IOC is currently regarded as the gold standard in the detection of choledocholithiasis during LC.[2,7] However, routine IOC during LC is often not performed because of increased operative time, radiation, and failure rate.[8] LUS is an attractive alternative with several potential advantages. The main advantages of LUS are that it does not involve ionizing radiation, is quicker to perform, has a lower failure rate and can be repeated during the procedure as required.[2] All the evidence shows excellent results with LUS in delineating the biliary anatomy. The advantages of LUS over IOC are the shorter procedure time, its noninvasive nature, and lack of use of radiation. Furthermore, it may be performed prior to dissection in Calot's triangle and repeated in uncertain cases. One of the main drawbacks of LUS is the reported long learning curve.[1] The aim of this study was to determine whether the routine LUS is an effective mean to reduce or prevent bile duct complications during LC. The study included 40 consecutive patients; 30 females and 10 males. This sex distribution coincided with the worldwide distribution of gall stone diseases.

The mean age of the patients included in the study was 43.5 years which is comparable to the same age group in a similar study.[3] The commonest presenting symptom was fatty dyspepsia in 32 patients (80%), followed by right hypochondrial pain in 28 patients (70%).

The mean time required by the LUS to perform the examination was 11.40 minutes which is slightly longer than the recorded time (8.2 minutes) in a similar study.[9] This was due to the early experience and our interest to get detailed anatomy. That time was not too long to make harmful effects on the final outcome of the surgery, but it was useful in identifying anatomical structures to avoid biliary complications. In another prospective study by Li JW et al, the success rate of IOC and LUS were 91.3% and 100% respectively and the time required for LUS was significantly shorter (P <0.01).[10] The visualization of intrapancreatic part of CBD by IOC (97.3%) was significantly higher than LUS (73.8%).

LUS can adequately demonstrate biliary anatomy. CHD, cystic duct, and CBD all were visualized and examined. In our study, the overall failure rate of CBD visualization was 0%, and for CHD was 5%. These results were comparable to the failure rates of 1% and 7 % in another study.[11] This identification was very helpful to avoid biliary complications.

The two main purposes of intraoperative imaging during LC are screening of the bile ducts for stones and clarification of the biliary anatomy for safe completion of the LC without BDI or other complications. A number of studies were performed to compare LUS and IOC.[12-14] The findings proved LUS to be superior than IOC because it produced fewer-false positive results. It was shown that LUS was a potentially useful imaging modality to confirm the absence of CBD stones without needing to cannulate the biliary system.[8] In this study, the ability of LUS to detect and exclude gall bladder and CBD stones was examined and found to have sensitivity and specificity of 94.8% and 100% respectively, which was comparable to previous reports (80%-100%), and (98%-100%).[15,16]

In another study to compare between LUS and IOC, LUS was superior to cholangiography with respect to its safety, shorter examination period, and ease of administration in all patients. In that study, the accuracy of LUS in identifying CBD stone was 97% compared to 95% by cholangiography.[17] In a prospective study from Belgium, LUS has been shown to be as effective as IOC as a primary imaging technique for bile duct. It permitted to detect CBD stones with a high specificity and sensitivity, and was not followed by an increase in BDI.[7]

Among the forty cases included in present study, there was one biliary complication. Bile leak from the liver bed

was diagnosed 3 days after LC for acute cholecystitis. This leak was treated nonoperatively by percutaneous drainage. No major BDI occurred, no retained or missed stones were discovered during the examination, and all of these patients have not subsequently reported symptoms or signs suggesting retained stones at the mean follow-up period for 12 months. These results were similar to a previous study done by Biffl et al.[3]

BDI is a serious and devastating injury which can lead to major complications. Biliary peritonitis or even multi organ failure can occur if the injury is not detected and properly treated in its early course. Also, vascular injury with its subsequent hemorrhage or ligation of a main hepatic vascular supply can lead to major complications to the biliary system and to liver parenchyma. In our study LUS was a reliable tool in identifying these structures and avoidance of its injury.

The use of LUS in another study helped to detect vascular anomalies of the hepatic arteries in 5/65 patients.[17] In present study, although there were no vascular abnormalities found in the studied patients, LUS proved to be an important diagnostic tool in delineation of vascular and biliary anatomy, and helped us to avoid its injury.

In this study LUS was found to be very helpful in identifying anatomical structures during dissection especially with the use of Color Doppler facility.

In a previous study, LUS is usually performed in case where IOC has failed or is contraindicated. The combination of both methods maximizes intraoperative detection of occult CBD stones and should at least be recommended as two complementary methods.[10]

CONCLUSION

LUS can become the routine method for evaluating the bile duct during LC. LUS is a noninvasive, fast, repeatable and provide real-time visualization of the operative field. It is more accurate than abdominal ultrasound. It facilitates dissection, delineates biliary anatomy, detects relevant pathological incidental findings and reduces bile duct complications during LC.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

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Cite this article as: Abou-Shady M. The feasibility and accuracy of laparoscopic ultrasonography during laparoscopic cholecystectomy. Int Surg J 2016;3:1150-5.