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Laparoscopic Ultrasonography in Detecting Common Bile Duct Stones during Laparoscopic Cholecystectomy: A Case Series

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ABSTRACT

Background: Research has shown that identifying retained stones and bile duct injury is difficult. This study aimed to explore the use of laparoscopic ultrasonography (LUS) in detecting common bile duct (CBD) stones and evaluating biliary anatomy during laparoscopic cholecystectomy for patients with gallbladder stones.

Methods: This case series enrolled 77 adult patients of both genders with symptomatic gallbladder stones who were scheduled for laparoscopic cholecystectomy. Patients underwent LUS to detect CBD stones before proceeding with the cholecystectomy. The primary outcome was the incidence of LUS-detected CBD stones and the ability to visualize the CBD clearly during surgery. Secondary outcomes included the length of hospital stay and the requirement for postoperative endoscopic retrograde cholangiopancreatography (ERCP) or magnetic resonance cholangiopancreatography.

Results: The patients' mean age was 44.08±13.32 years, with female predominance (62.34%). Intraoperative LUS detected CBD stones in 12.99% of patients, with a clear view of the CBD in 93.51% of patients. The mean duration of cholecystectomy was 132.2±6.56 min. Postoperative ERCP was done in 7.79% of patients. The mean hospital stay was 1.26±0.88 days. Obstructive jaundice occurred in 2.6% of patients in whom stones were not detected by LUS.

Conclusion: In adult patients undergoing laparoscopic cholecystectomy, intraoperative LUS is a feasible and useful adjunctive technique for evaluating the biliary architecture and identifying CBD stones, with an acceptable safety profile.

Keywords: common bile duct stones, laparoscopic cholecystectomy, laparoscopic ultrasonography

Abbreviations
CBD: common bile duct;
ERCP: Endoscopic Retrograde Cholangiopancreatography;
LUS: Laparoscopic ultrasonography;
MRCP: Magnetic Resonance Cholangiopancreatography;
n: number;
SD: standard deviation.

INTRODUCTION

Gallstone disease is a common gastrointestinal disorder worldwide, with a global prevalence of approximately 6% and evidence of rising incidence in recent decades. The prevalence increases progressively with advancing age, reaching nearly 9% among individuals older than 50 years (1).

Laparoscopic cholecystectomy is the preferred treatment modality for symptomatic gallstone disease and is recognized as the gold-standard approach in current clinical practice (2). Laparoscopic cholecystectomy has proved to be relatively safe when performed by an experienced surgeon, provided that there

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is clear visualization of the biliary ducts to prevent injury during the operation (3, 4). A key adverse consequence of laparoscopic cholecystectomy is the failure to detect asymptomatic common bile duct (CBD) stones, which may present later as retained or recurrent gallstone disease. Among patients with gallbladder stones, the prevalence of concomitant CBD stones widely ranges from 1 to 15% (5). The identification of CBD stones and the prevention of bile duct damage necessitate meticulous examination and delineation of the biliary tract.

Laparoscopic ultrasonography (LUS) uses an ultrasound transducer that is inserted through laparoscopic ports to scan the bile ducts from the hepatic duct confluence to the ampulla, allowing a comprehensive view of the CBD. It provides real-time, high-resolution visualization of the CBD, enabling the detection of stones and the prevention or prompt identification of biliary duct damage during laparoscopic cholecystectomy (6). The procedure has gained wide popularity due to its minimally invasive nature, cost-effectiveness, and lack of risk of radiation. Previous studies have found LUS comparable to, if not superior to, intraoperative cholangiography (7-9). For CBD stones, studies reported that the sensitivity of LUS ranges from 80% to 96% and specificity ranges from 96% to 100%, which aligns with or exceeds the sensitivity and specificity of intraoperative cholangiography (75% to 87% and 98% to 99%, respectively) (7,10,11).

However, the routine adoption of LUS varies across medical settings, and current evidence on its feasibility and impact on intraoperative decision-making remains limited. This debate is particularly important in patients who are classified as low risk for CBD stones according to the criteria of the American Society for Gastroenterology (ASGE) (12) and the European Society of Gastrointestinal Endoscopy (ESGE) (13), as current ASGE/ESGE guidelines recommend cholecystectomy with optional intraoperative imaging. However, a small but clinically meaningful proportion of those patients can still have occult CBD stones that become detected either intra- or postoperatively (14, 15). Assessment of the efficacy of LUS in detecting CBD stones in this subset of patients may reduce unnecessary ductal exploration, avoid postoperative ERCP, and potentially lower the risk of missed stones without subjecting the entire cohort to ionizing radiation or more costly imaging techniques. Therefore, this study aimed to explore the use of LUS in detecting common bile duct (CBD) stones and evaluating biliary anatomy during laparoscopic cholecystectomy for patients with gallbladder stones.

MATERIAL AND METHODS

Ethical Considerations

The Ethics Committee at Cairo University's Faculty of Medicine approved the study (approval code: MD-191-2022; date: 4/8/2022). All participants provided written informed consent before undergoing the procedure. Confidentiality of patients' data was strictly maintained by keeping anonymous data collection sheets after assigning a unique identifier to each patient.

Study Design, Setting, and Location

This case series was conducted at Cairo University Hospitals between August 2022 and April 2024.

Eligibility Criteria

Patients of both sexes, aged 18 to 65, with symptomatic gallbladder stones and normal liver enzymes who were scheduled for elective laparoscopic cholecystectomy were included in this study. Exclusion criteria were the detection of a CBD stone on transabdominal ultrasound, serum bilirubin greater than 4 mg/dL, refusal to participate, presence of psychiatric disorders, or presence of disease contraindicating a laparoscopic procedure.

Data Collection

A comprehensive history was obtained from each patient, followed by a meticulous clinical examination and a series of laboratory investigations. These investigations encompassed a complete blood count, liver function tests (alanine aminotransferase, aspartate aminotransferase, total and direct bilirubin, albumin, alkaline phosphatase enzyme, and gamma glutamyl transpeptidase), renal function tests (blood urea and serum creatinine), serum electrolytes, and a coagulation profile.

The diagnosis of gallbladder stones was determined by a thorough review of the patient's medical history, which included a complaint of right hypochondrial pain. Additionally, pelvic-abdominal ultrasonography was performed, which revealed the presence of gallbladder stones.

Patients were risk-stratified for bile duct stones according to the ASGE criteria. Those with no predictors (normal liver enzymes, bilirubin ≤ 4 mg/dL, and no CBD stone or dilation on ultrasound) were classified as low risk and, per guideline recommendations,

proceeded directly to elective laparoscopic cholecystectomy without routine preoperative magnetic resonance cholangiopancreatography (MRCP).

Preoperative MRCP was done for all patients with intermediate risk, such as those with abnormal liver function tests (elevated aminotransferases, alkaline phosphatase enzyme, or total bilirubin up to 4 mg/dL), age older than 55 years, or dilated common bile duct (> 6 mm) on abdominal ultrasonography without a visualized stone. We included in our study only patients with no MRCP-evident CBD stones.

Surgical Procedure

Subsequent to the insertion of the ports for the laparoscopic cholecystectomy, forceps were utilized to grasp and elevate the gallbladder's fundus and the liver's right lobe to enable the visualization of the hepatoduodenal ligament. The epigastric route was chosen to facilitate the insertion of the LUS transducer. Subsequently, the transducer was delicately positioned over the hepatoduodenal ligament, thereby enabling the evaluation of the CBD (*fig. 1*).

The radiological examination was initiated at the point of intersection between the cystic duct and the common hepatic duct, where the CBD was first observed. Furthermore, the CBD was tracked all the way down to the duodenum. The portal vein is located posteriorly and has been likened to the iconic figure of "Mickey's head," while the hepatic artery and the CBD constitute the anteriorly positioned right and left "ears," respectively. Using this "Mickey Mouse" appearance or sign facilitated identification of the hepatoduodenal ligament anatomy and measurement of the CBD diameter (*fig. 2*).

The portal vein and hepatic artery (which exhibit flow) were readily distinguished from the CBD, which lacks internal flow, by employing the Doppler function (*fig. 3*).

While some small CBD stones can theoretically pass spontaneously, small CBD stones < 4 mm (*fig. 4 a*) were cleared and managed through a transcystic route (16, 17) that minimizes invasiveness during definitive cholecystectomy to avoid future complications like cholangitis, pancreatitis, or jaundice. Transcystic CBD exploration provides a single-stage laparoscopic option for managing choledocholithiasis without requiring a formal choledochotomy. The required instrumentation includes mechanical balloon dilatation catheters (4-8 mm) for cystic duct expansion, Fogarty-type biliary balloon catheters (4–6 Fr) for stone extraction, and laparoscopic clips or Hem-o-lok clips for secure cystic duct stump closure. The cystic duct is identified, skeletonized, and milked toward the gallbladder to clear small debris. A distal clip is placed at the gallbladder-cystic duct junction to prevent continued stone spillage. A partial transverse incision is made on the anterolateral aspect of the cystic duct using laparoscopic micro-scissors or a hook cautery, taking care not to completely transect the duct. If the cystic duct lumen is narrow or spastic, step-wise mechanical dilatation is performed using a dedicated balloon dilator pressurized with saline. A balloon catheter is inflated proximal to the

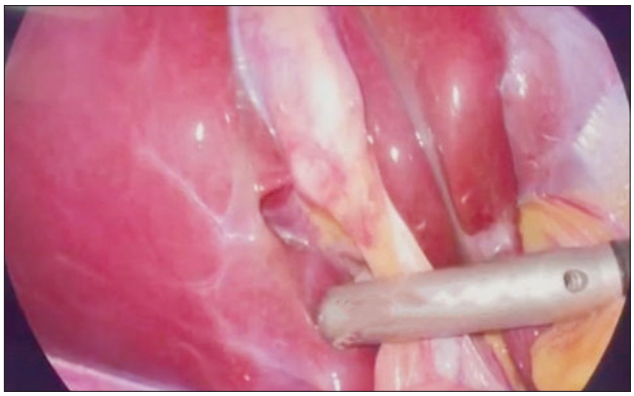

Figure 1 - Intraoperative laparoscopic ultrasonography of the common bile duct. The laparoscopic ultrasound probe is positioned over the hepatoduodenal ligament during laparoscopic cholecystectomy to obtain an ultrasound view of the common bile duct. The surrounding hepatobiliary structures are visualized in the operative field.

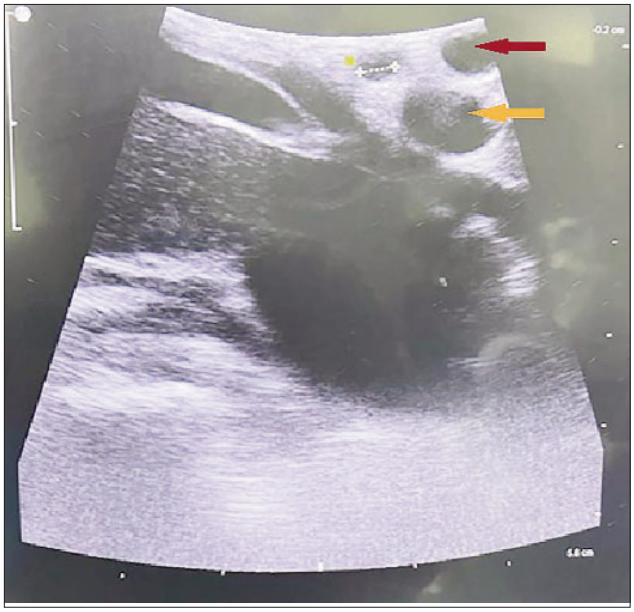

Figure 2 - Radiological evaluation of the common bile duct and measurement of its diameter. The portal vein (orange arrow) is located posteriorly and has been likened to the iconic figure of "Mickey's head," while the hepatic artery (red arrow) and the common bile duct (between the two + signs) constitute the anteriorly positioned right and left "ears," respectively.

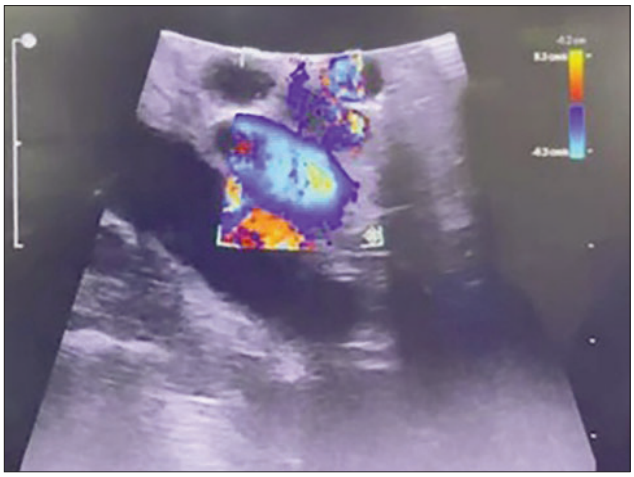

Figure 3 - Doppler function to distinguish the portal vein and hepatic artery from the common bile duct. The portal vein and hepatic artery (which exhibit flow, blue coloration) were readily distinguished from the common bile duct, which lacks internal flow.

stone and swept distally to push the stone through the sphincter of Oddi into the duodenum, often augmented by intravenous glucagon (1 mg) or smooth muscle relaxants to relax the ampullary sphincter (Balloon Flushing / Push Technique). Complete lithic clearance (removal or passage) of all identified CBD stones without retained fragments was confirmed by intraoperative LUS using a high-frequency flexible laparoscopic ultrasound probe applied directly along the porta hepatis and hepatoduodenal ligament, demonstrating an anechoic CBD lumen without hyperechoic foci or posterior acoustic shadowing.

Meanwhile, larger stones ≥4 mm (*fig. 4 b*) were cleared by postoperative endoscopic retrograde cholangiopancreatography (ERCP) in the same hospital admission as a standard alternative for laparoscopic CBD exploration.

Postoperative Complications

A meticulous observation of immediate postoperative complications was conducted, including anesthesia-related risks (such as cardiovascular complications) as well as procedure-related risks (such as pain, infection, bleeding, and leakage). The assessment of complications was conducted in accordance with the Clavien-Dindo classification system, a comprehensive framework utilized to categorize postoperative complications (18).

Study Outcomes

The primary outcomes were the incidence of LUS-detected CBD stones and the ability to visualize the CBD clearly during surgery. Secondary outcomes included the length of the procedure, the length of hospital stay, and the requirement for ERCP or magnetic resonance cholangiopancreatography (MRCP).

Regarding the detection of stones, CBD stones identified by intraoperative LUS were recorded. Following surgery, all patients were clinically monitored for evidence suggestive of retained CBD stones, including the development of jaundice and/or abnormal liver function tests. When such findings occurred, further diagnostic evaluation by ERCP was performed, and the presence of LUS-missed stones was confirmed.

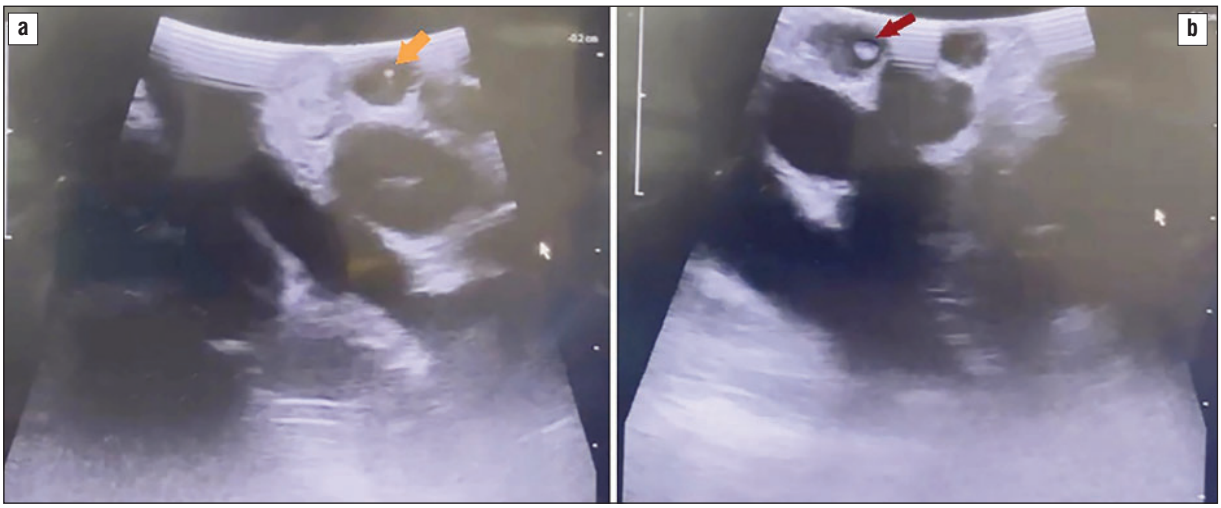

Figure 4 - (a) Small stone (orange arrow) < 4 mm in size detected in the common bile duct. (b) Large stone (red arrow) > 4 mm in size detected in the common bile duct.

Patients who did not develop clinical or biochemical evidence suggestive of retained CBD stones during postoperative follow-up were considered not to have clinically apparent retained CBD stones. According to the management protocol for such cases at our institution, ERCP was not performed systematically in all patients but was undertaken selectively when clinically indicated.

Statistical Analysis

The statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS v26, IBM, Inc., Chicago, IL, USA). Quantitative data were presented as the mean and standard deviation, median, and range, while qualitative data were presented as numbers and percentages. Statistical significance was adopted at p-value < 0.05.

RESULTS

As illustrated in *table 1*, the mean age of the included patients was 44.08 ± 13.32 years. Most patients were female (62.34%), had no history of abdominal surgeries (66.23%), and were free of comorbidities (79.22%).

Table 2 demonstrates that patients exhibited hemoglobin levels ranging from 10.1 to 13.4 g/dL. The values of total leukocyte count, platelet count, hepatic aminotransferases, bilirubin, serum albumin, alkaline phosphatase, gamma glutamyl transpeptidase, amylase, lipase, and C-reactive protein were within normal ranges. Preoperative ultrasonography revealed that the CBD diameter ranged from 2 to 9 mm, with a mean of 3.64 ± 1.22 mm. Furthermore, 5.19% of patients had intrahepatic biliary dilatation (IHBRD), and 7.79% had a history of pancreatitis before surgery. In this study, four patients (5.19%) with intermediate-risk predictors underwent preoperative MRCP, which was negative for CBD stones.

As shown in *table 3*, the operating time ranged from 122 to 151 minutes. Intraoperative LUS exhibited a clear view of the CBD in the majority of patients (93.51%), with detection of CBD stones in 12.99% of patients. The average stone size was 5.7 ± 1.9 mm. None of the patients developed intraoperative bleeding or injury to the CBD. No CBD injuries or hemorrhagic complications were observed. Postoperative jaundice occurred in two (2.6%) patients (Clavien–Dindo Grade IIIb), with no reported cases of leakage. Postoperative ERCP was performed in six (7.79%) patients: four patients in whom CBD stones were identified by LUS, and two other patients who had LUS-undetected CBD stones and experienced postoperative biliary obstruction. Thus, CBD stones were identified in 12 of the 77 patients (15.58%) based on intraoperative LUS findings and selective postoperative ERCP. No life-threatening complications (Grade IV) or postoperative mortalities (Grade V) were recorded.

Table 1 - Baseline characteristics, previous abdominal operations, and comorbidities (n=77)

Characteristic[a]	All patients (n=77)
Age (years), Mean ± SD	44.1 ± 13.32
Sex, n (%)	
Male	29 (37.66%)
Female	48 (62.34%)
Comorbidities, n (%)	
Free	61 (79.22%)
Hypertension	10 (12.99%)
Diabetes mellitus	7 (9.09%)
Asthma	16 (20.78%)
Previous abdominal surgeries, n (%)	
Yes	26 (33.77%)
No	51 (66.23%)

[a] n: number; SD: standard deviation.

Table 2 - Preoperative laboratory and ultrasonographic investigations (n = 77)

Characteristic[a]	All patients N = 77
Complete blood count	
Hb (g/dL), Mean ± SD (Range)	11.91 ± 0.96 (10.1 - 13.4)
TLC (x10^3/L), Mean ± SD (Range)	6.76 ± 1.70 (3.8 - 9.5)
PLT (X10^9/L), Mean ± SD (Range)	313.64 ± 73.77 (193 - 436)
Liver function tests	
ALT (U/L), Mean ± SD (Range)	24.55 ± 8.25 (9 - 36)
AST (U/L), Mean ± SD (Range)	19.21 ± 4.51 (11 - 27)
Total Bilirubin (mg/dL), Mean ± SD (Range)	0.41 ± 0.12 (0.16 - 0.61)
Direct Bilirubin (mg/dL), Mean ± SD (Range)	0.11 ± 0.04 (0.05 - 0.16)
Albumin (g/dL), Mean ± SD (Range)	4.37 ± 0.29 (3.9 - 4.9)
ALP (U/L), Mean ± SD (Range)	94.90 ± 25.78 (54 - 152)
GGT (U/L), Mean ± SD (Range)	24.43 ± 8.13 (9 - 53)
Enzymes and proteins	
Amylase (U/L), Mean ± SD (Range)	54.65 ± 7.94 (41 - 73)
Lipase (U/L), Mean ± SD (Range)	31.82 ± 10.29 (12 - 48)
CRP (mg/dL), Mean ± SD (Range)	1.82 ± 1.98 (0.3 - 17)
Preoperative sonographic investigations	
CBD diameter (mm), Mean ± SD (Range)	3.64 ± 1.22 (2 - 9)
IHBRD, n (%)	4 (5.19%)
Previous pancreatitis, n (%)	6 (7.79%)
Preoperative MRCP, n (%)	4 (5.19%)
Risk stratification (ASGE criteria), n (%)	
Low	73 (94.81%)
Intermediate	4 (5.19%)

[a] ASGE: American Society for Gastrointestinal Endoscopy; CBD: common bile duct; IHBRD: Intrahepatic biliary dilatation; MRCP: magnetic resonance cholangiopancreatography; n: Number; SD: Standard deviation

Table 3 - Operative time, intra-operative laparoscopic ultrasonography, and postoperative follow-up (n = 77)

Characteristica	All patients N = 77
Duration of the operation (min), Mean ± SD (Range)	132.22 ± 6.56 (122 - 151)
Laparoscopic Ultrasonography	
Clear view of CBD by LUS, n (%)	72 (93.51%)
CBD stones size (mm), Mean ± SD (Range)	5.7 ± 1.9 (3 - 8)
CBD stones, n (%)	10 (12.99%)
Bleeding, n (%)	0 (0%)
Injury to CBD, n (%)	0 (0%)
ERCP post-operatively, n (%)	6 (7.79%)
Hospital stay (days), Mean ± SD (Range)	1.26 ± 0.88 (1 - 5)
Postoperative complications	
Obstructive jaundice, n (%)	2 (2.60%)
Leakage, n (%)	0 (0%)

[a] CBD: Common bile duct; ERCP: Endoscopic retrograde cholangiopancreatography; n: Number; SD: Standard deviation

The mean duration of hospitalization was 1.26 ± 0.88 days.

DISCUSSION

The present study aimed to investigate the efficacy of LUS in detecting CBD stones and evaluating biliary anatomy during laparoscopic cholecystectomy in patients with gallbladder stones. The study population comprised patients with symptomatic gallstone disease who had normal preoperative biochemical findings and no identified CBD stones on preoperative investigations. According to the 2019 ASGE criteria, patients without additional predictors of CBD stones are considered low risk, whereas patients older than 55 years or those with a dilated CBD (>6 mm) are classified in the intermediate-risk category. Thus, the cohort included patients spanning the low- and intermediate-risk spectrum. The ASGE guidelines allow for cholecystectomy without additional ductal imaging in low-risk patients while recommending endoscopic ultrasonography, MRCP, IOC, or intraoperative LUS for intermediate-risk patients (12). This provided a clinically relevant population in which to evaluate whether intraoperative LUS could detect occult CBD stones despite reassuring preoperative biochemical and imaging findings.

In the current case series, baseline patient characteristics agreed with studies conducted in several countries, where adult females were more predominant than males (19,20).

The overall procedural time in our case series was 132.22 ± 6.56 minutes, including the laparoscopic cholecystectomy approach, intraoperative LUS, and the subsequent therapeutic steps. The time required specifically for LUS was not recorded separately in our cohort; therefore, the individual contribution of LUS to the total operative time cannot be quantified. The total procedure duration can be influenced by the learning curve associated with the adoption of LUS and the overall technique. Accordingly, the reported operative time should be interpreted in the context of the study setting and operator experience and cannot be generalized to other settings or regarded as the definitive time required for the technique. Previous systematic reviews found that the mean imaging time for LUS ranged between approximately 5 and 10 minutes (11,21). Future studies should assess the learning curve of LUS imaging time and subsequent therapeutic steps to allow a more precise assessment of its contribution to overall operative duration.

In the current study, intraoperative LUS detected CBD stones in 12.99% of patients, and a clear CBD visualization was achieved in 93.51% of cases, enabling reliable stone detection. The literature reports that intraoperative LUS can enable clear visualization of the CBD in approximately 85 to 98% of patients undergoing laparoscopic cholecystectomy (11,21). As regards the detection of CBD stones, a systematic review found that studies reported sensitivities for LUS ranging between 80 and 100%, with the reported specificities ranging between 96 and 100% (11). The detection rate in our case series should be cautiously interpreted as exploratory analyses, as gold standard tests were not consistently performed in all included patients, precluding a formal assessment of diagnostic accuracy. Despite the exploratory nature of the analysis, the present study contributes preliminary data on CBD stone detection in a low- to intermediate-risk population that has not been adequately characterized in previous research. As LUS remains inherently operator-dependent, achieving optimal CBD visualization demands specialized training and practiced expertise in ultrasound imaging. Future studies should assess the impact of surgeon expertise and learning curve on achieving CBD visualization rates and the diagnostic accuracy of LUS for detecting CBD stones.

In the present study, obstructive jaundice occurred in 2.59% of patients postoperatively, while no patient experienced leakage. The absence of intraoperative bleeding or CBD injury suggests intraoperative LUS safety. However, the incidence of bile duct injuries following laparoscopic cholecystectomy ranges from 0.3 to 0.5% (3,19), requiring a much larger sample size to assess whether the use of LUS reduces the incidence of these relatively uncommon adverse events.

Limitations

This single-center study with a relatively small sample size may yield findings less generalizable to other institutions. This is particularly important in interpreting the absence of rare complications, as the possibility of the occurrence of such rare events in larger cohorts cannot be ruled out. In addition, the study design, lacking a comparator and a consistent gold standard test in all cases, did not allow for formal assessment of the diagnostic performance of LUS in detecting occult CBD stones.

CONCLUSIONS

In adult patients who underwent laparoscopic cholecystectomy, LUS was a feasible and useful adjunctive method for detecting CBD stones and evaluating the biliary anatomy. However, future studies with larger sample sizes are required to confirm the safety of LUS and its potential incremental value in reducing the incidence of bile duct injury during laparoscopic cholecystectomy. Future trials should include a gold standard test for assessing the diagnostic accuracy of LUS in detecting CBD stones. In addition, the studies should assess the potential impact of operator and surgeon experience as well as the stage of the learning curve on the success of LUS in achieving clear visualization of CBD and detecting stones.

Conflicts of Interest: None.

Source of Funding: None.

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