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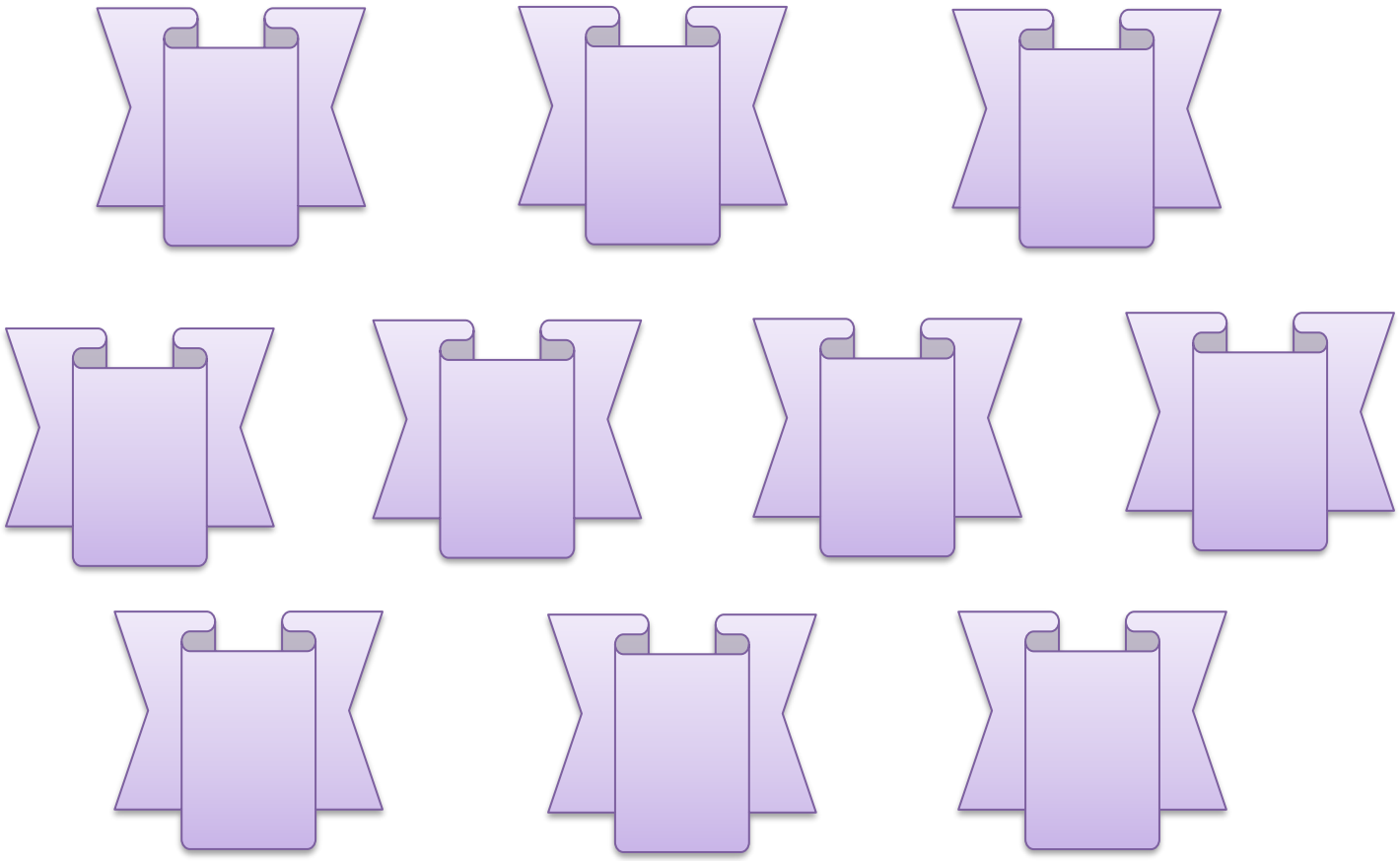

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Original Article

A Comparative Study between Operative Ultrasonography and Perioperative Cholangiography in Screening of The Common Bile Duct for Stones During Laparoscopic Cholecystectomy

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ABSTRACT

Background: The routine uses of intraoperative cholangiography [IOC] is still controversial. Some authors support routine IOC, while others favor selective IOC. The operative ultrasonography [OUS] probe provides a new modality for evaluating biliary anatomy and detection of Choledocholithiasis during laparoscopic cholecystectomy. It is considered a faster, safer, and non-invasive technique.

Aim of the Study: This study aims to compare the accuracy of operative ultrasonography [OUS] and IOC in the detection of common bile duct stones during laparoscopic cholecystectomy.

Patients and Methods: This prospective comparative study included 50 patients who underwent laparoscopic cholecystectomies with or without bile duct exploration, which was done at El-Hussein University Hospital in the period from March 2018 to December 2019. Operative laparoscopic ultrasonography was performed followed by an operative cholangiogram. Bile ducts were explored if CBD stones were seen and the patients were followed up by clinical evaluation, laboratory investigations, and abdominal ultrasound within one month from surgery.

Results: The IOUS timing which was the time after identification of the cystic duct and artery till the start of IOC, was significantly lower than the IOC Timing which was the time After IOUS till clipping of the proximal part of the cystic duct. The sensitivity and specificity of IOUS for detection of CBD stone was 100%, and 94.4% respectively in comparison to 100% sensitivity and specificity in the IOC.

Conclusion: During the exploration of the CBD stones, the IOUS is just as sensitive and specific as the IOC. It's less invasive than IOC and can be done quickly by any skilled surgeon, so during a laparoscopic cholecystectomy, IOUS can reliably replace IOC.

Keywords: Intraoperative cholangiography; Operative ultrasonography; Common bile duct.

INTRODUCTION

The value of intraoperative cholangiography [IOC] and operative ultrasonography [OUS] for evaluating the common bile duct [CBD] during cholecystectomy is debated. Symptomatic cholecystolithiasis is common, and choledocholithiasis can develop in up to 15% of individuals [1].

Determining whether or not there is a stone in the common bile duct is crucial because of the severe clinical consequences that remaining stones can have. Between 5 and 10 percent of those who present with gallbladder illness have a CBD stone. It rises in cases of acute cholecystitis and falls in those of asymptomatic cholecystolithiasis [2]. When it comes to achieving those two goals, the IOC has been held up as "the gold standard" ever since laparoscopic cystectomy [LC] became popular in the late 1980s. Intraoperative imaging of the common bile duct continues to be debated between those in support of a systematic strategy and those who urge for a more selective one [3].

The IOC approach has a failure rate of 3-17%, is time-consuming, and exposes the patient, operator, and staff to radiation. Increasingly, various commentators recommend the OUS as a viable replacement for the IOC. The use of intraoperative ultrasonography in open surgery has been common for quite some time. OUS in LC is being proposed and developed by some centers as a means to complement IOC to replace it as the primary imaging technique for cholecystectomy [4].

The current study aims to compare the accuracy of OUS and IOC in the detection of CBD stones during laparoscopic cholecystectomy.

PATIENTS AND METHODS

This prospective comparative study included 50 patients undergoing laparoscopic cholecystectomies with or without bile duct exploration, which was done in El-Hussein University Hospital in the period from March 2018 to December 2019. Our study followed the declaration principles of Helsinki, and ethical approval was obtained from Al-Azhar University. All patients signed informed consent at the time of recruitment. We included the patients based on the following criteria:

The inclusion criteria were: 1] All patients of both sexes planned for laparoscopic cholecystectomy [Repeated attacks of biliary colic with small tiny stones], 2] All patients planned preoperatively for exploration of CBD, 3] Patients identified with dilated CBD by abdominal ultrasound, 4] History of obstructive jaundice, 5] Patient with raised direct and/or indirect bilirubin, 6] Patient with isolated high alkaline phosphatase, and 7] Patients with raised gamma-glutamyl transferase [GGT].

The exclusion criteria were: 1] Patients unfit for surgery for medical problems, 2] Jaundiced patients at the time of surgery where MRCP was done and confirmed CBD stones, and 3] Patients with advanced liver cirrhosis [children B and C].

Data collection

All patients underwent, History taking [history of obstructive jaundice which was relieved spontaneously or by ERCP stone extraction, sphincterotomy, or stenting] and physical examination. Routine preoperative laboratory investigations [liver function tests, renal function tests, complete blood picture, prothrombin time and concentration, and fasting blood glucose] and abdominal ultrasonography were done for all patients. Also, a preoperative anesthetic assessment for any contraindication of laparoscopic surgery was conducted.

Operative laparoscopic ultrasonography was performed followed by an operative cholangiogram. Bile ducts were explored if CBD stones were seen and the patients were followed up by clinical evaluation, laboratory investigations, and abdominal ultrasound within one month from surgery. We evaluated the procedure time, visualization of the biliary tree, detection of any CBD stone, detection of biliary or vascular anomalies, failure of IOC, and evaluation of the intra or postoperative complications in the form of obstructive jaundice [missed CBD stone] or iatrogenic biliary injury [bile leakage].

Surgical technique

The patient lay in the supine position, and under general anesthesia, the following steps were done; Routine 4 port Reddick laparoscopic cholecystectomy was performed using the open method for induction of pneumo-peritoneum [Figure 1].

Scanning Technique of IOUS: The common bile duct can be examined for leaks using Ultrasound [US]. To observe where the

Laparoscopic Ultrasound [LUS] probe is being placed, a 10 mm laparoscope is inserted through a 10 mm opening in the epigastrium or umbilicus. The LUS probe is meticulously introduced via either the umbilical 10-mm port or a 10-mm epigastric port. Once properly positioned, the transducer is directed towards segment five of the liver, allowing for the initial identification of the gallbladder [GB]. This concise overview aims to elucidate the presence of gallstones exhibiting shadowing characteristics [Figure 2], as well as the identification of sludge, cholesterols, polyps, or thickening resulting from acute inflammation.

The assessment of the proximal biliary tree involved a sequential examination. Initially, a transhepatic approach was employed to visualize the confluence of the ducts by positioning the probe over segment four of the liver. Subsequently, a longitudinal view of the common hepatic duct, typically situated just inferior to the liver, was obtained. Finally, a cross-sectional section of the right hepatic artery, predominantly located between the common hepatic duct and portal vein, was acquired. The subsequent anatomical entity under consideration is the portal vein. The caudate lobe of the liver, constituting the fourth anatomical structure, and the vena cava, representing the fifth anatomical structure, are noteworthy entities within the human body [Figure 3].

After the transhepatic assessment is complete, the hepatoduodenal ligament can be evaluated longitudinally by inserting the probe between the liver and the front surface of the hepatoduodenal window. By manipulating the image's depth, nearby details can be blown up for a better look. The next step is to position the probe over the hepatic duct. If the common bile duct is hidden, the liver can be rotated clockwise and counterclockwise to expose the hepatoduodenal ligament and the cystic duct junction, allowing the bile duct to be located. Following the duct distally and proximally verifies its typical anatomical route and the lack of stone acoustic shadow, providing further confirmation of the duct's existence. A hyperechoic surface mimicking the shape of the stone is normal, and shadowing occurs afterward.

Doppler or color Doppler imaging can help verify that the common bile duct is non-vascular. The portal structures above the pancreas level are then shown in transverse. Lateral to the hepatic artery is where you'll find the common hepatic duct, and behind the liver you'll find the larger portal vein. The common bile duct and hepatic artery make up the mouse's ears, and the portal vein serves as the mouth in this "Mickey Mouse" perspective [Figure 4].

Subsequently, we advance in a distal direction towards the intrapancreatic common bile duct. In the transduodenal perspective, the distal end of the probe undergoes lateral deflection followed by a descent about the duodenum. The duct is meticulously traced from its proximal to distal extent, allowing for a comprehensive evaluation of its cross-sectional appearance. The proximal region of the pancreas exhibits a heightened echogenicity, ranging from hyperechoic to isoechoic while progressing distally with the probe, the pancreatic parenchyma typically assumes a relatively reduced echo-genicity. Near the ampulla, one may observe the pancreatic duct, as it approaches the common bile duct at an approximate angle of 90°.

IOC Technique

A distal clip is meticulously fixed to the duct near the gall bladder neck, effectively ensuring the stabilization of the infundibulo-cystic junction. A precise surgical procedure involves creating a minor cut in the cystic duct near the clip. This is accomplished using laparoscopic micro-scissors. Subsequently, the cystic duct is gently manipulated using the blades of Maryland forceps, to guarantee the removal of any stones and ensure unobstructed passage through the duct. The cystic duct undergoes dilation through the utilization of the Maryland tip. Subsequently, the cystic duct is cannulated employing a front-tipped, saline-flushed, size 5 ureteric catheter that is introduced via a cholangioclamp [Figure 5]. The latter procedure is initiated by introducing a 10 mm port in the epigastric region. The surgical blades are then carefully positioned around the cannulated cystic duct to ensure a secure fit, thereby minimizing the risk of any potential leakage. Preceding the administration of the injection, it is imperative to reposition the patient into a neutral stance, followed by a slight inclination [ranging between 15 to 20 degrees] towards the right side. This maneuver is performed to effectively eliminate the vertebral column from the x-ray field. A total volume of 10 milliliters of urogram was suitably diluted with an equal volume of normal saline solution, resulting in a final mixture. This mixture was then carefully loaded into a 20-milliliter syringe,

which was subsequently connected to the unoccupied terminal of the catheter. Under the meticulous supervision of fluoroscopic guidance, the aforementioned mixture was skillfully injected.

The patient undergoes screening with a C-arm apparatus during the injection. The evaluation of cholangiography is deemed comprehensive and devoid of any abnormalities if the following criteria are met: a] Adequate opacification of the non-dilated extra and intrahepatic biliary radicles, extending up to the second-order divisions. b. The biliary tree does not exhibit any filling defects. c. Unimpeded passage of the contrast agent into the duodenum [Figure 6].

Figure [1]: Routine 4 port

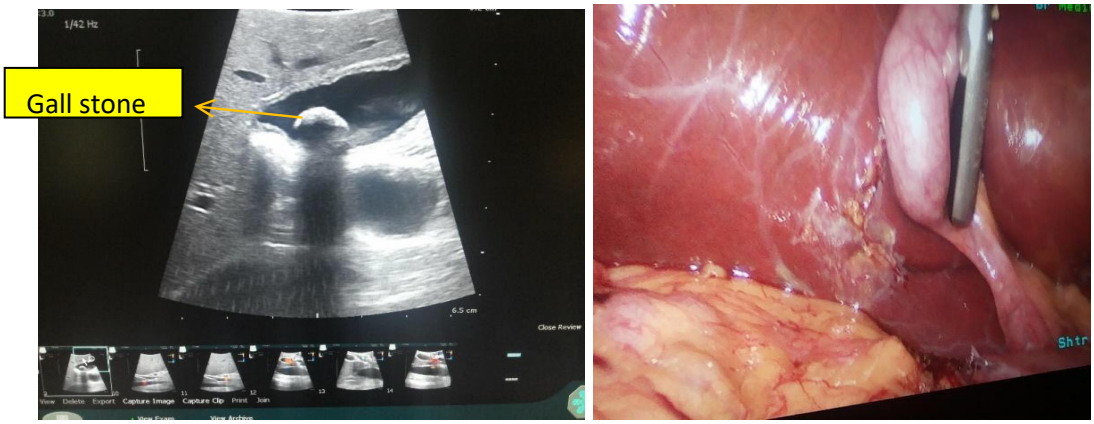

Figure [2]: Gall stone

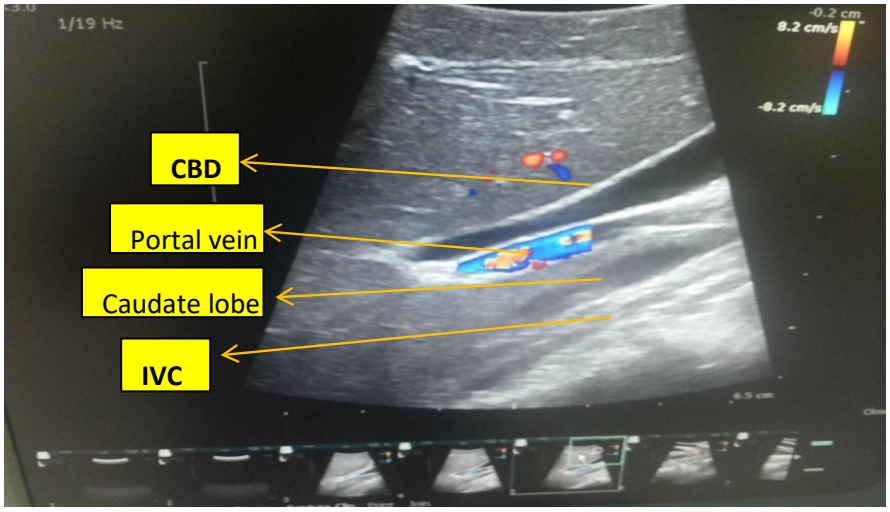

Figure [3]: Transhepatic view

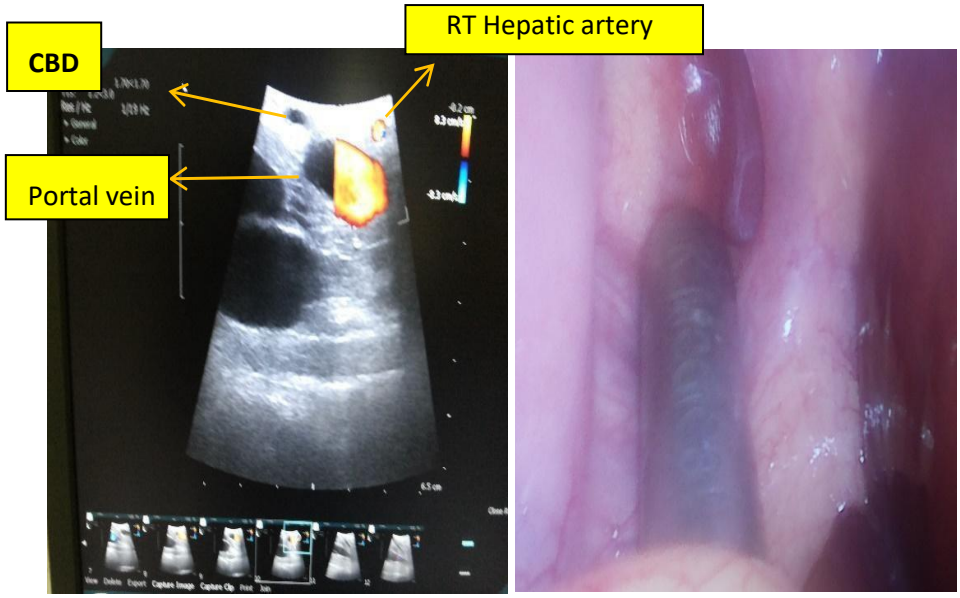

Figure [4]: "Mickey Mouse" view.

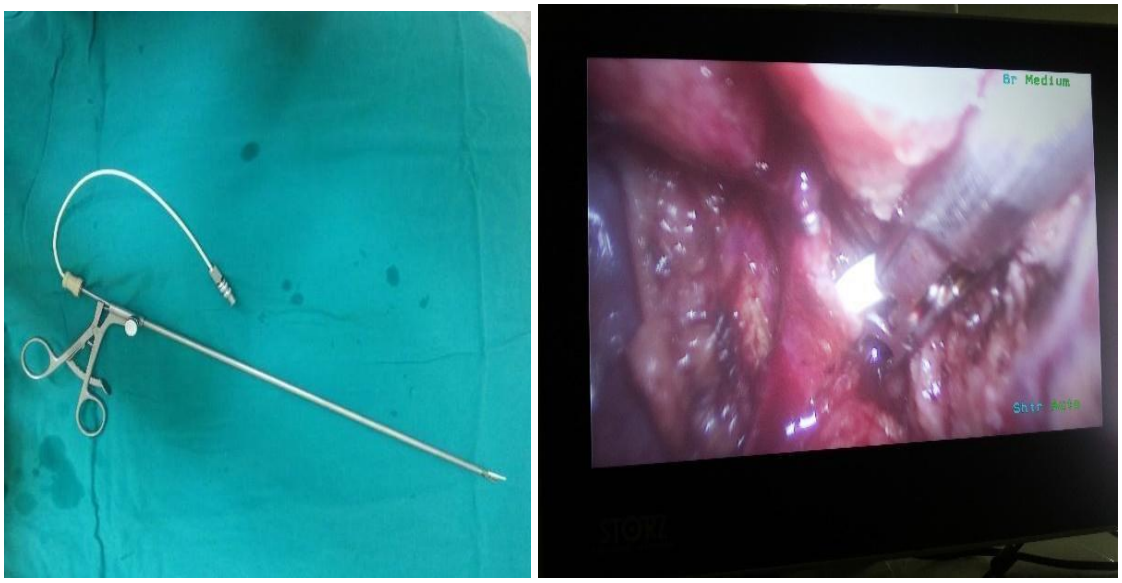

Figure [5]: Canulated cystic duct with the Cholangioclamp.

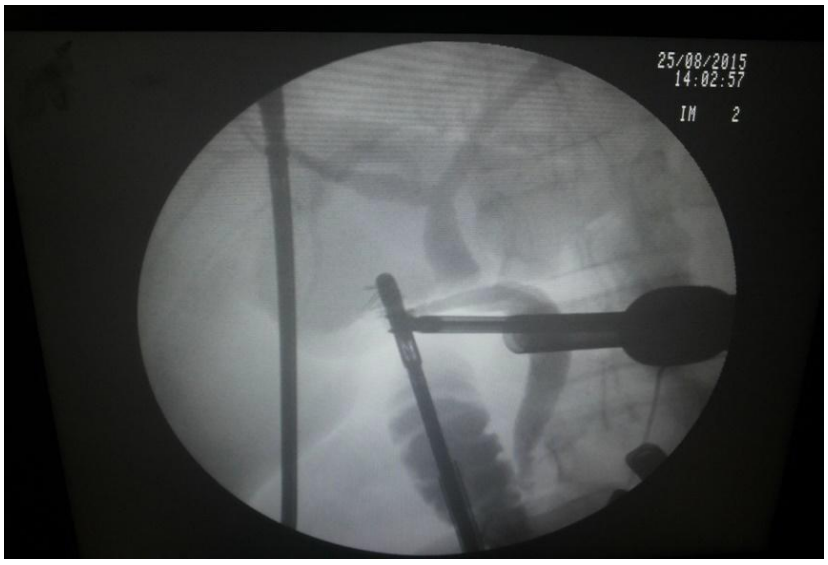

Figure [6]: IOC with No filling defects in the biliary tree with Free flow of the dye to the duodenum

Intraoperative treatment of choledocholithiasis

The intraoperative management of choledocholithiasis [CDL] is dependent upon several factors, including the quantity, dimensions, and location of the stones, the caliber of the common bile duct [CBD], and the proficiency of the surgeon. In the present investigation, a singular case was identified with an 8 mm CBD stone utilizing intraoperative ultrasound [IOUS] and intraoperative cholangiography [IOC]. Subsequently, the stone was successfully removed laparoscopically employing a Fogarty catheter via choledochotomy. Following the procedure, a thorough assessment was conducted using IOUS and IOC through the insertion of a T-tube. A subsequent case was determined to have cholelithiasis of the common bile duct [CBD] through the utilization of intraoperative ultrasonography [IOUS], rather than intraoperative cholangiography [IOC]. Subsequently, a postoperative magnetic resonance cholangiopancreatography [MRCP] was performed, yielding negative results for the presence of CBD stones. Elective surgery was conducted under the diligent oversight of consultant surgeons, with the invaluable support of a radiologist possessing a wealth of expertise in the realm of intraoperative ultrasound. Prospective data collection encompassed various parameters, namely the duration of the procedure, outcomes derived from intraoperative ultrasound [IOUS] and intraoperative cholangiography [IOC], as well as any operative and postoperative complications encountered.

Statistical methods: The data acquired from this study were subjected to statistical analysis utilizing SPSS software. The differences in rates were analyzed using the chi-square test, while means and standard deviations were analyzed using Student's t-test. The $p<0.05$ was considered significant.

RESULTS

This study included 50 patients admitted to El-Hussein University Hospital in the period from March 2018 to June 2019, where laparoscopic cholecystectomy with IOUS and IOC was done in 100% of the patients [50 patients]. Patients were 40 females [80%] and 10 males [20%] with a mean age of 43.84 ± 12.18 years old [range 21-55 years old] and mean body mass index [BMI] of 33 ± 3.648 kg/m2 [range 25-40 kg/m2] [table 1]. All patients have a history of jaundice [100%] which was relieved spontaneously in 45 cases [90%] and by ERCP in 5 cases [10%], 43 cases [86%] diagnosed as having chronic calcular cholecystitis and 7 cases [14%] diagnosed as having acute calcular cholecystitis, Preoperative ultrasound shows CBD diameter more than 8 mm in 35 cases [70%] [Table 2].

As regards the operative time, the IOUS timing which was the time after identification of the cystic duct and artery till the start of IOC, was significantly lower than the IOC Timing which was the time After IOUS till clipping of the proximal part of the cystic duct. The mean CBD was 5.280 ± 0.6957 mm in IOUS and 7.010 ± 0.7162 mm in IOC. In terms of the visualization of the Biliary tree, in IOUS, the proximal 2/3 of CBD was visualized in 50 cases [100%], Distal 1/3 of CBD was visualized in 40 cases [80%], and 50 cases after transcystic injection of saline [100%]. In IOC, the proximal 2/3 of CBD was visualized in 30 cases [60%], and the distal 1/3 of CBD was visualized in 30 cases [60%]. The IOUS detected one vascular anomaly, however, the IOC didn't detect anyone. The sensitivity and specificity of IOUS for detection of CBD stone was 100%, and 94.4% respectively in comparison to 100% sensitivity and specificity in the IOC. As regards the intraoperative complications, no intraoperative complications in the IOUS, however in IOC, a bile leak from the cystic duct was detected during cannulation in 50 cases [Table 3]. There were no post-operative complications in the form of obstructive jaundice [missed CBD stone] or iatrogenic biliary injury [bile leakage].

Table [1]: Patient demographics

Variable	Findings	
Age [years]	Mean ± SD	43.84 ± 12.189
Sex [No., %]	Females Males	40 [80%] 10 [20%]
Body mass index [Kg/m^2]	Mean ± SD	33 ± 3.648

Table [2]: Patient history

		NO.	%
History of jaundice		50	100%
Released: [spontaneous]		45	90%
ERCP		5	10%
Diagnosis	Chronic Acute	43 7	86% 14%
Preoperative ultrasound: CBD diameter > 8 mm		35	70%

Table [3]: Intra-operative assessment

		IOS	IOC	P value
Operating time [min.]	Mean ± SD Range	8.733 ± 1.252 [3-25]	13.60 ± 1.326 [5-30]	**0.008**
CBD diameter [mm]	Mean ± SD Range	5.280 ± 0.6957 [2.8–18]	7.010 ± 0.7162 [3.5–22]	0.0785
Visualization of CBD	Proximal 2/3 Distal 1/3	100% 80%/100%	100% 100%	NS
Detection of CBD stone				
True negative		46	48	NS
True positive		2	2	
False-negative		0	0	
False positive		2	0	
Sensitivity		100%	100%	
Specificity.		94.4%	100%	
Detection of anomalies		1	No	NS
complications		No	1	NS

DISCUSSION

Three percent to ten percent of patients undergoing cholecystectomy are diagnosed with choledocholithiasis. Cholecystectomy alone is not sufficient treatment for these patients; the biliary ductal system must be cleared as well. Since the beginning of biliary tract surgery, this has been a technical difficulty for the surgeon [5].

Several studies have compared LUS and IOC in terms of their ability to detect CBD stones. Although each patient in these trials underwent both LUS and IOC, and the results were compared, there are significant methodological concerns to consider when assessing their conclusions. The most crucial issue is the lack of a single, definitive test that can be used to validate the presence or absence of stones across all diagnostic methods. The authors assumed that absent the eventual clinical manifestation of a missed stone, a negative result on both LUS and IOC indicates a real lack of CBD stones. As missing stones might pass without causing symptoms, this assumption may underestimate the number of false-negative examinations. Most research has looked at whether a positive exam [on LUS or IOC] may be confirmed and the duct cleared through surgical CBD exploration or endoscopy. However, it is possible that the frequency of false positives would be overestimated with this procedure since CBD stones found intraoperatively might have gone by the time of the CBD exploration or ERCP. Furthermore, in the majority of trials, the surgeon observed both tests without blinding, potentially influencing the performance and interpretation of the second test [often IOC] in the case of a favorable initial result. Keep these caveats in mind when you assess the following information. Studies have shown that LUS has a sensitivity of 80-96% for detecting CBD stones, whereas IOC has a sensitivity of 75%-100% [6].

However, when the authors divided their series into three time periods, they discovered that the sensitivity for LUS decreased from 77% in the first cohort of 140 patients to 100% in the second cohort of 78 patients and 96% in the third cohort of 142 patients. The enhancement was mostly attributable to the enhanced detection of intrapancreatic CBD stones. The authors frequently cannulated the cystic duct and administered saline to enlarge the CBD in the second patient cohort. In the third group of patients, this procedure was conducted selectively, only when the initial examination failed to reveal an adequate view of the distal CBD. The sensitivity of LUS, as determined by Birth and coworkers, was 83%, while that of IOC was 100%. All four stones that were missed by LUS were located in the distal CBD, just as in the

prior study. After injecting 400 ml of saline into the stomach and duodenum using a nasogastric tube, LUS was able to detect three of these missing stones [7].

Since they were first missed by LUS and only found after an IOC, the authors considered them to be false negatives. The findings of these two investigations demonstrate that LUS sensitivity can be raised to a level equal to or greater than IOC by a combination of enhanced operator experience and adjunct maneuvers to improve distal CBD imaging. Surgeons should be aware, though, that imaging the distal CBD with LUS can be tricky. An IOC should be done to confirm the absence of stones if an intra-pancreatic part of the duct cannot be viewed clearly. LUS has an almost 0% false positive rate compared to IOC, even though both modalities are very selective in the identification of CBD stones. False-positive results are quite uncommon during IOC, and they are mostly caused by mistaking air bubbles in the CBD for stones. Because of this, when an IOC result for a CBD stone is positive, some writers recommend performing a confirmatory [8].

With the introduction of LC came the need to educate surgeons on laparoscopic theory and technique. Laparoscopic treatment of CBDS was not possible or desirable in the first phases of LC because surgeons lacked the essential expertise. As a result, preoperative ERCP was routinely performed on patients with even a remote possibility of CBDS, leading to an excessive number of needless procedures. Morbidity and death following diagnostic and therapeutic ERCP are not insignificant, and long-term consequences are possible as well. Open duct exploration during laparotomy for the treatment of CBD stones is also associated with a high risk of complications, insufficient stone clearance, and significant postoperative morbidity.

As laparoscopic surgical proficiency increased, attention shifted to the central nervous system. The bile ducts may need to be extensively manipulated, and laparoscopic suturing of the CBD may be necessary during LCBDE. Due to its many benefits over open and endoscopic surgery for CBD stones, LCBDE has quickly replaced them as the treatment of choice in the last decade or so. In addition to being a safe and affordable option, it offers a one-time treatment for both gallstones and CBD stones, with minimal patient discomfort and all the benefits of minimally invasive surgery.

Incisional cholecystectomy [IOC] is less common due to the normal preoperative workup for individuals presenting with gallstones. Most individuals only need to have a clinical exam and history taken, as well as liver function tests and abdominal ultrasounds performed. Indicators of choledocholithiasis include aberrant results from the aforementioned tests. Unfortunately, neither of these approaches is precise enough to the CBD stone to be relied upon for accurate prediction. Preoperative CBD stone diagnosis may also be accomplished by the use of MRCP and ERCP.

Dissection targets, including the common bile duct, cystic duct, and hilar vascular systems, must be mapped during laparoscopic cholecyst-ectomy to ensure a successful outcome. Careful dissection prevents harm, although it might be challenging to accomplish when there is fibrosis, severe inflammation, an abnormal biliary architecture, or a small cystic duct.

Analysis of hilar architecture during chole-cystectomy is being debated for its potential to reduce surgical site infections and other problems. Due to the risks associated with the proposed "gold standard" technique [IOC], such as irradiation of the patient and the surgical team, dissection of the Calot's triangle to identify the cystic duct, and cannulation of the cystic duct, which may cause avulsion or perforation, many surgeons choose not to perform analyses. IOC is also thought to be time-consuming and costly.

Understanding the diseases of the biliary tract is facilitated by cholangiography [9]. However, a randomized controlled experiment is needed to settle the debate about its preventative impact against BDI. Furthermore, there is always the possibility of ductal damage occurring during cannulation in cholangiography because of the nature of the investigation. Patients in whom the cystic duct has fused with the auxiliary bile duct provide an additional challenge in that they will always be at risk for developing BDI. In contrast to cholangiography, IOUS is a less intrusive treatment. The biliary tree is not damaged, and the procedure can be done many times [10]. Furthermore, it does not necessitate the addition of radiologists, laboratory technicians, or state-of-the-art X-ray equipment. The diagnostic performance of IOUS for bile duct stones is comparable to, if not better than, that of cholangiography, according to numerous investigations, including two randomized control trials [11].

At least 10 cases are recommended for learning the process. There have been various reports on IOUS's effectiveness, but no systematic evaluation of its clinical results or the costs incurred during its inevitable "learning curve" [12].

Frequencies of a number with IOUS, we may get detailed pictures of the ampulla of Vater, biliary tree, pancreas, and liver. Since the transducer is flexible, it can make good acoustic contact with a wide variety of surfaces. It has been proven that intraoperative ultrasound in traditional surgery is just as effective as cholangiography in the detection of CDL [12]. According to the results of our research, IOUS is very similar to IOC in this regard. Together, the two methods achieved a perfect rate of success during intraoperative stone removal. Expertise in both traditional and laparoscopic intra-operative ultra-sonography is recommended for the training of IOUS technicians. There is unquestionably a phenomenon of a learning curve. This explains the initial false-positive cases we encountered. During practice, one learns to mentally rebuild ultrasound images. Throughout our work, we found that the amount of time needed to perform a thorough evaluation of the biliary tree decreased over time. In less than 5 minutes, a skilled surgeon can do a full biliary IOUS. This quick turnaround time is evidence of the approachability of this innovative method. Intracystic injection of saline allows for clear imaging of the distal CBD, even in morbidly obese patients. We were successful in 80% of cases before administering the saline injection and 100% of cases afterward.

Results showed that both IOUS and IOC were successful every time, with IOUS taking 8.7 minutes and IOC 13.6 minutes. Contrary to ours, **Chreiman *et al.*** [12] found that the success rate was 95% in IOUS and 92% in IOC while the timing was 9 min in IOUS and 16 min in IOC. The success rate was >99% in IOUS and 92% in IOC, with a time to completion of 7 minutes for IOUS and 16 minutes for IOC, according to research by **Dyab *et al.*** [13]. According to a 2002 study by **Catheline *et al.*** [14], The IOUS group had a perfect 100% success rate, whereas the IOC group only had an 85% success rate in a time frame of 18 minutes.

The CBD's mean caliber at IOC was higher than what was reported at IOUS. In contrast to ultrasonography, which produces more accurate and, hence, lifelike images, X-ray films have a natural magnification factor. The average CBD diameter in IOUS is 5.2 mm while in IOC it is 7.0 mm, according to this study. We found that the average CBD diameter was 7 mm in IOC, but **Catheline *et al.*** [14] found it to be 5.5 mm in IOUS. The total price tag for an IOUS evaluation of the biliary tree needs to be determined. However, it should be emphasized that the same multi-function equipment can also be utilized for percutaneous ultrasound examinations and Doppler investigations, as well as staging of gastro-intestinal cancers.

LUS, which has been used for more than 30 years, is a non-invasive and radiation-free method for studying the biliary tract. LUS is simply conducted before the dissection to advise the surgeon and can be crucial to the success of the procedure in challenging situations where anatomical structures are concealed, such as during inflammation or fibrosis. With the extra benefit of reusing on demand during the operation, this saves both time and money. Although LUS may appear less accurate than IOC when studying the intra-pancreatic portion of the bile duct, it provides an excellent investigation of the CBD still. Few writers provide in-depth anatomical descriptions of abnormal biliary anatomy, such as a cystic duct arising from the right posterior sector. There needs to be more findings for a segment-by-segment anatomical examination.

However, it appears that LUS can offer a perfectly mapped biliary duct in the hands of an expert. LUS has the potential to elucidate the anatomy and even avoid conversion when studying the cystic-common bile duct junction, a small cystic duct, or Mirizzi's syndrome.

No BDIs were described in the analyzed series, even when patients with acute or chronic inflammatory disease were included, suggesting that the ability to distinguish anatomy may have a protective role; nevertheless, no definitive evidence regarding the prevention of BDIs was observed.

LUS is as good as, if not better than, IOC in detecting CBDS and sludge, and it offers fewer false positive tests. In addition, LUS helps examine neighboring organs thoroughly, which paves the way for incidental pathology diagnoses.

Last but not least, LUS is not a monopoly. In many contexts, IOC is useful. Therefore, every

surgeon should be familiar with both methods, as they are complementary in identifying stones in the common bile duct.

Many methods have been described to improve understanding of anatomy during laparoscopic cholecystectomy. LUS, on the other hand, seems to be the best option because it offers the most benefits and can be employed in a wider variety of contexts and operations. Furthermore, LUS is likely the most cost-effective, an important feature in this age of budgetary restraints. Surgeons' hesitance, likely due to a perceived lengthy learning curve, appears to be the primary barrier to the adoption of LUS as a common imaging tool of the CBD during LC.

However, as ultrasound and laparoscopy become more commonplace in modern surgery, most surgical trainees and junior surgeons will have more opportunities to learn these methods. In this way, we foresee that aversion to LUS will become unnecessary. Surgeons should also think about how using LUS during LC can help them get more comfortable with a method that can be applied to other procedures.

Conclusion: During the exploration of the CBD stones, the IOUS is just as sensitive and specific as the IOC. It's less invasive than IOC and can be done quickly by any skilled surgeon, so during a laparoscopic cholecystectomy, IOUS can reliably replace IOC. However, for someone unfamiliar with intraoperative ultrasound, a reasonable amount of time is needed. The distal CBD is not easily visible but can be seen after an intracystic injection of saline. Doppler is useful for spotting vascular irregularities.

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