An auspicious experience with laparoscopic common bile duct exploration

ElGhamry E. ElGhamry[a], Mohamed ElSheikh[a], Hamdy Abdelhady[a], Mohamed A. Hablus[a], Amir F. Abdelhamid[a], Hosam Soliman[b], Ahmad Nassar[c]

[a]Gastrointestinal and Laparoscopic Surgery Unit, General Surgery Department, Faculty of Medicine, Tanta University, Tanta, [b]Surgery Department, National Liver Institute, Menoufia University, Menoufia, Egypt, [c]Surgery department, University Hospital Monkland, Lanarkshire, Scotland, UK

Correspondence to ElGhamry E ElGhamry, MSC, Gastrointestinal and Laparoscopic Surgery Unit, General Surgery Department, Faculty of Medicine, Tanta University, Tanta, 31527, Egypt. Tel: +20403574222; fax: +20403574222; e-mail: elghamry2@yahoo.com

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Background and aim
Common bile duct (CBD) stones are the second most common complication of gallbladder stones. The best management of patients with it remains controversial. The aim of this study was to evaluate the methods, operative time, failure rate, complications, and hospital stay of laparoscopic common bile duct exploration (LCBDE).

Patients and methods
This prospective study was conducted on 30 patients with CBD stones through 2 years. CBD stricture was excluded. We used transcystic or transcholedochotomy approaches for LCBDE either with or without choledoschopic guidance. Primary repair of the choledochotomy incision was done.

Results
The mean age was 48.90±11.84 years. Biliary colic was the presentation in 63.3% of patients, 20% presented with jaundice while 16.7% presented with both jaundice and right hypochondrial pain. The transcystic approach for CBD exploration was used in 16 cases without conversion; 11 cases completed without a choledochoscope, while five cases with choledochoscopic-guided extraction. Choledochotomy approach had been used in 13 cases, six cases completed with a choledochoscope and seven cases without it, two of them failed. One case failed from the beginning and went for open exploration. Five previously inserted stents through endoscopic retrograde cholangiopancreatography were removed. The mean operative time was 162.33±74.67 min. Transcholedochotomy approach takes longer time than transcystic. Bile leakage occurred in two cases following the choledochotomy approach. The mean hospital stay was 3.37±1.38 days. The hospital stay increased with long operative time and postoperative complications, especially bile leakage.

Conclusion
LCBDE is an auspicious approach to CBD stones. It is a feasible, effective, and safe procedure, depending on proper training and gaining experience. The availability of adequate equipment is mandatory and can avoid the drawbacks of endoscopic retrograde cholangiopancreatography and open CBD exploration.

Keywords:
choledochotomy, common bile duct stone, laparoscopic common bile duct exploration

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Introduction

The incidence of gallbladder stones in adults ranges from 6 to 10% [1]. Choledocholithiasis occurs in about 10–15% of patients with gallbladder stones and can lead to a lot of complications, such as obstructive jaundice, biliary colic, cholangitis, and pancreatitis [2]. After worldwide acceptance of laparoscopic cholecystectomy as the gold standard for the management of gallbladder stone disease, extension of the benefits of the laparoscopic approach to the treatment of common bile duct (CBD) stones becomes the logical next step [3]. The best management of patients with CBD stones has always been challenging, and it remains controversial [4]. Progress in endoscopic technology and equipment and improvement in laparoscopic expertise established the principal minimally invasive techniques [5]. However, managing CBD stones remains controversial, with the debate between a single-stage procedure in the form of laparoscopic common bile duct exploration (LCBDE) with cholecystectomy and two-stage procedure using endoscopic retrograde cholangiopancreatography (ERCP) either before or after cholecystectomy [6]. The utilization of LCBDE is gradually increasing and is being accepted for CBD clearance; it is associated with reduced hospital stay compared with

preoperative ERCP followed by laparoscopic cholecystectomy [7–9]. However, as LCBDE needs more advanced laparoscopic skills and manipulation of the flexible choledochoscope, the preferred procedure in many hospitals remains to do ERCP either before or after laparoscopic cholecystectomy [10].

Patients and methods

This prospective study was conducted after ethical committee approval on 30 patients admitted with CBD stones to the Gastro intestinal and Laparoscopic Surgery Unit, Department of General Surgery, Tanta University Hospitals and National Liver Institute Menoufia University with accepted written consents during the period from December 2016 to December 2018. All patients with CBD stones were included in this study while cases with CBD strictures diagnosed by magnetic resonance cholangiopancreatography (MRCP) were excluded. Preoperatively, full laboratory investigations were done including serum levels of bilirubin, serum glutamic pyruvic transaminase (SGPT), serum glutamic oxaloacetic transaminase (SGOT), amylase, and lipase levels. Abdominopelvic ultrasonography (US) and MRCP were performed with comment on gallbladder wall thickness, number of stones, CBD diameter, and number of stones and intrahepatic biliary radicle dilatation (Fig. 1). A history of previous ERCP and stenting (Fig. 2) was carefully recorded.

In addition to the basic set used for laparoscopic cholecystectomy, we prepared a fluoroscopic unit and a mobile C-arm unit with an image intensifier, Olsen cholangiography fixation clamp (not always used), a 4 Fr cholangiography catheter, urographine 76% 20 ml ampoules or ultravest diluted 1 : 2 with normal saline, needle holders, stone extraction baskets, three-wire (Dormia) size 3 Fr. and a four-wire (Segura). Choledochoscopes (3 and 5 mm) were placed on a separate stand.

The Calot triangle was dissected, displaying the critical view of safety and exposing the cystic duct-CBD junction and/or the anterior surface of the CBD. This is to allow for the insertion of instruments and the removal of stones. The cystic artery is identified and secured with clips or ties and then divided. A tie was then applied to the cystic duct at the gallbladder neck to prevent stone migration into the CBD during surgery (Fig. 3).

Intra operative cholangiography (IOC) was done through a small incision of the cystic duct using scissors (Fig. 4);

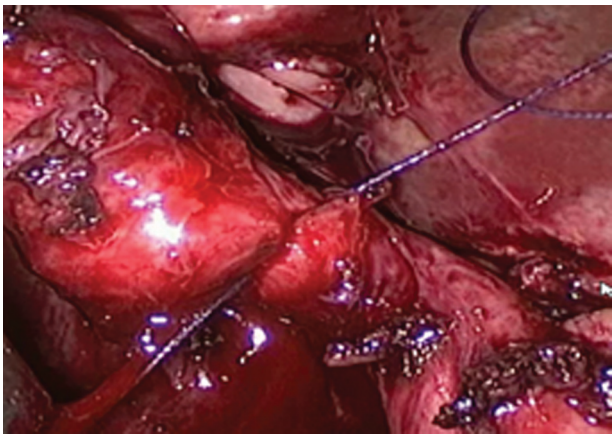
Figure 1

MRCP showing dilated CBD and IHBR with multiple stones: CBD, common bile duct; IHBR, intrahepatic biliary radicle; and MRCP, magnetic resonance cholangiopancreatography.

Figure 2

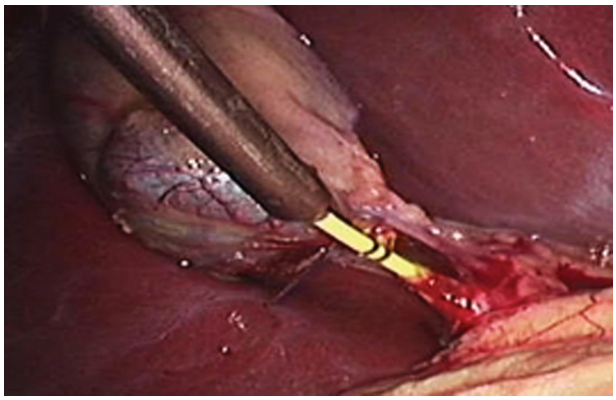
MRCP showing single CBD stone with stent inserted with previous ERCP and hepatic duct dilatation: CBD, common bile duct; ERCP, endoscopic retrograde cholangiopancreatography; MRCP, magnetic resonance cholangiopancreatography.

Figure 3



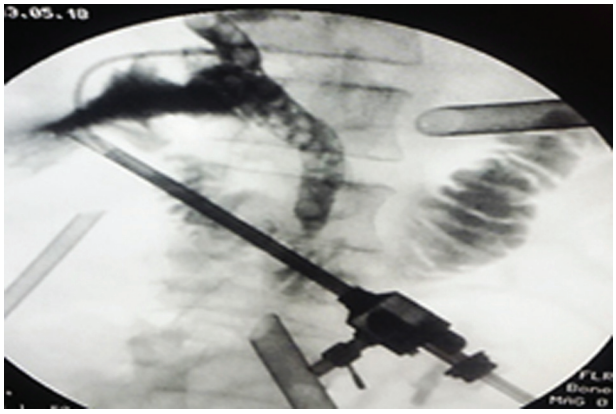
Tying of the cystic duct (at the neck of the gallbladder).

Figure 4



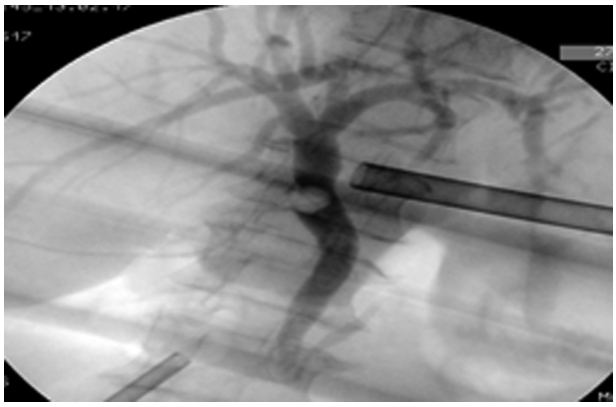
Laparoscopic cannulation of cystic duct for IOC.

Figure 5



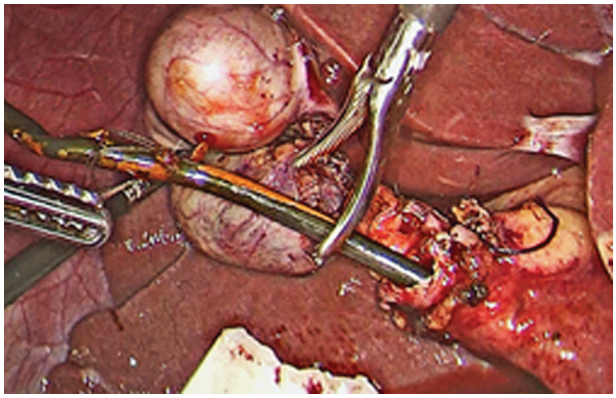
Numerous CBD stones by IOC: CBD, common bile duct.

Figure 6



Single CBD stone by IOC: CBD, common bile duct.

Figure 7



Transcystic extraction of previous ERCP stent with the Dormia basket. ERCP, endoscopic retrograde cholangiopancreatography

care was taken to avoid introduction of air bubbles during the performance of the IOC so as to avoid false results. We reviewed the images of the cholangiography for the presence of stones and their sites (Figs 5, 6).

The transcystic approach began with flushing the CBD with warm saline via the catheter in the cystic duct. Small stones may be flushed this way, especially after intravenous injection of hyoscine (buscopan). If flushing was inadequate to clear the small stones, we used fluoroscopic-guided stone retrieval basket Seigura or Dormia baskets (Boston Scientific, Marlborough, Massachusetts USA) for extraction of the CBD stones, inserted through the cholangiography catheter. This is the basket in catheter technique [11].

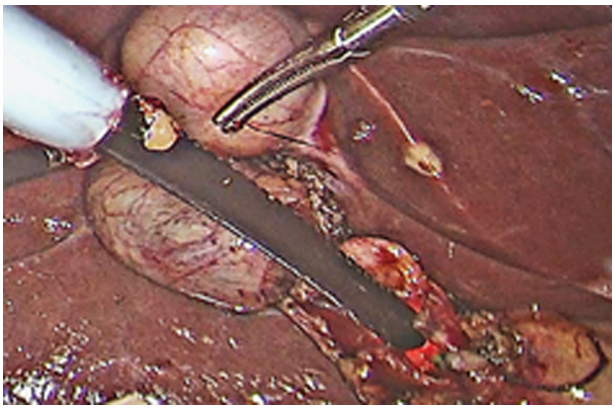
Once the basket engaged a stone, it was then delivered from the abdomen. We used this maneuver in most of our cases. This was also capable of the removal and extraction of previously inserted ERCP stents (Fig. 7).

In some cases, we used a 3 mm choledochoscope (Karl Storz, Tuttlingen, Germany) for guiding the stone extraction (Fig. 8). A retrieval basket was inserted through the choledochoscope catching the stone (s) under vision followed by extraction (Fig. 9). Intrahepatic exploration can be achieved through 180° angulation and moving the tip of the choledochoscope up into the CHD to complete the inspection of the intrahepatic ducts and carry out stone extraction if necessary. This is the 'wiper-blade maneuver' [12].

Using the same steps as before, postprocedure IOC is carried out for confirmation of clearance of the CBD. The cystic duct stump was occluded with ties (Vicryl 2/0) or clips and then divided. Cholecystectomy was then completed in the usual steps; intra-abdominal drain was inserted in most of our cases.

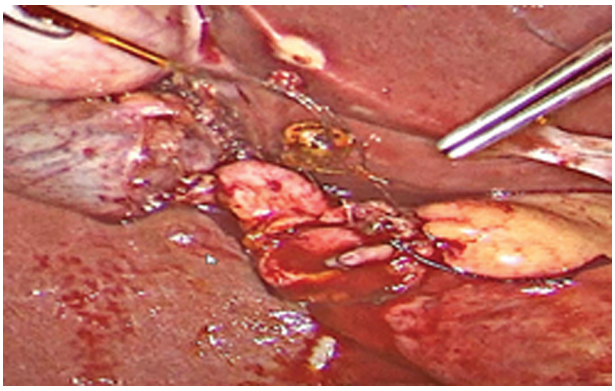
The choledochotomy approach was used in case of failed transcystic approach or in case of large stones. It

Figure 8



Choledochoscopic-guided transcystic CBD exploration. CBD, common bile duct.

Figure 9



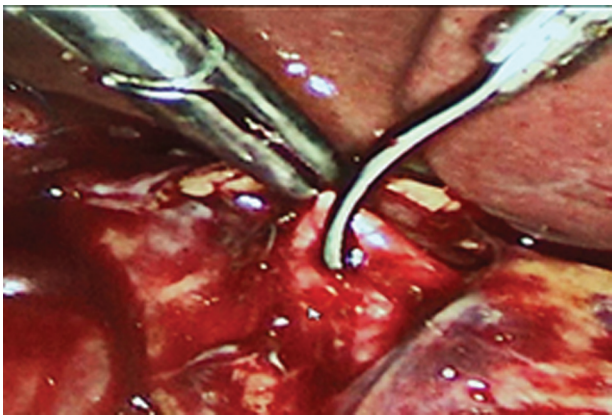
Transcystic stone retrieval by the Dormia basket.

began with dissection of the peritoneal covering of the supraduodenal portion of the CBD. A longitudinal choledochotomy incision of about 1 cm in length was made using laparoscopic scissors (Fig. 10).

Stone extraction was done either by directly grasping stones appearing at the incision, milking of the CBD from below upwards using blunt atraumatic graspers for delivering stones to the choledochotomy or by irrigation with warm saline through the choledochotomy (Fig. 11). Stone extraction can be done blindly using a basket or by a 5 mm choledochoscope through which a retrieval basket can be inserted under direct vision. Primary repair of the choledochotomy incision was done in our cases without stenting nor drainage with simple interrupted sutures with 4/0 vicryl or poly dioxanone suture (PDS) (Fig. 12). This was followed by completion IOC followed by cholecystectomy and drain insertion.

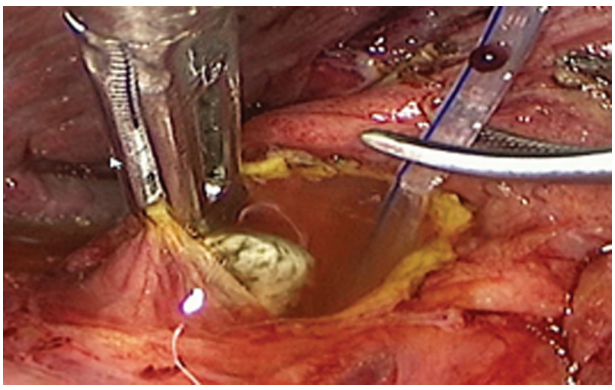
All the patients included in this study were subjected to short-term follow-up 2 weeks and 2 months after

Figure 10



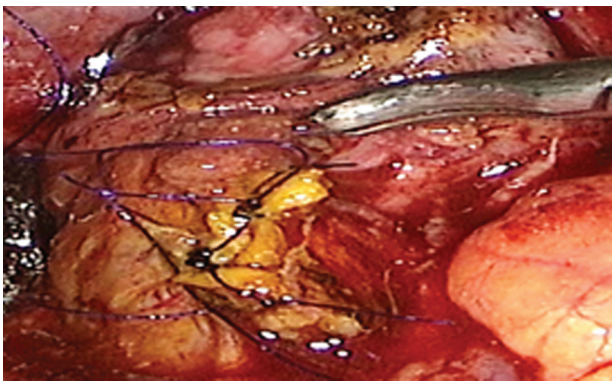
Choledochotomy incision in CBD by scissors. CBD, common bile duct.

Figure 11



CBD stone extraction with saline choledochotomy pushing irrigation. CBD, common bile duct.

Figure 12



Primary closure of choledochotomy incision with PDS 4/0.

operation using clinical examination, US for CBD diameter and any missed stones detection and laboratory investigations, total and direct bilirubin, SGOT, and SGPT.

Data were analyzed using IBM SPSS software package, version 20.0. (IBM Corp., Armonk, New York, USA). Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, SD, and median. Significance of the obtained results was judged at the 5% level.

Results

There were 21 (70%) women and nine (30%) men with a mean age of 48.90±11.84 years. Nine (30%) patients had controlled hypertension, three (10%) patients had controlled diabetes mellitus, and one (3.3%) had cardiac disease. Of the patients, 13.3% had a previous history of abdominal surgeries.

Right hypochondrial pain in the form of biliary colic was the presentation in 19 (63.3%) patients. Six (20%) patients presented with jaundice while five (16.7%) patients presented with both jaundice and right hypochondrial pain (Table 2) and nine (30%) of them were HCV Ab positive. According to preoperative laboratory investigations, serum total and direct bilirubin were elevated in 13 cases with a mean level of 2.74±2.80 mg/dl for total and 2.20 ±2.49 mg/dl for direct, serum amylase, and lipase were in normal range in all cases while liver functions including SGOT and SGPT were elevated in 17 cases with a mean of SGOT 115.37±114.95 U/l and 131.17±131.95 U/l for SGPT.

All patients had preoperative US and MRCP. There was no significant statistical difference between the two modalities, regarding all items except CBD diameter. This was significantly higher in MRCP than in US with a *P* value of less than or equal to 0.001 (Table 1).

Preoperative ERCP was done and failed in eight (26.7%) cases. Five cases had undergone stenting. IOC was done in all cases except one (3.3%) in which cystic duct cannulation failed due to severe adhesions. Eighteen of 29 (62.1%) cases had single CBD stones while 11 (37.9%) cases had multiple stones.

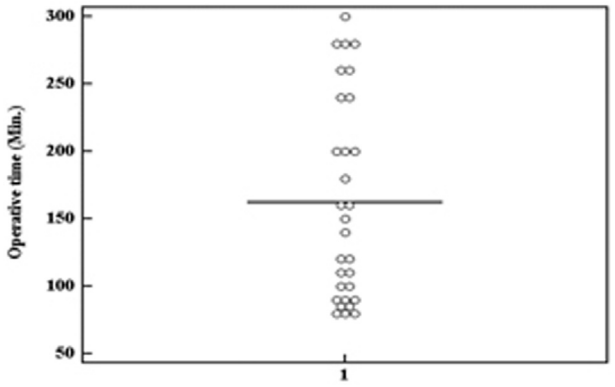
The transcystic approach for CBD exploration was used in 16 (53.3%) cases without conversion to open surgery; 11 (36.7%) cases were completed without choledochoscopy; six cases with stone extraction basket and five cases with saline irrigation. Five (16.7%) cases were completed with choledochoscopic-guided extraction without failure. The choledochotomy approach was used in 13 (43.3%) cases; six cases were completed with choledochoscopy and seven cases without it. Two cases failed and were converted to open surgery due to stone impaction at the ampulla with failure of all attempts to extract the stones. Open CBD exploration succeeded in one case with hepaticojejunostomy bypass. In addition, three of the five previously inserted stents were removed transcystically and two through choledochotomy. Biliary drainage (T-tube)

Table 1 Distribution of the studied cases according to ultrasound and magnetic resonance cholangiopancreatography findings (*N*=30)

	Ultrasound finding [*n* (%)]	MRCP finding [*n* (%)]	Test of significance	*P*
Thickened wall of GB				
No	9 (30.0)	9 (30.0)	McN	1.000
Yes	21 (70.0)	21 (70.0)		
Number of stones in GB				
Single	2 (6.7)	2 (6.7)	McN	1.000
Multiple	28 (93.3)	28 (93.7)		
CBD diameter (mm)				
Minimum–maximum	6.0–20.0	6.0–20.0	*Z*=3.926*	<0.001*
Mean±SD	11.30±5.08	12.43±5.22		
Median	12.0	13.50		
CBD stones				
Single	18 (60.0)	18 (60.0)	McN	1.000
Multiple	12 (40.0)	12 (40.0)		
IHBR dilation				
No	12 (40.0)	12 (40.0)	McN	1.000
Yes	18 (60.0)	18 (60.0)		

CBD, common bile duct; GB, gallbladder; IHBR, intrahepatic biliary radicle; McN: McNemar's test; MRCP, magnetic resonance cholangiopancreatography. *Z*, Wilcoxon signed-rank test. *P*, *P* value for comparing between ultrasound finding and MRCP finding.
*Statistically significant at a *P* value of less than or equal to 0.05.

Figure 13



Descriptive analysis of the studied cases according to operative time (min) (*N*=30).

was not done in any choledochotomy cases. All were primarily repaired with sutures (11 cases).

Completion cholangiography was done in the 27 laparoscopically completed cases without any abnormal finding. We placed a subhepatic drain in 25 (83.3%) cases.

The operative time ranged from 80 to 300 min with a mean of 162.33±74.67 min (Fig. 13).

We found that the operative time increased in cases with elevated SGPT and with thickened gallbladder wall, increased CBD diameter, and with intrahepatic biliary radicle dilatation; there were statistically significant differences with a *P* value of 0.043, 0.001, 0.001, 0.001, respectively (Tables 2 and 3).

The operative time was longer in the choledochotomy approach than with transcystic exploration. This was statistically significant with a *P* value of less than or equal to 0.001 (Table 4).

Wound (port site) infection requiring antibiotics occurred in two (6.7%) patients and chest infection in two cases. In addition, bile leakage occurred in two cases of choledochotomy approach with primary CBD repair. It appeared on the second day in one case, with 200 ml bile in the drain bag which decreased gradually on conservative management till it disappeared on the fifth postoperative day. The other case developed bile in the drain by the third day with 600 ml of bile which increased to 1000 ml by the fifth day. ERCP was done with a sphincterotomy revealing edema at the sphincter of oddi without residual stones. This case had 45 stones removed from the CBD. The bile leak stopped, the drain was removed, and the patient was discharged on the eighth day. Most intra-abdominal drains were

Table 2 Correlation between operative time (min) and different parameters (*N*=30)

	Operative time (min)	
	r_s	*P*
SGPT (U/l)	0.372	0.043*
CBD diameter (mm) by ultrasound finding	0.647	<0.001*
CBD diameter (mm) by MRCP finding	0.620	<0.001*

CBD, common bile duct; MRCP, magnetic resonance cholangiopancreatography; r_s, Spearman's coefficient; SGPT, serum glutamic pyruvic transaminase. *Statistically significant at a *P* value of less than or equal to 0.05.

removed on the second or third postoperative day with a mean of 2.28±0.98 except in the previous two complicated cases.

Serum bilirubin was measured on the third day, after 2 weeks and after 2 months. Abdominal US was carried out to measure the diameter of CBD at the time of discharge, after 2 weeks and after 2 months. These showed normal bilirubin levels and CBD diameter after 2 months.

The postoperative hospital stay ranged from 2 to 8 days with a mean period of 3.37±1.38 days (Fig. 14) (Tables 5 and 6)

Finally, there was an increased duration of hospital stay in relation with increased operative time with a *P* value less of than 0.0001 (Fig. 15).

Discussion

An increasing number of centers worldwide have started adopting one-stage management of CBD stones by LC with LCBDE [11].

The present study included 63.3% of cases presented with right hypochondrial pain, 20% presented with jaundice while 16.7% presented with both right hypochondrial pain and jaundice. In the study of Mohamed *et al.* [14] 87% presented with acute biliary pain with jaundice, 8% presented with acute pancreatitis while 6% presented only with jaundice. Tan and colleagues reported the initial presentations of 60.0% with right hypochondrial pain and 46.0% with jaundice. Acute cholangitis accounted for 32% of the emergency presentations, followed by acute pancreatitis in 10.0% and acute cholecystitis in 10.0% [13]. Salama *et al.* [16] reported 45.7% with biliary pain, 7% with jaundice, and 10% with pancreatitis. Helmy and Ahmed's [17] study presented calcular obstructive jaundice in 60

Table 3 Relation between operative time (min) and Radiological findings

	N	Operative time (min)			*U*	*P*
		Minimum–maximum	Mean±SD	Median		
Thickened wall of GB by ultrasound finding						
No	9	80.0–160.0	97.22±25.63	90.0	18.0*	<0.001*
Yes	21	85.0–300.0	190.24±71.39	200.0		
Thickened wall of GB by MRCP finding						
No	9	80.0–160.0	97.22±25.63	90.0	18.0*	<0.001*
Yes	21	85.0–300.0	190.24±71.39	200.0		
IHBR dilation by ultrasound finding						
No	12	80.0–120.0	92.50±12.70	90.0	2.0*	<0.001*
Yes	18	110.0–300.0	208.89±60.57	200.0		
IHBR dilation by MRCP finding						
No	12	80.0–120.0	92.50±12.70	90.0	2.0*	<0.001*
Yes	18	110.0–300.0	208.89±60.57	200.0		

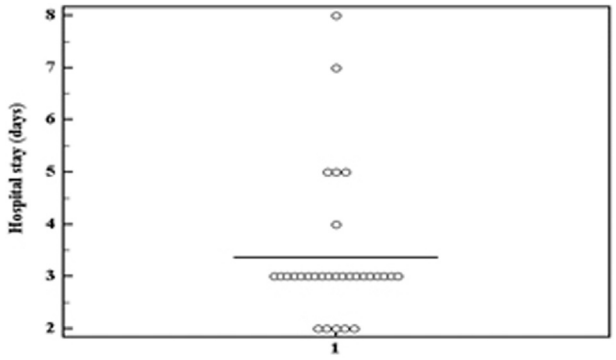
GB, gallbladder; IHBR, intrahepatic biliary radicle; MRCP, magnetic resonance cholangiopancreatography; *U*, Mann–Whitney test. [a]Excluded from the association due to the small number of cases (*N*=1). *P*, *P* value for the association between hospital stay (days) and different parameters. *Statistically significant at a *P* value of less than or equal to 0.05.

Table 4 Relation between operative time (min) and approaches used (*N*=30)

Approaches used	*N*	Operative time (min)			*U*	*P*
		Minimum–maximum	Mean±SD	Median		
Transcystic approach	16	8.0–200.0	106.88±32.55	95.0	7.50*	<0.001*
Choledochotomy approach	13	120.0–300.0	223.08±57.06	240.0		
Failed procedure	1[a]	260.0				

U, Mann–Whitney test. [a]Excluded from the association due to the small number of cases (*N*=1). *P*, *P* value for the association between operative time (min) and different parameters. *Statistically significant at a *P* value of less than or equal to 0.05.

Figure 14



Descriptive analysis of the studied cases according to hospital stay (days) (*N*=30).

Table 5 Correlation between hospital stay (days) and preoperative parameters (*N*=30)

	Hospital stay (days)	
	r_s	*P*
Total bilirubin (mg/dl)	0.563	0.001*
Direct bilirubin (mg/dl)	0.492	0.006*
SGOT (U/l)	0.643	<0.001*
SGPT (U/l)	0.579	0.001*
CBD diameter (mm) by ultrasound finding	0.481	0.007*
CBD diameter (mm) by MRCP finding	0.502	0.005*
Operative time (min)	0.743	<0.001*

CBD, common bile duct; MRCP, magnetic resonance cholangiopancreatography; r_s, Spearman's coefficient; SGOT, serum glutamic oxaloacetic transaminase; SGPT, serum glutamic pyruvic transaminase. *Statistically significant at a *P* value of less than or equal to 0.05.

patients (54.3%), biliary colic in 29 (24.1%), cholangitis in 15 (12.5%), and accidental discovery in 16 (13.3 %.).

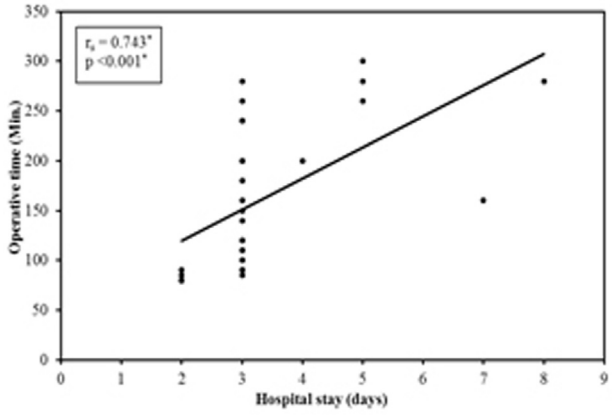
Seventy percent of our cases had a thickened gallbladder wall by both US and MRCP, 93.3% of cases had multiple gallbladder stones, dilated CBD with a mean diameter of 11.30±5.08 mm by US and 12.43±5.22 mm by MRCP, which has a statistically significant increase in the diameter of CBD by MRCP than US. The study of Grubnik *et al.* [18], reported a mean CBD diameter of 10.2 by US. Khan and colleagues reached the diagnosis of CBD calculi in 76.25% of patients by transabdominal US, whereas the other 23.75% of patients underwent MRCP for confirmation of stones, 6.25% of them had only CBD stones without gallbladder stones, 90% had multiple CBD calculi, and 10% had a solitary CBD

Table 6 Relation between hospital stay (days) and different parameters (*N*=30)

	N	Hospital stay (days)			*U*	*P*
		Minimum–maximum	Mean±SD	Median		
Thickened wall of GB by ultrasound finding						
No	9	2.0–3.0	2.44±0.53	2.0	30.0*	0.003*
Yes	21	3.0–8.0	3.76±1.45	3.0		
Thickened wall of GB by MRCP finding						
No	9	2.0–3.0	2.44±0.53	2.0	30.0*	0.003*
Yes	21	3.0–8.0	3.76±1.45	3.0		
IHBR by ultrasound finding						
No	12	2.0–3.0	2.58±0.51	3.0	42.0	0.004*
Yes	18	3.0–8.0	3.89±1.53	3.0		
IHBR by MRCP finding						
No	12	2.0–3.0	2.58±0.51	3.0	42.0	0.004*
Yes	18	3.0–8.0	3.89±1.53	3.0		
Bile leakage post						
No	28	2.0–5.0	3.07±0.81	3.0	0.0*	<0.001*
Yes	2	7.0–8.0	7.50±0.71	7.50		
Wound infection						
No	28	2.0–8.0	3.25±1.35	3.0	5.0	0.055
Yes	2	5.0–5.0	5.0±0.0	5.0		
Chest infection						
No	28	2.0–8.0	3.25±1.35	3.0	5.0	0.055
Yes	2	5.0–5.0	5.0±0.0	5.0		
Transcystic approach	16	2.0–3.0	2.69±0.48	3.0	44.0	0.008*
Choledochotomy approach	13	3.0–8.0	4.08±1.71	3.0		
Failed procedure	1[a]	5.0				

GB, gallbladder; IHBR, intrahepatic biliary radicle; MRCP, magnetic resonance cholangiopancreatography; *U*, Mann–Whitney test.
[a]Excluded from the association due to the small number of cases (*N*=1). *P*, *P* value for the association between hospital stay (days) and approaches used. *Statistically significant at a *P* value of less than or equal to 0.05.

Figure 15



Correlation between hospital stay (days) and operative time (min) (*N*=30).

stone. The mean CBD diameter was 15.3 mm (range, 10–37 mm) [19].

The minimum diameter of the CBD at which LCBDE by choledochotomy is feasible and safe is controversial. Petelin [20] has reported that it is feasible to do LCBDE with a CBD diameter as small as 6 mm. However, Crawford *et al.* [21] reported that LCBDE is safer when the CBD is more than 8 mm in diameter. Verbesey and Birkett [22] reported that choledochotomy should be avoided if the CBD is less than 1 cm in diameter for fear of CBD stricture. Choledochotomy was only performed if the CBD diameter was at least 10 mm in the Quaresima *et al.* [23] study.

We selected the cases for either transcystic or transcholedochotomy approaches according to cystic duct diameter, CBD diameter, and the number and size of stones in CBD. Our success rate in LCBDE was 90%. Thesuccess rate with choledochoscopy in either approach was 84.7% in the choledochotomy approach and 100% in the transcystic approach.

The total number of conversions to open surgery was three cases. The Zhang *et al.* [24] study reported that the stone removal success rate was 96.2% (228/237) and only nine (3.8%) failed and needed endoscopic sphincterotomy or endoscopic papillary balloon dilation. Zhou *et al.* [25] (72 cases) reported that six cases were converted to open operation due to impacted stones with a success rate of 91.7%. In the study by Helmy and colleagues, choledochoscopy was

performed routinely in all cases. Conversion to open surgery was done in two cases with a success rate of 96.7% [15]. Feng and colleagues showed that stone clearance was achieved in 87.3% of patients in the choledochotomy approach and in 88.9% in the transcystic approach. There was no significant difference between the two approaches. Conversion occurred in 7.5% of choledochotomy cases and 10.9% of patients undergoing transcystic exploration [26]. In Quaresima *et al.* [23], causes of conversion were inadequate experience at the beginning of the authors' learning curve and intrahepatic stones. In the study by Tan *et al.* [15], there were 8.0% conversions, while only 6% conversion was seen in the Bansel *et al.* [27] study. In the study of Mohamed *et al.* [14], out of 75 cases, 4% of cases were converted to open surgery.

The choledochotomy incision in the current study was done longitudinally for a length of 1 cm, extended in the presence of large stones in the supraduodenal portion of the CBD. Khan *et al.* [19] performed a longitudinal choledochotomy incision using a cold knife for a length of 1–1.5 cm. On the other hand, Khaled *et al.* [28] performed a transverse choledochotomy incision. They reported that a transverse choledochotomy is laparoscopically more accessible to closure and reduces the risk of duct stenosis. Tang *et al.* [29] reported the use of energy in the form of an US dissecting device for incising the CBD to avoid bleeding. Choledochotomy incision management after successful laparoscopic transcholedochal CBD exploration is a matter of debate. It was believed that a CBD drain could decrease intraductal pressure by draining bile until papillary edema and biliary obstruction resolve, thereby preventing bile leakage. T-tubes remain the preferred method of duct drainage following CBD exploration. Complications associated with the use of T-tubes were fluid and electrolyte disturbances, sepsis, bile leak, premature dislodgement, biliary peritonitis, localized pain, prolonged biliary fistulae, and late biliary stricture [18,30]. Our choledoshotomy cases were managed by primary closure with interrupted absorbable sutures. Eighteen percent developed biliary leakage, and this agreed with Khan and colleagues, who routinely closed the CBD primarily. They used T-tubes only when the stone load in the CBD resulted in prolonged and extensive manipulation within the CBD with evidence of residual ductal edema [19]. Zhou *et al.* [25] reported primary closure of 72 patients after choledochotomy. Twelve (16%) cases had slight bile leaks, which resolved spontaneously with the drain [25]. In their study Chen *et al.* [31] observed that primary closure is safe after LCBDE (n=194). Vidagany and colleagues did primary closure after LCBDE in 160 patients. Bile leakage was reported in only 6.8%. They concluded that primary closure after LCBDE is a safe technique with excellent results [32].

In a retrospective study done by Yi and colleagues, long-term results of primary closure after LCBDE were compared with T-tube drainage. They concluded that primary closure after LCBDE with choledochoscopy is as safe and effective as T-tube drainage in terms of long-term results [33]. Podda and colleagues did a meta-analysis of all studies comparing primary duct closure and T-tube drainage after LCBDE (total 16 studies, 1770 patients). Primary duct closure showed a significant advantage over T-tube in terms of postoperative bile peritonitis, operative time, hospitalization, and median hospital cost (all $P<0.00001$) [34].

The mean operative time was 162.33±74.67 min in the current study. This was consistent with most similar studies. Helmy *et al.* [17] reported that operative time ranged from 90 to 220 min. In Zhou *et al.* [25], the mean operative time was 145 min. In the study of Cai *et al.* [35], the mean operative time was 125.7 ±32.6 min. Chander *et al.* [36] reported that the mean duration of surgery was 139.9±26.3 min (90–205 min). In Bansal *et al.* [9], the operative time for LCBDE ranged from 120 to 240 min. In Sharma *et al.* [1], the average duration of surgery was 139.9 ±26.3 min. In Karaliotas *et al.* [4], the mean operative time was 155±42.7 min (range, 75–270 min), and in Darkahi *et al.* [37], the mean operative time was 194 min, in the range of 75–420 min. There was no significant difference regarding the mean operative time between the present study and the mentioned literatures.

We also noticed a significant reduction in time of the transcystic approach (80–200 min) compared with the choledochotomy approach (120–300 min). It can be explained by the time needed for dissection of the CBD, intracorporal suturing, and knot tying. This agreed with the study of Quaresim *et al.* [23], with a significant difference between transcystic and choledochotomy approaches. In Zhang *et al.* [24], patients in the transcystic approach group were significantly younger, and had smaller and fewer stones. Consequently, the operating time was significantly shorter [24]. In Tokumura *et al.* [38], laparoscopic choledochotomy needed a longer operating time than the transcystic approach. In

Aawsaj *et al.* [39], the mean operative time for laparoscopic transcystic exploration was 96 min and the time for laparoscopic choledocotomy was 137 min (range, 67–235 min). The study done by Puhalla *et al.* [40] reported an increased operative time with choledochotomy, and also in Dong *et al.* [41], study, the mean operative time was much shorter in transcystic than in choledochotomy (102.6 ±15.2 min versus 128.6±20.4 min). On the other hand, Salama *et al.* [16] found no significant change in the operative time in both transcystic and choledochotomy groups. This was also reported by Hongjun *et al.* [42].

Bile leakage occurred in two cases in the choledochotomy approach in the current study. Helmy *et al.* [17] reported the occurrence of postoperative complications in three (5%) patients; two patients had minor bile leaks which stopped spontaneously in 2 and 4 days and one case of a missed stone. Mohamed *et al.* [14] reported two cases with cholangitis and a bile leakage due to T-tube slippagemanaged conservatively until it stopped. Zhou *et al.* [25] reported that 12 cases of 78 had slight bile leaks (drainage <150 ml/day), which resolved spontaneously with the drain in position. In Dong *et al.* [41], bile peritonitis was seen in two (2.22%) patients after T-tube removal, and the two patients recovered with expectant treatment. In the study of Bansal *et al.* [27], there were two cases with transient bile leakage which did not require any treatment. Grubnik *et al.* [18] reported that three patients were reoperated: two for dislocation of drainage and one for progressive bile peritonitis. Four patients had intra-abdominal abscesses, which were successfully drained under US guidance.

The mean hospital stay was from 3.37±2 to 8 days. The patients with conversion to open procedures and those who developed complications had the longest stay. The hospital stay decreased with increasing experience, and it was longer in the early cases for fear of complications (Table 7).

Table 7 Comparison between hospital stay in our study and in other studies

Study	Hospital stay duration (days)	Mean
Our study	2 to 8	3.37
Kadam *et al.* [43]	2 to 9	–
Bansal *et al.* [9]	3 to 9	–
Tan *et al.* [15]	1 to 15	–
Tekin *et al.* [44]	3 to 7	1.7
Helmy *et al.* [17]	2 to 4	3
Topal *et al.* [45]	1 to 12	3.5

When we analyzed correlations of length of hospital stay with other data, we noticed an increased hospital stay with increased gallbladder wall thickness and CBD diameter on US and MRCP and with increased liver enzymes. In the choledochotomy approach, hospital stay ranged from 3 to 8 days while in the transcystic approach, it ranged from 2 to 3 days. Hongjun *et al.* [42] showed significant differences in hospital stay between the transcystic LCBDE group 9.82±3.48 day and the transcholedochal LCBDE group (10.74 ±5.34 day). In Zhang *et al.* [24], patients in the transcystic group had significantly shorter postoperative hospital stay than the choledochotomy group (5.1±1.6/8.4±2.8 days). In Topal *et al.* [45], the duration of LCBDE with choledochotomy was significantly longer than with transcystic exploration. Grubnik *et al.* [18] reported shorter hospital stay in the transcystic approach (3.4±1.7) than in the choledochotomy approach (7.6±2.5). There was a significant increase in hospital stay with the occurrence of bile leakage, which was also reported in the studies Topal *et al.* [45], Quareisma *et al.* [23], Karaliotas *et al.* [4], Tekin *et al.* [44], Grubnik *et al.* [18], Tan *et al.* [15], and Hongium *et al.* [42], who reported increased length of hospital stay with bile leakage.

However, it has been stated in the literature that the length of hospital stay should not be a criterion for outcome assessment of surgery because it is not only dependent on the surgical procedure performed, but is influenced by several factors independent of patient's postoperative recovery [45].

Conclusion

Although this study was our first experience in the laparoscopic treatment of CBD stones, it was a fruitful experience. LCBDE is a feasible, effective, and safe procedure, depending on several factors including proper training and gaining experience, adequate equipment, and laparoscopic and choledochoscopic facilities, avoiding the drawbacks of ERCP as well as open CBD approach.

IOC is an important maneuver and should be done in any suspicious case to outline the biliary anatomy and help proper decision-making. It is technically challenging to perform choledochoscopy, and if it is achievable, with practice and skills development, it facilitates the extraction of stones under direct visualization, and this of course increases the success rate of LCBDE. Transcholedocotomy LCBDE is better to be done when there is a large stone from

the beginning and with a CBD diameter of more than 1 cm. It is safe to do primary interrupted closure of CBD; in this case T-tube drainage is unnecessary for decompression of the biliary tree. The longer operative time and hospital stay in LCBDE should not be a barrier against gaining surgical experience and developing learning curves needed for LCBDE. ERCP still holds an important role in the management of choledocholithiasis and in complicated biliary surgery. This study helped change the attitude to CBD stones treatment in our institution.

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There are no conflicts of interest.

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