Laparoscopic common bile duct exploration for choledocholithiasis (primary repair vs T-tube drainage)

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Received: 23 November 2019
Accepted: 26 December 2019
Published: 27 April 2020

The Egyptian Journal of Surgery 2020, 39:317–324

Background
Laparoscopic common bile duct exploration (LCBDE) offers good clinical outcomes in dealing with common bile duct stones. Surgeons experienced in laparoscopy can perform this procedure securely and efficiently. The goal of this study was to assess the security and possibility of primary repair as a substitute to usual T-tube drainage after LCBDE.

Patients and methods
This was a prospective study that included 40 successive patients who were subjected to LCBDE for common bile duct stones. After LCBDE, the choledochotomy was repaired either by primary repair (group A) in 20 patients or with T-tube insertion (group B) in 20 patients. The preoperative data, intraoperative details, and postoperative results of the two groups were assessed and evaluated with a mean follow-up of 12 months.

Results
The mean operation period was considerably lesser in group A than group B (101.1 ±27.7 min for group A vs 140.3±26 min for group B; P=0.000). Moreover, the hospital stay was considerably shorter in group A than in group B (2.8 days for group A vs 6.1 days for group B; P=0.017). Postoperative bile leakage occurred in two cases in each group.

Conclusion
Primary repair of choledochotomy is a secure alternate to usual T-tube insertion after LCBDE.

Keywords:
choledocholithiasis, choledochotomy, laparoscopic common bile duct exploration, primary repair

Egyptian J Surgery 39:317–324

1110-1121

Introduction

The treatment modalities of choledocholithiasis are different, extending from open surgery, laparoscopic operation, to endoscopic retrograde cholangiopancreatography (ERCP). Laparoscopic common bile duct exploration (LCBDE) is gaining popularity as a minimally invasive choice for management of choledocholithiasis [1,2]. There are two main ways to do LCBDE: choledochotomy and through cystic approach. Choledochotomy is strictly challenging and must be achieved by surgeons with pronounced laparoscopic skills [3].

The transcystic method is a much easier way, but it is restricted to a small group of cases, as it merely permits the removal of stones with small size, and the entrance to the common hepatic duct is inaccessible [4]. The choledochotomy approach has the benefit that it can offer unrestricted entrance to both the common bile duct (CBD) and the common hepatic duct, allowing the removal of challenging stones [5].

T-tube insertion in CBD has been commonly performed in the management of choledochotomy centered on the practice of open CBD exploration. Yet, there are many reports on the complications that occur with T-tube insertion [6,7]. Latest universal reviews revealed that primary repair of the CBD only is higher to T-tube insertion at the base of the short-term result [8,9]. Our purpose in this study was to evaluate primary closure of CBD instead of T-tube insertion after laparoscopic exploration of CBD.

Patients and methods

This prospective study was conducted from October 2015 to October 2018 at Assiut University Hospitals. The study protocol was permitted by the Organized Ethics Commission, and the patients signed a written

 DOI: 10.4103/ejs.ejs_208_19

informed consent form before enlisting. A total of 42 patients with choledocholithiasis were randomly chosen either to primary repair group or T-tube drainage group. Preoperative diagnosis was based on a combination of clinical evaluation, liver function, abdominal ultrasound, and magnetic resonance cholangiopancreatography (MRCP). MRCP was performed using 1.5 T Siemens Sempra scanner.

We included patients with age from 18 to 65 years, CBD diameter more than 10 mm, and imaging-based diagnosis of gallstones and concomitant CBD stones. Patients with cholangitis, pancreatitis, advanced liver cirrhosis, and pregnancy were excluded. Conversion to open procedure was done when there was a failure of advancement with the operation (nearby 2 h), if there is large stone burden in an obviously dilated bile duct (better to convert to do drainage procedure), difficult anatomy, or uncontrollable bleeding.

Clinical examination and laboratory investigations were noted, as well as operative period parameters including anesthesia, intraoperative cholangiogram, intraoperative complications, mortality, and postoperative. We recorded laboratory investigations, bleeding, wound infection, abdominal collection, bile leakage, and hospital stay, and finally, we recorded patient follow-up regarding residual or recurrent stones, biliary strictures, and their management. Preoperatively in a patient with obstructive jaundice, vitamin K was given to correct any clotting defect and cover with prophylactic antibiotics.

Operative procedure

Laparoscopic cholecystectomy is performed using the usual location for the four trocars. Exposure and dissection over the cystic duct and the CBD anteriorly was done. Initial cholangiogram by closure of the distal cystic duct near to neck of gall bladder was done. The cystic duct was cannulated using a cholangiogram catheter. In our study, laparoscopic CBD exploration is performed through the CBD choledochotomy approach with cephalic traction of the gallbladder, and extension of the dissection over the CBD distal to the fusion of the cystic duct for ~1–2 cm.

The ductotomy was made vertically by a hook with diathermy. Milking of the duct is tried first, followed by flushing with saline for removal of loose stones, and then the ERCP instrument, balloon and basket, and Fogarty's catheter were used to remove CBD stones owing to the unavailability of the specially designed basket for LCBDE. Clearance of duct stones was accomplished by usual completion cholangiography through the whole biliary tree, using Foley's catheter to occlude the choledochotomy gently.

Criteria of successful cholangiogram are visualization of intrahepatic and extrahepatic biliary system, free passage of dye to the duodenum, and no filling defect. Following ductal clearance, either a 12–16-F latex rubber tube was inserted into the CBD (Fig. 1), or primary duct closure was performed by interrupted 3-0 or 4-0 vicryl sutures (Fig. 2). A small nelaton drain (20 F) was placed routinely in the subhepatic space. T-tubes were removed after cholangiography was performed, and a clear biliary tree was verified at 14 days. Choledochoscopy was not available in all cases, and we used rigid ureteroscope and Ambu scope, which is a flexible bronchoscope to ensure ductal clearance of stones in some cases in this study, but this is considered a major drawback as a flexible scope was not available in all cases, as it was an expensive and fragile instrument (Fig. 3).

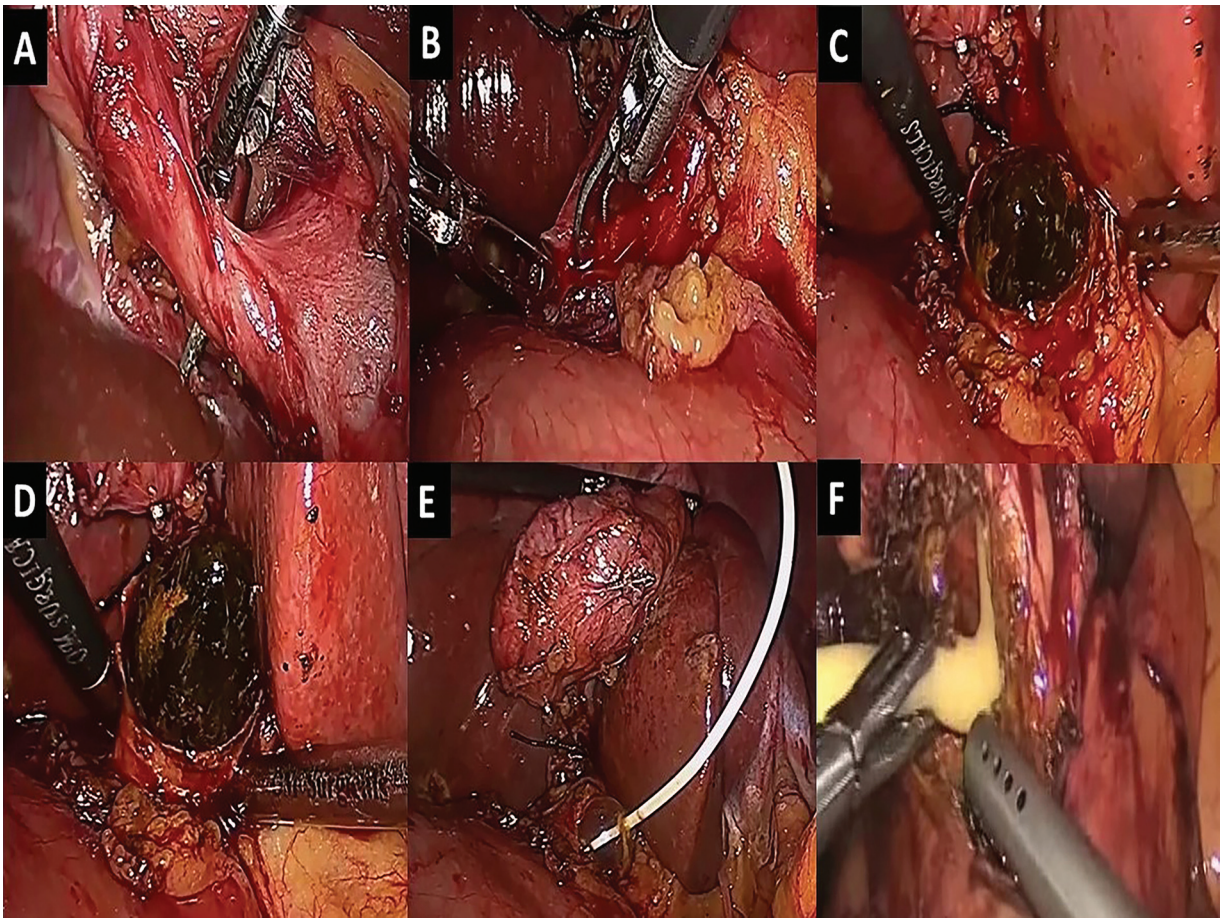
Definitions of outcome and follow-up period

Operative time was demarcated as the period (minutes) between the first skin opening and skin closing. The number of days the patient stay in the hospital after operation is defined as the hospital stay. Complications were graded according to a certified grouping system established by Dindo *et al.* [10]. Postoperative biliary leak was demarcated as fluid with a high bilirubin level (more than three times the serum bilirubin level measured at the same time) in the subhepatic drain or in the intraperitoneal fluid collection, or there was a need for interventional radiology to drain abdominal collections or re-exploration to manage biliary peritonitis. Follow-up evaluation using liver chemistry and ultrasound was done at 2 weeks and every 3–6 months postoperatively. If the patient complains of persistent right hypochondrial pain, or abnormal in liver chemistry, a computed tomography abdomen or MRCP was done to exclude possibility of stricture of bile duct or stone recurrence.

Statistical analysis

Categorical records were expressed as the number and percentage, whereas continuous data were expressed as median and range or mean and SD. A comparison of the two groups was done by χ^2-test for categorical variables and Mann–Whitney test for continuous variables. Statistical analysis was done using IBM SPSS Statistics for Windows, Version 20.0, Armonk, NY: IBM Corp. A P value of less than 0.05 indicated a statistically considerable difference.

Figure 1



(a) Prominent common bile duct stone; (b) ductotomy; (c and d) stone delivery; (e) balloon seepage; and (f) tube drainage.

Results

A total of 42 patients were recruited after fulfilling the inclusion criteria, but two patients were excluded owing to the absence of CBD stones during intraoperative cholangiogram and diagnosed as a stone passer. Then, the remaining patients were randomly assigned, where 20 cases were enrolled in each group.

Preoperative data

Regarding the preoperative demographic, clinical, laboratory, and radiological data of the two groups, there was no statistically considerable difference between the two groups. In six (30%) cases in group A and in 10 (50%) cases in group B, there was a history of previous failed stone extraction by ERCP (Table 1).

The sensitivity of ultrasound in the detection of choledocholithiasis was 85%, whereas it was 100% for MRCP.

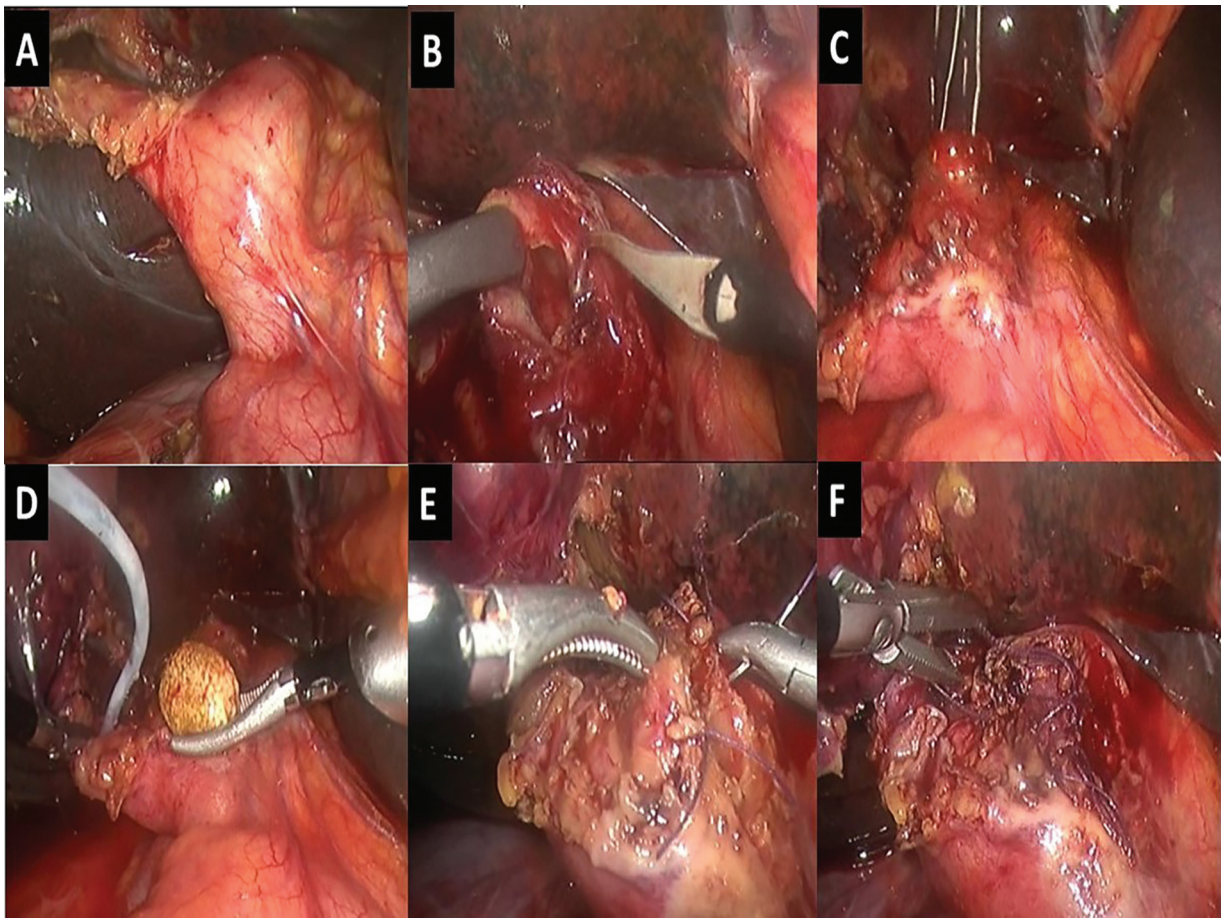
Operative data

Intraoperative cholangiogram was done in only 50% of cases (10 cases) in group A and done for only 70% of cases (14 cases) in group B. All cases underwent CBD exploration via choledochotomy, and all cases had assumed clearance of duct stones at the end of the technique. Conversion from laparoscopic to open occurred in only 30% of cases (six cases) in group A, and the cause of conversion was owing to failure of stone extraction in four cases (three of them due to multiple stones and one of them due to impacted distal stone) and bleeding at the choledotomy site in two cases that failed to be controlled laparoscopically, but in group B, conversion from laparoscopic to open occurred in four (20%) patients, and the cause of conversion was owing to failure of stone extraction in two cases and owing to adhesions and unclear anatomy in another two cases.

Final cholangiogram was done to confirm ductal clearance at the end of procedure by a Foley's catheter to occlude choledochotomy site.

Ambu scope and rigid ureteroscope were used to ensure ductal clearance of stones in eight (40%) of patients in group A and 10 (50%) of patients in group B. The

Figure 2



(a) Prominent common bile duct stone; (b) ductotomy; (c and d) stone extraction; and (e and f) primary repair of ductotomy.

detailed operative data are shown in Table 2. There was no statistically considerable difference between the two groups except for operative period and blood loss, which were more in group B than in group A (P=0.018 and 0.048, respectively).

Postoperative data

In group A, two patients developed bile leakage and conservative management was failed and managed by ERCP and insertion of a stent. In group B, two patients presented with residual stones in CBD during T-tube cholangiogram; one was managed by ERCP and extraction of stone/s, and the other case was managed by redo open surgery owing to failure identification of the papilla (atrophic papilla).

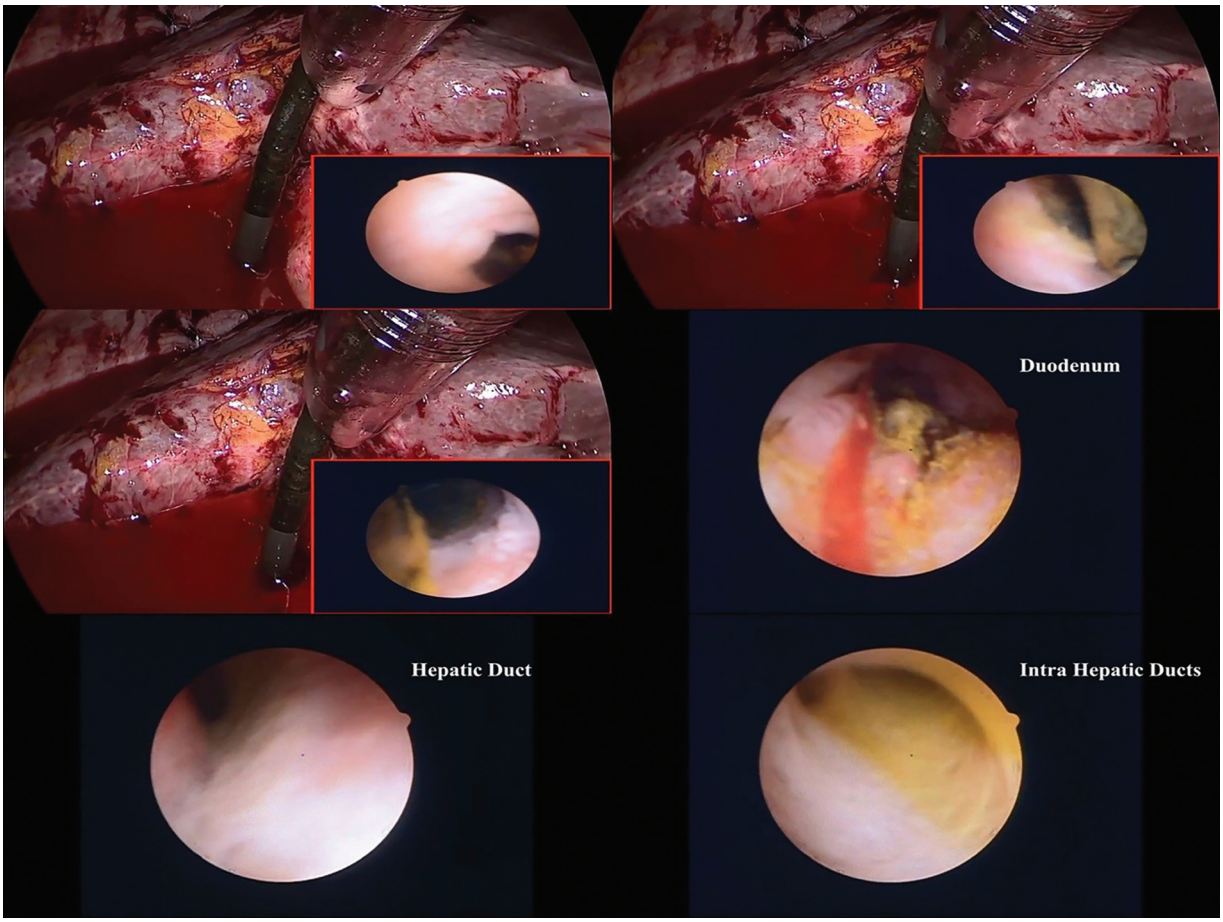
Mean hospital stay in group A was 2.8 days (range: 2–8 days), and the longest hospital stay was 8 days in one of two cases that developed complications, but in group B, mean hospital stay was 6.1 days (range: 3–22 days), and the longest hospital stay was 22 days in the case that developed complications and needed redo surgery. There was no considerable difference between the two groups. There was shorter hospital stay and no residual stones in primary closure. The detailed postoperative data are shown in Table 3.

Discussion

Recently with the great progress in laparoscopic skills, treatment of the patients by LCBDE become a substitute to ERCP presenting safe one-setting treatment with considerably lesser hospital stay and less expenses, less traumatic, quick recovery, and no abdominal scars. Moreover, LCBDE does not disturb the function of sphincter of Oddi and its sequelae such as papillary stricture and recurrent distal CBD stones [11–13].

All of our laparoscopic CBD exploration had involved direct choledochotomy instead of transcystic exploration of CBD, in contrary to the texts [14,15]. This is owing to the stone burden in our cases was heavy, and it was not possible to accomplish total ductal stone clearance by transcystic approach, which is similar to the Thompson and Tranter series [16].

Figure 3



Cholodechoscope finding during laparoscopic common bile duct exploration to ensure ductal stone clearance.

Other studies described that a transcystic way was not very reasonable in attaining total removal of the CBD stones [15,17]. Traditionally, CBD exploration was accompanied by T-tube insertion to reduce the hazard of postoperative complications, biliary tract decompression, and the possibility to do transtubal cholangiogram and removal of missed stones. Furthermore, T-tube diversion of bile allows the time for edema of the papillary sphincter to subside following the surgical manipulation. However, the reported rate of T-tube complications was ~10–15% such as biliary abdominal collection after removal of T-tube or bile leakage because of dislodgment of the T-tube and persistent biliary fistula [18,19]. Moreover, the T-tube causes persistent pain and discomfort to the patient and ileus owing to fluid and electrolyte disturbance and delays return to normal activity and work [20].

The primary repair of CBD after choledochotomy is secure. Many authors support this procedure as a substitute to T-tube insertion [21–23]. However, a study by Cai and colleagues described that primary repair of CBD after LCBDE was not allowed for cases with suppurative cholangitis owing to CBD obstruction, papillary stricture of CBD, as they need diversion of bile, and patients with a very narrow CBD have relative contraindication for primary duct repair owing to high incidence of bile leak [24].

Regarding conversion to open procedure, in this study, it was high, as we are still in learning curve and gaining skills and progress in LCBDE. The rate was 6/20 and 4/20 in both groups, compared with Hua *et al.* [25], with 16 in first 250 cases and nine in second 250 cases. According to Guan *et al.* [26], 2/68 in LCBDE group and in study of Yi *et al.* [27] 3/91 and 2/51 converted to open surgery.

Regarding operative time and blood loss, in this study, there were statistically significant differences lesser in the primary closure group regarding operative time and blood loss than T-tube group (P=0.000 and 0.002, respectively). This was matched with Zhang *et al.* [18] and a meta-analysis by Podda *et al.* [28], and a Cochrane appraisal by Gurusamy *et al.* [17].

Table 1 Preoperative data (diabetes mellitus, hypertension, chronic liver disease)

	Primary closure group A (*N*=20) [*n* (%)]	T-tube group B (*N*=20) [*n* (%)]	*P* value
Age (years)	48.1 (34–65)	50.6 (27–65)	0.528
Sex			0.525
Male	8 (40)	10 (50)	
Female	12 (60)	10 (50)	
Presentation			
Pain	4 (20)	6 (30)	0.606
Jaundice	16 (80)	14 (70)	
Associated diseases			
HTN	6 (30)	6 (30)	1
DM	4 (20)	4 (20)	
No	10 (50)	10 (50)	
Laboratory			
WBC ($\times 10^3$/ml)	6.88 (4–13.8)	7.66 (3.8–11.1)	0.507
HB level (mg/dl)	12.51 (11–14)	12.68 (10–15)	0.773
Platelets	307 (200–400)	291.9 (180–450)	0.695
Albumin (g/dl)	3.67 (3–4.3)	3.6 (2.9–4.2)	0.719
Total bilirubin (mg/dl)	3.62 (0.5–9.1)	3.87 (0.5–12.5)	0.864
Direct bilirubin (mg/dl)	3.312 (0.2–8.42)	3.46 (0.2–12)	0.917
SGPT (μl/ml)	52 (20–245)	47.6 (20–200)	0.875
SGOT (μl/ml)	52.6 (21–258)	37.6 (14–152)	0.575
INR	1.1 (1–1.3)	1.14 (1–1.4)	0.605
Amylase (IU/l)	63.2 (21–374)	66.4 (39–174)	0.932
Imaging			
Ultrasound			
Liver			
Normal	16 (80)	14 (70)	0.465
Fatty	4 (20)	6 (30)	
CBD size (mm)	12.72 (7–20)	13.9 (8–21)	0.489
Stone number			
Negative	2 (10)	4 (20)	0.42
Single	14 (70)	10 (50)	
Multiple	4 (20)	6 (30)	
Stone size (mm)	12.1 (7–22)	10.49 (5–16)	0.804
MRCP			
CBD size (mm)	15.62 (10–23)	15.4 (10–22)	0.895
Stone number			
Single	11 (55)	6 (30)	0.11
Multiple	9 (45)	14 (70)	
Stone size (mm)	12.7 (5–22)	13.1 (5–24)	0.870
Preoperative ERCP			
Done and failed	6 (30)	10 (50)	
Not done	14 (70)	10 (50)	0.197

CBD, common bile duct; ERCP, endoscopic retrograde cholangiopancreatography; INR, international normalized ratio; MRCP, magnetic resonance cholangiopancreatography; SGPT, serum glutamic pyruvic transaminase; SGOT, serum glutamic oxaloacetic transaminase.

In this study, hospital stay after operation was statistically less in primary repair group than T-tube group, with *P* value 0.017, and this matched with multiple studies, such as by Wu *et al.* [29], Ahmad *et al.* [30], Ambreen *et al.* [31], and Ha *et al.* [32].

Regarding bile leakage in this study, there was no statistically significant change among the primary repair group and T-tube group, as bile leak occurred in two patients of primary repair group and managed with ERCP and stenting and in two cases of T-tube group, which was managed conservatively; this matched with a meta-analysis by Podda *et al.* [28].

There were no complications following the removal of T-tube in this study compared with a meta-analysis by Podda *et al.* [28]. No events regarding biliary peritonitis were described in the primary closure group, whereas 12 (2.3%) events were reported in the T-tube group. Moreover, in a meta-analysis by Zhu and colleagues [33] their results favored the primary closure group.

Table 2 Operative data of both groups

Operative	*N* (%)	*N* (%)	*N* (%)
Procedure			
Laparoscopic	14 (70)	16 (80)	0.465
Conversion	6 (30)	4 (20)	
Cause of conversion			
Failed complete extraction	4 (20)	2 (10)	0.187
Bleeding	2 (10)	0	
Adhesion	0	2 (10)	
Intraoperative cholangiogram	10 (50)	14 (70)	0.197
Choledechoscope	8 (40)	10 (50)	0.525
CBD size (mm)	15.8 (10–23)	15.7 (14.3–22)	0.942
Suture material			
Vicryl	18 (90)	20 (100)	0.147
PDS	2 (10)	0	
Suture method			
Continuous	2 (10)	0	0.147
Interrupted	18 (90)	20 (100)	
Suture size			
3/0	18 (90)	0	0.147
4/0	2 (10)	20 (100)	
T-tube size			
No	0 (100)	20 (0)	0.000
12	0	2 (10)	
14	0	16 (80)	
16	0	2 (10)	
Operation time (min)	101.1±27.7	140.3±26	0.000
Blood loss (ml)	51.8±22.5	83.4±36	0.002
Transfusion	0	0	–

CBD, common bile duct.

Table 3 Postoperative data of both groups

	Primary closure group A (*N*=20)	T-tube group B (*N*=20)	*P* value
First day bilirubin			
Total	3.39 (0.4–8.5)	3.51 (4–11)	0.894
Direct	2.61 (0.1–7)	2.96 (0.2–10)	0.673
Hospital stay (days)	2.8 (2–8)	6.1 (3–22)	0.017
Postoperative complications	4 (20)	8 (40)	0.168
Clavien–Dindo classification			0.356
Grade I	2 (10)	4 (20)	
IIIa	0	2 (10)	
IIIb	2 (10)	2 (10)	
Bleeding	0	0	–
Wound infection	2 (10)	0	0.147
Management			
Bedside treatment	2 (10)	0	0.147
Ileus	0	2 (10)	0.147
Abdominal collection	0	2 (10)	0.147
Bile leakage	2 (10)	2 (0)	0.698
Management			
Conservative	0	2 (10)	0.135
ERCP stent	2 (10)	0	
Residual stone	0	2 (10)	0.147
Management			
ERCP	0	1 (5)	0.349
Redo surgery	0	1 (5)	

ERCP, endoscopic retrograde cholangiopancreatography.

In this study, there were no considerable differences among the two group regarding residual stones, although there were residual stones in two cases in T-tube group, but study by Ambreen *et al.* [31] and Zhang *et al.* [18] showed that the application of intraoperative choledochoscopy reduced the rate of residual stones to 0%.In this study, after a mean follow-up of 1 year (range: 8–18 months), only rate of port site hernia (one case) in the primary repair group after 12 months. No cases of recurrent stone or biliary stricture during our follow-up. This is in contrast with a study by Zhang *et al.* [18], which showed that stone recurrence occurred in 2% in primary repair and 3.26% in T-tube insertion (*P*=0.672), during the period of median follow-up of 40 months.

A series by Riciardi *et al.* [34], with a median follow-up of 43 months, observed no biliary complications (either stone recurrent /s or stricture).

Regarding preoperative imaging, we found that ultrasound has low sensitivity in detecting CBD stone compared with MRCP and intraoperative cholangiogram. This was in agreement with previous work by Mitchell *et al.* [35]. Future works should include endoscopic ultrasound, which has a comparable sensitivity to MRCP [36].

Conclusion

LCBDE is a safe and feasible procedure. Primary repair of ductotomy is a secure substitute to T-tube drainage.

Acknowledgements

The authors would like to thank Nahed A Makhlouf (Professor of Tropical Medicine and Gastroenterology, Faculty of Medicine, Assiut University) for checking language, grammars and helping the authors in revising the manuscript.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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