JOURNAL OF LAPAROENDOSCOPIC & ADVANCED SURGICAL TECHNIQUES
Volume 15, Number 3, 2005

Laparoscopic Common Bile Duct Exploration with T-Tube Choledochotomy for the Management of Choledocholithiasis

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ABSTRACT

Although laparoscopic cholecystectomy (LC) has become the gold standard for the management of gallstone disease, the application of laparoscopic common bile duct exploration (LCBDE) for choledocholithiasis has been slower. The aim of this study is to determine the feasibility and effectiveness of LCBDE.

A retrospective cohort study was conducted to compare LCBDE (n = 82) with conventional common bile duct exploration (CCBDE) (n = 75) and endoscopic sphincterotomy (EST) (n = 80) in the management of choledocholithiasis. All our LCBDEs were performed through choledochotomy with T-tube placement. The mean operative time of the LCBDE group (124 ± 48 minutes) was not significantly longer then the CCBDE group (118 ± 35 minutes), while the postoperative hospitalization was shorter in both the LCBDE (8 ± 5 days) and EST (9 ± 4 days) groups than in the CCBDE (13 ± 6 days) group. In the LCBDE group, 14 patients (17.1%) required postoperative choledochoscopy to clear residual stones through the T-tube tract. The only mortality occurred in the CCBDE group. The morbidity rate was 3.7% (3/82) in the LCBDE group, including bile leakage in 1 case and bile peritonitis in 2 cases; 6.7% (5/75) in the CCBDE group, including atlectasis in 2 cases, sepsis in 1, and wound infection in 2. There were 2 cases of postoperative pancreatitis (2.5%; 2/80) in the EST group. The difference in the average number of sessions needed for complete clearance of choledocholithiasis in each group was statistically significant (EST, 1.46 ± 0.67; LCBDE, 1.23 ± 0.42; and CCBDE, 1.09 ± 0.28; $P < 0.0001$). Our results suggested that EST and LCBDE tended to require more therapeutic sessions then CCBDE, although these sessions were less invasive. The benefits of LCBDE include minimal invasiveness, concurrent treatment of gallbladder stone and CBD stones in a single session, and a shorter postoperative hospital stay. However a longer learning curve is needed. Selection of the most suitable therapeutic option for individual patients by an experienced surgeon gives the most benefits to patients.

INTRODUCTION

THE ADOPTION of laparoscopic common bile duct exploration (LCBDE) for the management of choledocholithiasis in our institution has been much slower than the adoption of laparoscopic cholecystectomy (LC) for the management of gallstone disease (82 LCBDEs since June 1993 vs. 5000 LCs since December 1990).[1–4] This may have been due to the advanced laparoscopic technique demanded for LCBDE. Other treatment modalities, such as conventional common bile duct exploration through laparotomy (CCBDE) and endoscopic sphincterotomy (EST), also offer satisfactory results for the management of choledocholithiasis.[5–8] These facts have

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slowed the adaptation of LCBDE.[9–11] In this study we compare and try to define the role of LCBDE along with two other modalities in the management of choledocholithiasis.

MATERIALS AND METHODS

Since July 1993, 82 LCBDEs had been performed for choledocholithiasis at our hospital through anterior choledochotomy (79 patients had concomitant LC for gallbladder stones, and 3 patients had had a previous LC). The criteria for selecting LCBDE included a common bile duct (CBD) diameter > 1 cm (0.8 cm for the last 30 cases); ≤2 stones in the CBD in our early experience, and ≥5 by the end of the series; stone size < 1 cm in our early experience and < 1.5 cm later in the series; and no association with recent severe acute pancreatitis or biliary tract infection. Patients with intrahepatic stones were excluded. During the same period, we collected data on 80 cases of EST combined with LC the following day. Another cohort of 75 patients, whose CBD stones and gallstones were treated with CCBDE through laparotomy in the past 18 months were also collected for comparison. Data including age, sex, operative time, postoperative hospitalization, surgical complications, incidence of residual CBD stones, and subsequent interventions for complete clearance of stones, were collected for analysis. In the LCBDE group, CBD stones were diagnosed in with abdominal sonography and elevated liver enzymes in 13 patients; in 51 cases with preoperative endoscopic retrograde cholangiopancreatography (ERCP); intraoperative cholangiography (IOC) in 7 cases; IOC in addition to ERCP in 6 patients; and MRCP in 5.

Two sets of video systems were used for the LCBDE: one for the laparoscopic procedure and the other for the intraoperative choledochoscopy. The procedure for LCBDE is initially the same as for LC. Following ligation of the cystic duct and artery with clips, these structures remain undivided for convenience of traction; the choledochotomy is performed routinely through longitudinal incision on the anterior wall of the CBD. After the CBD is opened, the fifth trocar is introduced through the right subcostal area just above the choledochotomy; intraoperative choledochoscopy is performed through this working port. Both the dormia basket and electric hydraulic lithotriptor (EHL) were used for clearance of the CBD stones. EHL was useful when the stones were impacted tightly or the stones were too large to be entrapped by the basket. Excessive fragmentation of CBD stones should be avoided because this will prolong the procedure due to removal of all of the fragments. Balloon dilatation of the ampulla of Vater was not performed in our series. We did, however, try to pass the closed basket catheter through the ampulla of Vater to reduce the risk of small stone impaction. The T-tube was prepared as for open surgery. Watertight closure of the CBD around the T-tube was performed using 4-0 Vicryl with intracorporeal suturing and knotting. Knotting is performed as in open surgery, with one surgical tie followed by two square ties. Sometimes an additional clip can be used to fix the first surgical tie. An adequate size of choledochotomy and a change in the direction of the T-tube to facilitate needle passage are critical to successful indwelling and fixation of the T-tube. We prefer to place the first stitch from the caudal side of the choledochotomy with the trunk of the T-tube pushed cephalically. The second stitch is then passed through the cephalic site of the choledochotomy with the trunk of T-tube moved caudally. The third stitch is placed cephalically to the first stitch and caudally to the trunk of the T-tube (Fig. 1). Our aim was to perform the procedure laparoscopically in the same way we performed the conventional choledocholithotomy.

A T-tube cholangiogram was performed 6 days after LCBDE on our patients. The T-tube was removed 1 week later if there were no remaining residual stones. If residual stones were demonstrated, a subsequent choledochoscopy through the T-tube tract was conducted 4 weeks

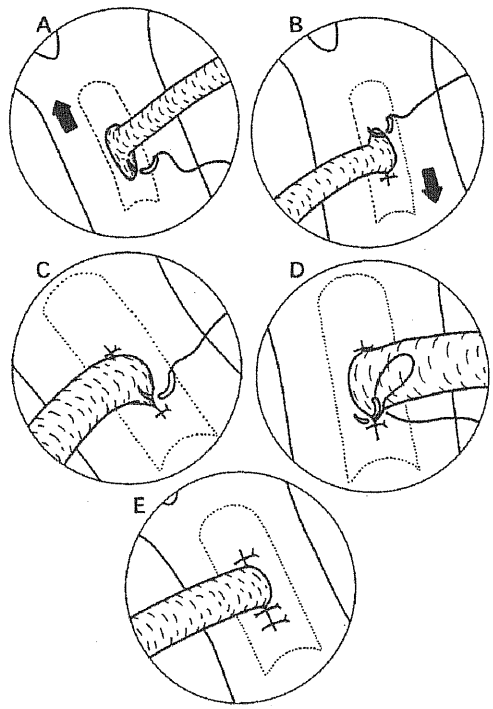

FIG. 1. Laparoscopic choledochotomy. **A.** Pushing the T-tube cephalically to place the first stitch. **B.** Pushing the T-tube caudally to place the second stitch. **C, D.** Pushing the T-tube to the side to place stitches within a narrow space. **E.** Fixing the T-tube tightly with three stitches.

after LCBDE, as an outpatient procedure. This was well-tolerated and did not require any type of anesthesia.

RESULTS

Of the 82 patients managed with LCBDE, 31 were male and 51 were female, ages ranging from 27 to 87 years (mean, 60 ± 17 years). In the CCBDE group, 41 patients were male and 34 were female, ages ranging from 25 to 95 years (mean, 64 ± 16 years). In the EST group, 39 patients were male and 41 were female. Ages in this group ranged from 24 to 82 years (mean, 49 ± 15 years), significantly younger ($P < 0.001$) than in the other two groups. There were no statistically significant differences in the sex distribution among the three groups (P = 0.138, Chi-square test). The mean operation time of the LCBDE group was 124 ± 48 minutes (range, 60-310 minutes); of the CCBDE group, 118 ± 35 minutes (range, 45-215 minutes) ($P = 0.416$).

In the LCBDE group, 14 patients (17.1%) required postoperative choledochoscopy to clear the residual stones through the T-tube tract, while in the CCBDE group the rate of residual stone was 9.3% (7/75), but the difference was not significant ($P = 0.140$). The mean postoperative hospital stay was longer in the CCBDE group (13 ± 6 days; range, 6–36 days) than for the LCBDE group (8 ± 5 days; range, 4–33 days) or the EST group (9 ± 4 days; range, 4–20 days) ($P < 0.001$).

We also compared the mean number of procedures each patient needed to reach complete CBD clearance. In the EST group, 80 patients underwent 94 sessions of EST, 17 sessions of LCBDE, and 6 open choledochotomies (117/80; mean, 1.46 ± 0.67 sessions). In the LCBDE group, 82 patients had 82 sessions of LCBDE, 5 open choledochotomies, and 14 postoperative choledochoscopic choledocholithotomies (101/82; mean, 1.23 ± 0.42 sessions). In the CCBDE group, 75 patients underwent 75 choledochotomies and 7 postoperative choledochoscopic choledocholithotomies (82/75; mean, 1.09 ± 0.28 sessions). The difference was statistically significant (Table 1).

In the EST group, 12 patients each required one additional EST treatment, and 1 patient needed 3 additional ESTs (16.3%, 13/80); 17 patients (21.3%; 17/80) needed LCBDE to remove residual CBD stones and 6 of these cases were converted to laparotomy. Six cases in the EST group needed IOC during LC to further confirm the presence of choledocholithiasis and 4 of these needed LCBDE to remove the CBD stones.

The conversion rate in the LCBDE group was 9.8% (8/82): 3 cases of severe gallbladder inflammation and 5 cases of difficulty in performing stone removal or placing a T-tube. In 5 patients in the LCBDE group (6.1%), the CBD stone could not be identified: this same condition was found in 2 patients in the CCBDE group.

The single mortality in this series occurred 3 days postoperatively in the CCBDE group and was due to septic shock and multiple organ failure. The morbidity rate was 3.7% (3/82) in the LCBDE group: in one patient, transient biliary leakage sealed spontaneously one week later. In 2 patients, bile leakage developed after removal of the T-tube and required re-exploration and drainage (laparotomy in one and a laparoscopic approach in the other), and both recovered uneventfully. The morbidity rate was 6.7% (5/75) in the CCBDE group, including postoperative atelectasis in 2 cases, sepsis in 1, and wound infection in 2. Two cases of postoperative pancreatitis occurred in the EST group (2.5%).

DISCUSSION

Before the introduction of laparoscopic and endoscopic procedures, choledocholithiasis was treated by choledocholithotomy through laparotomy.[12] In recent years, however, the traditional approach to CBD exploration has been supplemented by newer, less-invasive proce-

TABLE 1. STATISTICAL COMPARISON BETWEEN THE LAPAROSCOPIC COMMON BILE DUCT EXPLORATION (LCBDE), CONVENTIONAL COMMON BILE DUCT EXPLORATION (CCBDE), AND ENDOSCOPIC SPHINCTEROTOMY (EST) GROUPS

	LCBDE (n = *82*)	*CCBDE* (n = *75*)	*EST* (n = *80*)	P *value*
Male	31 (37.8%)	41 (54.7%)	39 (48.75%)	0.138[a]
Female	51 (62.2%)	34 (45.3%)	41 (51.25%)	
Age	60 ± 17	64 ± 16	49 ± 15	<0.001[b]
Mean operation time, minutes	124 ± 48	118 ± 35		0.416[c]
Mean postoperative hospital stay, days	8 ± 5	13 ± 6	9 ± 4	<0.001[b]
Residual stones	14 (17.1%)	7 (9.3%)		0.140[a]
Average sessions	1.23 ± 0.42	1.09 ± 0.28	1.46 ± 0.67	<0.001[b]

[a]Chi-square test.
[b]Based on ANOVA.
[c]Two-sample *t*-test.

dures.[13,14] The principal minimally invasive options for treatment of CBD stones include EST and LCBDE. The latter can be performed via the cystic duct approach or thecholedochotomy approach.[15,16] The major challenges of a successful LCBDE with choledochotomy include using choledochoscopy to remove CBD stones laparoscopically, indwelling of a T-tube through choledochotomy, and intracorporeal suturing and knotting for T-tube fixation. Once the surgeon is familiar with these procedures, however, LCBDE can be performed as smoothly as conventional surgery. With the LCBDE technique, once CBD stones are suspected by operative finding or proved by IOC during LC, surgeons can treat the CBD stones concurrently with the gallstones, as in the conventional laparotomy approach.[17,18] Only a modest increase in total operative time benefits the patient with a single minimally invasive session, as well as a cost-saving by avoiding another intervention. Based on our results, LCBDE offers significant benefits, including minimal invasiveness when compared with the laparotomy approach, and treatment of CBD stones and gallstones within a single laparoscopic session when compared with the EST group.

The drawbacks of LCBDE include substantial requirements for equipment, including two sets of video systems (one for laparoscopy and one for choledochoscopic procedures), a choledochoscopy set, and the EHL apparatus. It might be easier for a high-volume institute to budget for all this equipment. LCBDE involves a longer learning curve, reflecting the requirement of mastering the intracorporeal suturing and knotting and intraoperative choledochoscopy: the surgeon should have demonstrated competence with both the laparoscopic and endoscopic techniques.

LCBDE can be performed within an operative time comparable to that required for open surgery. Our mean operative time for LCBDE was similar to the laparotomy group at about 2 hours. There should be no hesitation in converting any LCBDE attempt that exceeds this time interval when there is no progress in the procedure. Conversion itself is a strategy for preventing complications and should be considered seriously during a difficult LCBDE. Open surgery is still the simple and straightforward solution for management of choledocholithiasis and offers an excellent stone-clearance rate.

In this series, 3 patients underwent LCBDE 1-2 years after their LC, but the intra-abdominal adhesions were minor. Previous upper abdominal surgery remains an exclusion criterion of ours for LCBDE in order to avoid wasting too much time in adhesiolysis and the risk of injury to the CBD or surrounding organs. When a patient's general condition is poor (e.g., patients who cannot tolerate general anesthesia or pneumoperitoneum), there exists the less invasive, safe, and effective procedure of percutaneous drainage for temporary release of the pressure on the bile duct system.[19,20]

In contrast to many reports in which the cystic duct approach was selected for exploration of the CBD, we preferred choledochotomy in all of our cases.[15,16,21,22] While it is difficult to compare these two procedures, the choice depends on the surgeon's experience.[23,24] The cystic duct approach necessitates dilation of the cystic duct, while the choledochotomy approach requires indwelling and suture fixation of the T-tube; otherwise, both techniques demand fluent use of intraoperative choledochoscopy. The 4.9 mm diameter choledochoscope (Olympus CHF-P20, Tokyo, Japan) we used in LCBDE is more durable then those used for the cystic duct approach (e.g., Olympus CHF-BP30, 3.4 mm diameter or smaller). We had no fiber breakage of our choledochoscope through the 5-mm trocar during LCBDE.

In our experience, much practice is needed to overcome the learning curve of LCBDE. Most of the conversions occurred during the first half of our series (cases 15, 19, 25, 29, and 32); the other 3 conversions were due to severe gallbladder inflammation.

In the EST group, 63% (50/80) of patients had one session of successful EST, followed by LC the next day, and a shorter hospitalization. Some patients experienced one or more sessions of failed EST and were shifted to other interventions. Much depends on the surgeons' ability and experience to lower the failure rate of each group and to assign each patient to the most suitable treatment modality.

In our series the incidence of retained CBD stone in the LCBDE group was higher then in the OCBDE group (17.1% vs. 9.3%, $P = 0.140$). In the LCBDE group, CBD exploration could only be done through the choledochoscope while in the OCBDE group direct manual manipulation of the CBD or exploration of the CBD with stone forceps could be performed easily. From our experience, the higher rate of retained CBD stones could be overcome through accumulated experience of LCBDE. Bile leaks after planned removal of the T-tube in the LCBDE group is an important specific complication not encountered in the OCBDE group. This might be due to the minimally invasive nature of LCBDE, which frustrates the formation of choledochocutaneous fistulae. The hospital stay in the OCBDE group was longer than in the other two groups in our series. The length of hospital stay in all three groups was longer than in the Unites States. Social and cultural differences may account for the longer hospital stays. Most of our patients believe that only after all the stitches and tubes are removed can they be discharged from the hospital. Lack of appropriate patient education and social resources may also play a role.

The greatest advantage of LCBDE is its ability to treat gallstone and CBD stone in one laparoscopic session. It is feasible and effective but requires a longer learning curve. Strict patient selection for each procedure can lower the failure rate and maximize patient success. Each

treatment modality has its own failure rate, and a shift from one failed procedure to another still requires facing the same situation, that is, the patient not only suffers from the poor results of a failed procedure but also faces the potential risks of subsequent procedures. New technology may offer a shortcut to the original goal; however, it should be safer, easier, and faster then the conventional methods. Surgeons should be familiar with the benefits and limitations of all these treatment strategies, such as EST, LCBDE, open surgery, and percutaneous drainage. Close cooperation between the surgeons, the endoscopist, and the radiologist will ensure an excellent result in the management of choledocholithiasis.

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