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Towards T-Tube Free Laparoscopic Bile Duct Exploration

A Methodologic Evolution During 300 Consecutive Procedures

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Objective
To establish a simple, reproducible, and safe technique of laparoscopic common bile duct exploration (CBDE) with high clearance rates and low morbidity and mortality rates.

Summary Background Data
For most general surgeons, laparoscopic CBDE appears an unduly complex and demanding procedure. Since the introduction of laparoscopic cholecystectomy, many surgeons use endoscopic cholangiography (ERC) and endoscopic sphincterotomy as their only option in treating bile duct stones. ERC is more specific if used after surgery, but it carries an appreciable morbidity rate and has the disadvantage of requiring a second procedure to deal with bile duct stones. To this end, various methods of laparoscopic CBDE have been developed.

Methods
Between August 1991 and February 1997, 300 consecutive unselected patients underwent laparoscopic CBDE.

Results
Of 300 laparoscopic CBDE procedures, 173 (58%) were managed using a transcystic approach and 127 (42%) with choledochotomy. Successful laparoscopic stone clearance was achieved in 271 (90%). Of the 29 (10%) patients not cleared laparoscopically, 10 had an elective postsurgical ERC, 12 were converted to an open procedure early in the series, and 7 had unexpected retained stones. There was one death (mortality rate 0.3%) and major morbidity occurred in 22 patients (7%). The last 100 procedures were performed from July 1995 to February 1997, and stone clearance was unsuccessful in only two patients.

Conclusions
Laparoscopic transcystic basket extraction of common duct stones under fluoroscopic guidance is a relatively quick, successful, and safe technique. Choledochotomy, when required, is associated with a higher morbidity rate, particularly with T-tube insertion, and the authors advocate primary bile duct closure with or without insertion of a biliary stent as a more satisfactory technique for both surgeon and patient. Most patients with gallbladder and common duct calculi should expect a curative one-stage laparoscopic procedure without the need for external biliary drainage or ERC.

Management of bile duct stones in the laparoscopic era has been the subject of much discussion.[1–3] During the 1970s, endoscopic management of bile duct stones was developed, and it became the treatment of choice in elderly patients unfit for open surgery.[4] In the 1980s, the benefits of endoscopic cholangiography (ERC) and endoscopic sphincterotomy for common duct stones became evident in patients with acute suppurative cholangitis[5] and severe pancreatitis.[6] Open bile duct exploration, however, remained the principal treatment for patients found to have stones at cholecystectomy, and many surgeons had reservations about more widespread use of ERC, particularly in younger patients. In the 1990s, with the introduction of laparoscopic cholecystectomy, many surgeons abandoned duct exploration and used ERC and endoscopic sphincterotomy as their only option in treating bile duct stones. For most general surgeons, laparoscopic common bile duct exploration (CBDE) appears an unduly complex and demanding procedure.

Before laparoscopic cholecystectomy, even in selected patients with biochemical or ultrasound indicators, ERC results in many unnecessary procedures, because >50% of patients will have no evidence of bile duct stones at sur-

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gery.[7] Also, the procedure itself is not without risk.[7–9] Postsurgical ERC, although more specific, still carries the risks of ERC and the disadvantage that the patient needs a second procedure to deal with bile duct stones. Various methods of laparoscopic CBDE have been developed. Some surgeons advocate traditional techniques laparosurgically with choledochotomy and T-tube placement;[10] however, several groups have reported high success rates and low morbidity rates with transcystic instrumental bile duct stone extraction.[11,12] This paper describes 300 consecutive CBDE procedures, from the procedure's infancy to our current approach, to demonstrate how increasing experience has led to improved results and a change of practice.

PATIENTS AND METHODS

Between August 1991 and February 1997, we performed laparoscopic CBDE on 300 patients. Patient data were retrieved by a retrospective review of the first 100 case records and prospective data collection of the last 200 patients.

From August 1991 to January 1993, patients considered for laparoscopic CBDE were those with biliary colic who were found to have bile duct stones incidentally on routine surgical cholangiography. From January 1993 to February 1997, all patients with bile duct stones were considered for surgery, but those medically unfit or with severe cholangitis or pancreatitis were offered ERC. In this latter period, laparoscopic CBDE was considered in patients who had undergone unsuccessful ERC.

Operative Methods

For all cases, operative cholangiography was performed using the Olsen/Reddich cholangiography forceps with a 4 or 5 French ureteric catheter and more recently a Nathanson cholangiocatheter (Cook, Australia), which facilitates transcystic exploration of the duct. Dynamic fluoroscopic images were obtained with a mobile C-arm to confirm bile duct stones. For small stones (<1 cm) distal to the cystic duct–common duct junction, transcystic exploration was attempted. Laparoscopic choledochotomy was reserved for large stones (>1 cm) or stones that remained above the cystic duct–common duct junction, or in cases in which transcystic exploration failed.

Transcystic Duct Exploration

The initial 15 patients were treated by saline flushing alone, after glucagon relaxation of the sphincter of Oddi.[3,13] Subsequently, transcystic exploration was performed using a helical 4.5-mm ureteric stone basket (Wilson Cook, Indiana), passed into the cystic duct using the cholangiography forceps. When difficulty was encountered, the cystic duct was not dilated but was dissected closer to the common bile duct to prevent the basket from catching on the spiral valves.

The basket was screened to the ampulla and was opened at the stone in the bile duct under fluoroscopic guidance. The Nathanson catheter's three-way tap allows repeated injection of contrast during basket extraction without the need for a catheter change. Duct clearance was confirmed cholangiographically, and the cystic duct was closed with two clips or an endoloop. If the stones were impacted, a Fogarty balloon catheter (4 or 5 French) was passed to the ampulla and the balloon was used to disimpact the stones, avoiding displacement proximally into the common hepatic duct. Electrohydraulic lithotripsy was available since 1993 to fragment impacted stones but was not required in this series. In patients with cholangitis or delayed flow of contrast into the duodenum, antegrade stents were positioned across the ampulla using a guidewire under fluoroscopic guidance, as described previously.[14] If the bile duct was not cleared of stones, open choledochotomy or postsurgical ERC was undertaken before January 1993; subsequently, laparoscopic choledochotomy has been the preferred procedure.

Laparoscopic Choledochotomy

This procedure was considered safe only for bile ducts >7 mm in diameter. Ducts <10 mm were occasionally dilated with saline through the cystic duct to facilitate a safe choledochotomy. A fifth operating port (5 mm) was often inserted left of the falciform ligament to improve retraction for suturing. The bile duct was dissected and exposed by traction on Hartmann's pouch to the right with an intact cystic duct or on the cystic duct stump. A longitudinal choledochotomy was fashioned with scissors and the duct was sequentially cleared of stones using the cholangiography catheter or irrigation device to flush the duct with saline, followed by a 4 French Fogarty balloon catheter. Residual stones detected by repeated cholangiography were extracted with a 4.5-mm Dormia basket. Free stones were retrieved using a 10-mm stone scoop or bag device. Choledochoscopy was used selectively, and duct clearance was confirmed by routine completion cholangiography proximally and distally, using the Olsen–Reddich clamp to occlude the choledochotomy gently. During our initial experience, the duct was closed around a T-tube, but from January 1995, primary duct closure was performed using continuous or interrupted 4-0 PDS sutures. Antegrade stents were inserted in cases of cholangitis or when more than five stones were found in the duct. This was performed by simply pushing the stent down the choledochotomy and confirming its entry into the duodenum with fluoroscopy. Choledochoduodenostomy was performed in cases of ampullary stenosis with ducts dilated to >15 mm in diameter.[15] The anastomosis was performed using a continuous 3-0 or 4-0 PDS suture. A small suction drain was placed routinely in the subhepatic space. T-tubes were clamped at 7 days and cholangiography was performed at 21 days before tube removal.

Table 1. DATA FOR PATIENTS TREATED BY LAPAROSCOPIC EXPLORATION OF THE BILE DUCT ACCORDING TO OPERATIVE TECHNIQUE

Technique	No. of Patients [stent] (%)	Age (years)*	Operating Time (min)*	Clearance (%)	Hospital Stay (days)*
All patients	300 [18]	51 (19–100)	101 (35–300)	271 (90)	2 (1–35)
Flushing	15 (5)	52	90 (50–140)	11 (73)	1 (1–3)
Transcystic exploration with basket	158 (53) [4]	48 (19–100)	80 (35–240)	145 (92)	2 (1–13)
Choledochotomy and T-tube insertion	61 (21)	56 (19–94)	130 (45–300)	51 (84)	4 (1–35)
Choledochotomy and primary duct closure	55 (18) [14]	52 (24–83)	125 (45–250)	54 (98)	2 (1–8)
Choledochoduodenostomy	11 (4)	65 (50–90)	145 (120–200)	11 (100)	4 (3–7)

* Values are median (range).

Discharge Policy

Patients were discharged when they were comfortable and when the drain had been removed. T-tubes were taped and the patients were encouraged to return to normal activity with the T-tube *in situ.* Stents were removed at 4 to 6 weeks endoscopically, without reimaging the biliary tree in most patients.

RESULTS

Over a 5.5-year period, laparoscopic CBDE was attempted in 300 patients with a median age of 51 years (range 19 to 100) (Table 1). Sixty-two (21%) of the patients were jaundiced at surgery, and in 22 patients (7%) CBDE was indicated because of failure of endoscopic treatment of bile duct stones. The remaining 216 patients had unexpected bile duct stones found at routine cholangiography during elective cholecystectomy. The overall duct clearance rate was 90%, with a median surgical duration, including cholecystectomy, of 101 minutes and postsurgical stay of 2 days (range 1 to 35 days).

Flushing and Transcystic Exploration

The first 15 patients underwent transcystic flushing with a success rate was 73% and a median procedure time of 90 minutes. Subsequently, transcystic CBDE with basket extraction was used without resorting to choledochotomy in 158 patients with a median age of 48 years. The clearance rate for transcystic exploration alone was 92%, with a median procedure time of 80 minutes and hospital stay of 2 days. Four patients had transcystic insertion of an antegrade stent without any complications. A further 14 patients proceeded to laparoscopic choledochotomy after a transcystic attempt was unsuccessful because of failure to position the basket into the common duct (seven patients) or inability to engage the stones into the basket (seven patients).

Choledochotomy

Choledochotomy was performed in 127 patients, with closure around a T-tube in 61 patients and primarily in 55 patients. Eleven patients underwent choledochoduodenostomy. The T-tube group had a median age of 56 years and a clearance rate of 84%, with a median procedure time of 130 minutes and hospital stay of 4 days. Fifty-five choledochotomies were closed primarily and 14 patients (25%) had an antegrade stent inserted; the median age was 52 years, the clearance rate was 98%, and the hospital stay was 2 days. Eleven patients underwent laparoscopic choledochoduodenostomy without postoperative complications; the median age was 65 years, the procedure duration was 145 minutes, and the hospital stay was 4 days.

Eight patients had a negative bile duct exploration (four transcystic, four choledochotomy) because of false-positive cholangiography results. Three of the four choledochotomies that followed transcystic exploration for residual filling defects were thought to represent small clots or debris.

Laparoscopic Failures

Of the 12 patients (4%) converted to an open procedure, 5 had impacted stones; access difficulties occurred in 3 patients because of adhesions or periductal inflammation; in 1 patient, the procedure was performed during the early transcystic flushing period; and in 1 patient, a ductal injury occurred (see below). The two remaining patients had tumors of the lower bile duct and were converted to an open operation for definitive surgery.

Ten patients (3%) who underwent surgery before January

Table 2. REOPERATIONS REQUIRED IN 11 PATIENTS AFTER LAPAROSCOPIC BILE DUCT EXPLORATION ACCORDING TO OPERATIVE TECHNIQUE

Initial Laparoscopic Procedure	Complication	Days Postoperative	Second Procedure
Transcystic exploration	Hemorrhage	1	Laparoscopy to reclip cystic artery
T-tube insertion	1. T-tube dislodged	1	Laparoscopic replacement of T-tube
	2. Peritonitis on T-tube removal	18	Laparotomy and drain insertion
	3. T-tube could not be removed	21	Laparoscopic removal of T-tube and drainage
	4. Pain and poor biliary drainage (2cm CBD)	165	Open Roux-en-Y hepaticojejunostomy
	5. Biliary stricture*	180	Open Roux-en-Y choledochojejunostomy
Primary duct closure	1. Bile leak	2	Laparoscopic resuturing
	2. Bile leak	2	Laparoscopic removal of retained stone, antegrade stent and resuturing
	3. Worsening jaundice, stitch occluding duct	3	ERCP, laparoscopic resuturing
	4. Bile ascites	8	ERCP with stent, laparoscopic washout
Primary duct closure with antegrade stent	5. Worsening jaundice, stent not in duodenum	2	Failed ERCP, laparoscopic removal of stent and insertion of T-tube (ampullary oedema)

* Discussed in text.

1993 had a failed laparoscopic clearance, and a decision was made to perform postsurgical ERC rather than convert to open surgery. Three ERCs followed flushing, six followed transcystic basketing, and one followed choledochotomy.

Seven patients (2%) had retained stones after laparoscopic bile duct clearance. They were detected by ERC in six patients for recurrent pain or jaundice and during repeated laparoscopy for bile peritonitis in one patient. Three occurred after transcystic exploration, three after choledochotomy with T-tube placement, and one after primary duct closure. A further six patients (four transcystic, two primary closure) underwent a postsurgical ERC for suspected retained stones, but no stones were demonstrated.

Complications During Surgery

During transcystic exploration, in one patient the Dormia basket impacted at the ampulla, requiring endoscopic manipulation during surgery; in another patient, extraction of an 8-mm stone caused a split at the cystic duct–common bile duct junction, which resulted in a bile leak that persisted for 5 days. During one procedure, the gallbladder fundal retractor detached and the right hemidiaphragm was perforated; it was repaired laparoscopically.

In one patient, a laparoscopic choledochotomy was performed for a stone in a 5-mm bile duct. The duct was transected for 75% of its diameter and converted for open duct repair over a T-tube. Six months after duct exploration, a Roux-en-y choledochojejunostomy was necessary to repair a tight stricture at the site of the original choledochotomy. The patient made a good recovery thereafter.

Postoperative Complications

There was one death (mortality rate 0.3%); it occurred in a 77-year-old patient who died from multiorgan failure and sepsis after surgery. This patient had developed biliary peritonitis 1 week before surgery after a liver biopsy. ERC had failed, and the laparoscopic procedure was converted to an open procedure because of gross fibrinous peritonitis. An 84-year-old patient suffered a stroke on the second day after surgery, resulting in a persistent, dense hemiparesis. Clinical pancreatitis was observed in one patient after transcystic extraction of an impacted stone at the ampulla, resulting in a hospital stay of 4 days.

T-tubes resulted in complications in 10 of 61 patients (16.4% of those with T-tubes). Three patients required repeated surgery (Table 2), day 1, day 18, and day 21 after surgery for bile peritonitis. Two required percutaneous drain insertion for subhepatic biliary collections. One required admission for pain 18 hours after T-tube removal. In a further three patients, the T-tube was found to be dislodged without consequence at postsurgical cholangiography. One patient developed cellulitis around the T-tube.

Of 55 primary bile duct closures, the five complications encountered all required repeated laparoscopy (see Table 2). Of the three patients with bile leaks, one underwent ERC and stent insertion before repeated laparoscopy, during which procedure peritoneal lavage alone was performed; two patients required laparoscopic resuturing, one after removal of a retained calculus. Two patients had a postsurgical ERC for worsening jaundice. One revealed a stitch occluding the bile duct, and the other had gross ampullary edema without evidence of the antegrade stent in the duo-

denum. Both situations were corrected laparoscopically without further problems.

Of the 27 postsurgical ERC procedures, 10 were electively undertaken early in the series, 14 were performed for clinically suspected stones (confirmed in seven patients, not confirmed in seven patients), 2 were performed for worsening jaundice (suture occluding the bile duct, antegrade stent not in duodenum), and 1 was performed for the bile duct stricture previously discussed. The 11 repeat procedures are shown in Table 2.

The last 100 laparoscopic CBDEs were performed from July 1995 to February 1997. There were 58 transcystic explorations and 42 choledochotomies, with primary closure in 35 patients (12 over an antegrade stent), one closure about a T-tube, and six laparoscopic choledochoduodenostomies. There were no conversions to open procedures. However, with limited follow-up, two patients have had unsuccessful stone clearance (transcystic exploration one, primary closure alone one), and there have been three laparoscopic repeat procedures (see Table 2: primary duct closure patients 3, 4, and 5).

DISCUSSION

This 5.5-year review shows that >90% of common bile duct stones can be dealt with laparoscopically. Indeed, we have been able to clear 98 of the last 100 unselected patients with bile duct stones, probably a result of the learning curve required for successful laparoscopic CBDE. The morbidity rate in our series—22/300 (7%)—compares favorably with that of open CBDE.[14] The mortality rate—0.3%—is also low compared with that of either open surgery or ERC.[7,15,16] These results support the findings of both Liberman et al.[17] and more recently Rhodes and Sussman18 that laparoscopic CBDE has reduced morbidity rates, length of hospital stay, and costs when compared with laparoscopic cholecystectomy plus ERC.

Surgery in this series was performed on a unit with a special interest in minimal access surgery; however, operations were performed both by consultants and senior trainees (IM, IB, and MR). Our results are similar to those of other authors who have reported on laparoscopic CBDE.[19–22] Khoo et al.[19] attempted 59 laparoscopic CBDEs with an overall clearance rate of 75%. Stones were not confirmed in 8 of 59 patients, reflecting the difficulties with still-plate exposures rather than dynamic fluoroscopy, an essential component of image-guided basket retrieval. Berthou et al.[20] reported on 200 laparoscopic CBDEs from two institutions in France with an overall success rate of 95%. Of 100 attempted transcystic explorations, only 68 (67.3%) were successful, despite cystic duct dilation followed by choledochoscopic extraction of stones. However, both Philips et al.[11] and Petelin,[12] reporting on 66 and 86 laparoscopic CBDEs respectively, found the transcystic technique to be applicable, with perseverance, in >80% of bile duct stones.

Lezoche et al.[21] reported on 100 laparoscopic CBDEs with five retained calculi and a procedure-related morbidity rate of 8%. In contrast to our series, they inserted a biliary drain in 20 of 32 transcystic explorations and 28 of 33 choledochotomies. Similarly, Millat et al.[22] reported on 115 laparoscopic CBDEs with an 87% clearance rate. External biliary drainage was used in 35 of 71 transcystic explorations and all of the 33 choledochotomies. In our experience, external biliary drainage increased the morbidity rate, and we have reserved internal antegrade stenting for cases of cholangitis, sludge, or numerous (more than five) stones in the duct. Laparoscopic choledochoduodenostomy was performed in elderly patients with ampullary stenosis and ducts dilated beyond 15 mm in diameter. This may be technically challenging; however, our early results support continuation of this practice.

Although management of bile duct stones may vary around the world, depending on local expertise, our figures suggest that with practice, surgeons can tackle ≥90% of stones successfully with laparoscopic cholecystectomy, avoiding ERC or T-tubes in the vast majority. The techniques used are simple and applicable to biliary surgeons the world over. Initial exploration of the bile duct requires simply a ureteric stone basket and C-arm screening, which is available in most operating suites. Although some authors make extensive use of a 3- or 5-mm choledochoscope, we have not found it necessary for successful transcystic basket extraction of stones, which is a safe technique and often relatively simple. In contrast, choledochotomy requires particular rehearsed experience in dissection and suturing techniques to achieve similarly good results. The increased morbidity rates associated with choledochotomy warrant comparison with those of postsurgical ERC and endoscopic sphincterotomy in randomized trials. Primary duct closure, in our experience, is a simpler and less hazardous alternative to T-tube insertion. Our selective use of an antegrade stent has prevented bile leak in all cases where this has been used.

In conclusion, we have demonstrated that laparoscopic CBDE is both feasible and safe. As our experience with the technique has grown, we have used both transcystic and direct choledochotomy to deal with bile duct stones. The vast majority of patients fit for surgery with gallbladder and bile duct stones can expect to be managed with a single laparoscopic procedure without biliary drains or ERC. ERC and endoscopic sphincterotomy carry substantial morbidity and mortality rates, even in young patients, and these risks now equal or exceed those of patients undergoing laparoscopic CBDE. Surgeons who operate regularly on the gallbladder should aim to master laparoscopic CBDE as an essential surgical option in the management of bile duct calculi.

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