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Laparoscopic Transcystic Choledochotomy with Primary Suture for Choledocholith

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ABSTRACT

Background and Objectives: To investigate the possibility of extracting common bile duct (CBD) stones by laparoscopically inserting choledochoscope through the natural orifice of the cystic duct and a mini-incision on the CBD, and the safety of laparoscopic primary double-layer suture of the cystic duct and CBD.

Methods: Laparoscopic transcystic choledochotomy and extraction of stones with primary suture was performed on 194 patients with gallbladder and CBD stones from October 1, 2009, through April 30, 2012. The cystic duct was left at a diameter of 1 to 1.5 cm after removal of the gallbladder. The duct was longitudinally cut at its ventral side to the confluence with the CBD, and the anterior wall of the CBD was also cut longitudinally. A choledochoscope was then inserted via the enlarged opening, and the stones were extracted from the CBD. Finally, the CBD and cystic duct were closed by continuous mucous layer suture and seromuscular Lembert suture, respectively. The cystic duct was ligated close to the CBD and an abdominal drainage tube was placed.

Results: All surgical procedures were successfully performed. The caliber at the confluence between the cystic duct and the CBD was 0.3 to 0.8 cm (SD 0.4 ± 0.1 cm), and the mini-incision of the CBD was 0.1 to 1.1 cm (SD 0.3 ± 0.2 cm). Abdominal drainage lasted 3 to 5 days. Magnetic resonance cholangiopancreatography (MRCP) in 55 patients showed no abnormal change in the CBD diameter. Two patients had bile leakage. Another patient had intermittent abdominal pain and jaundice 5 to 7 days postoperatively, and the retained stones spontaneously passed. The postoperative hospital stay was 6 to 13 days (SD 8 ± 2.1 days). Observation of 176 patients (90%) lasting 1 to 30 months (SD 11 ± 8 months) showed no recurrent stones or stricture of the CBD.

Conclusion: The surgical procedure of laparoscopic transcystic choledochotomy and extraction of stones with primary suture is feasible and safe.

Key Words: Common bile duct stones, Laparoscope, Primary closure of common bile duct, Transcystic.

INTRODUCTION

Compared with traditional laparotomy, laparoscopic choledochotomy with T-tube drainage has dramatically decreased surgical trauma for patients. In this case, the problems caused by placing a T-tube—for example, the inconvenience to the patient caused by the T tube and drainage bag, bile-induced peritonitis after removal of the T tube, and accidental slippage of the T tube from the common bile duct (CBD)—gradually aroused the concern of surgeons.[1–5] With the use of laparoscopic choledochotomy and extraction of stones with primary closure, we have improved the traditional technique used for laparoscopic choledochotomy in China, which was laparoscopic transcystic choledochotomy and extraction of stones with primary closure. By making use of the natural tube of the cystic duct, this procedure minimizes the size of the incision into the common bile duct (CBD), and the application of separate laparoscopic double-layer suture of the mucous and seromuscular layers dramatically decreases the postoperative incidence of bile leakage. Furthermore, the novel procedure can shorten the postoperative stay, reduce hospitalization costs, and speed the patient's recovery.

From October 1, 2009, through April 30, 2012, 194 laparoscopic transcystic choledochotomies with extraction of stones and primary closure were performed. A description of the surgical procedure and the results in our patient cohort follows.

METHODS

The group of 194 patients consisted of 69 men and 125 women aged 29 to 93 years (SD 57.2 ± 18.1 years). All of them had a medical history of intermittent right upper quadrant pain for 3 months to 10 years. On admission, 37

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Table 1.
Preoperative CBD Caliber and Liver Function of the Patients

	CBD Caliber (cm)	ALT(μ/L)	AST(U/L)	TBil (μmol/L)	DBil (μmol/L)	GGT (U/L)	ALP (U/L)
Mean	0.953	178	126.9	48.45	22.48	341.5	214.9
SD	0.408	185.1	177.4	53.57	31.65	303.2	155.1
Maximum	1.7	867	567	274.1	142.6	1071	586
Minimum	0.3	13	13	6.8	1.4	19	53

N = 194. Normal level for ALT (alanine aminotransferase), 7–40 U/L (to convert to the SI unit μkat/L, multiply by 0.0167); AST (aspartate aminotransferase), 13–35 U/L; GGT (γ-glutamyltransferase), 7–45 U/L; ALP (alkaline phosphatase), 35–135 U/L; Tbil (total bilirubin), 5–30 μmol/L; and Dbil (direct bilirubin), 0–5μmol/L.

patients (19.1%) had acute onset of abdominal pain with concurrent jaundice and fever for 3 to 5 days. The abdominal pain had abated in 157 patients (80.9%). Different degrees of jaundice were found in 128 patients (81.5%), with total bilirubin ranging from 41 to 310 μmol/L (normal range, 5–30 μmol/L). Twenty-three patients had concurrent fever, with body temperature from 37 to 38.5°C (SD 37.6 ± 1.2°C). Diagnostic blood biochemical tests, B-type ultrasound, computed tomography (CT), and magnetic resonance cholangiopancreatography (MRCP) were completed in each patient (Table 1).

Finally, cholecystolithiasis combined with concurrent CBD stones was diagnosed by MRCP in 194 patients; all were secondary choledocholithiasis without cirrhosis. Chronic cholecystitis without concurrent acute CBD inflammation was present in 112 patients (58%).

Inclusion criteria were CBD diameter more than 5 mm; somewhat large CBD stones or incarcerated ampullary stones that could be treated with a lithotripter (holmium laser lithotripter; Aikekaineng Technology Co, Ltd, Beijing, China); stones completely extracted from the intrahepatic and extrahepatic ducts, confirmed by choledochoscopy after laparoscopic bile duct exploration; and no edema or stricture in the CBD ampulla, duodenal papilla, or CBD outlet. The surgical procedure would be converted to conventional laparoscopic choledochotomy with primary closure or T-tube drainage in the following conditions: intrahepatic stones could not be extracted entirely during the operation; if the cystic duct enters the CBD through the back wall of CBD; and the cystic and common hepatic ducts ran in parallel for too long.

Surgical procedure

General anesthesia and endotracheal intubation were performed. Two 10-mm trocars were placed below the xiphoid process and through the right margin of the umbilicus. Two 5-mm trocars were then placed at the right costal margin on the collarbone midline and lower right abdomen. First, a laparoscopic cholecystectomy was performed, and the residual cystic duct diameter was retained at 1 to 1.5 cm. The cystic duct was cut longitudinally on its ventral side up to the confluence of the cystic duct and CBD, after which the a longitudinal cut of approximately 3 cm was made in the anterior wall of the CBD (**Figure 1**). A choledochoscope (4.5 mm CHF-V Electric Choledochoscope; Olympus, Tokyo, Japan) was then inserted through the enlarged opening for exploration of the distal CBD and extraction of stones (**Figures 2** and **3**), after which it was turned upward for exploration of the common hepatic duct and intrahepatic ducts, bypassing the valvular septum around the confluence (**Figure 4**). The distal CBD was checked for a second time after the intrahepatic exploration identified no stones.

If no edema or stricture was found in the duodenal papilla, the irrigation water flowed smoothly through the CBD, and the sphincter of Oddi worked normally, the mucous layer was continuously sutured from the distal end of the combined incision to the cystic duct end with 5-0 sutures (**Figure 5**). The muscular layer was then closed by the Lembert technique, with the same absorbable suture (**Figure 6**). The cystic duct, 0.2 cm away from the CBD, was double ligated with an endoloop. Excess distal cystic duct was removed and a drainage tube was placed in the gallbladder bed.

RESULTS

Acute cholecystitis with concurrent acute cholangitis and acute liver injury were found in 82 patients (42%) and 71 patients (36.5%), respectively. Acute pancreatitis occurred in 21 patients (10.8%), with elevated blood and urine amylase level of 110 to 1230 U/L (to convert to SI unit μkat/L, multiply by 0.0167) and 460 to 9800 U/L, respectively (normal level for blood and urine amylase, 0–96 U/L and 0–450 U/L, respectively). Twelve patients (6.2%) had blood electrolyte disturbances, with serum K^+,

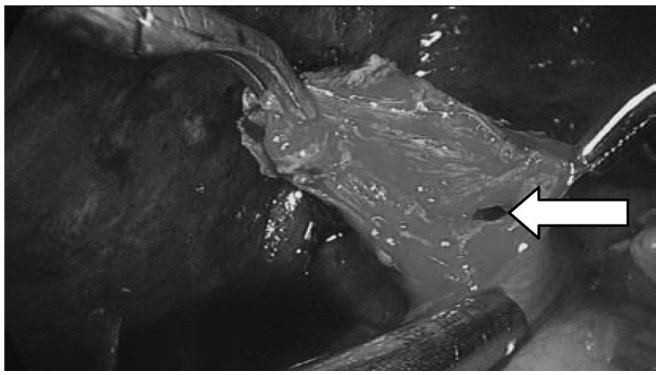

Figure 1. Cystic duct opening.

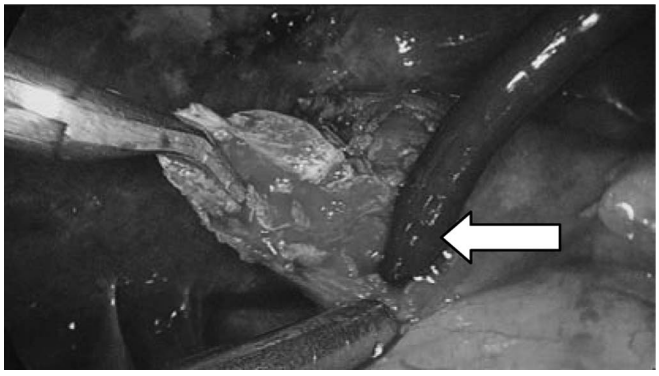

Figure 2. Choledochoscope insertion.

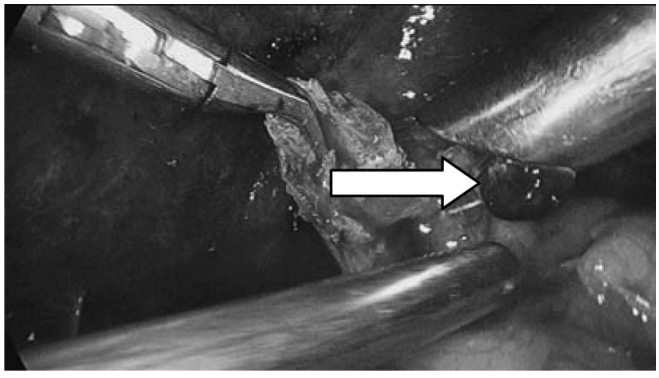

Figure 3. Extraction of stones.

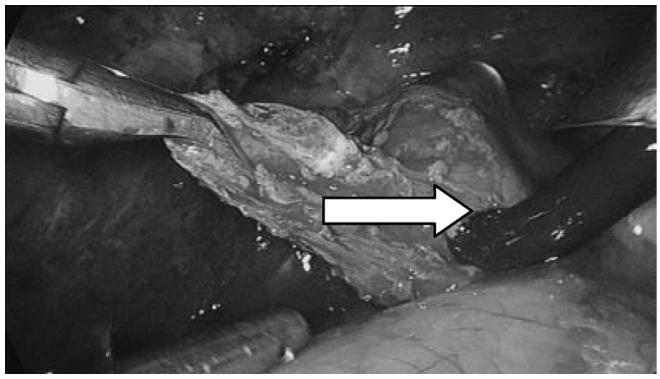

Figure 4. Intrahepatic duct exploration.

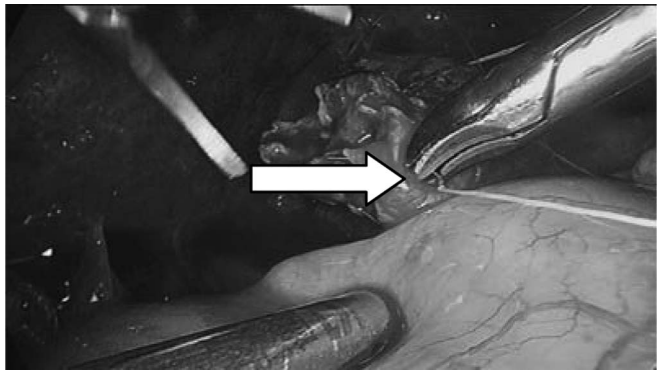

Figure 5. Mucous layer suture.

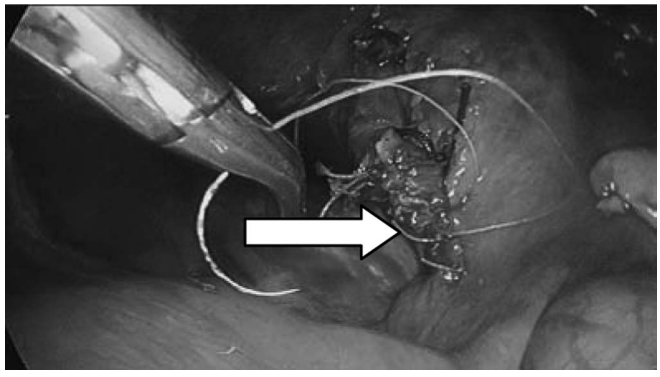

Figure 6. Seromuscular layer suture.

2.9 to 3.5 μmol/L; Na^+, 129 to 130 μmol/L; Cl^-, 89–101 μmol/L; Ca^{2+}, 1.9–2.3 μmol/L (normal level for K^+, Na^+, Cl^-, and Ca^{2+}: 3.5–5.3 mmol/L, 137–147 mmol/L, 99–110 mmol/L, and 2.1–2.6 mmol/L, respectively) One patient had a 3.5-cm abscess on the anterior right lobe of the liver, identified by CT. In the 194 patients, concurrent coronary heart disease, type 2 diabetes mellitus, hypertension, and arrhythmia were present in 18 (9.3%), 13 (6.7%), 10 (5.1%), and 11 (5.7%), respectively. One patient had a history of subtotal gastrectomy, and another 2 had a history of biliary tract surgery.

Laparoscopic cholecystectomy with transcystic choledochotomy and intraoperative bile duct exploration was performed in 194 patients. Perioperative conditions of all patients are shown in Table 2. A comparison between preoperative and postoperative MRCP of 55 patients showed no obvious change in the CBD (**Figure 7**). Of all 194 operations, the choledochoscope was directly inserted through the cystic duct without incision in 5 (2.5%), whereas in 56 (28%), it was inserted through a mini-incision in the cystic duct. In the rest (133 patients), a 0.1- to 1.1-cm transcystic

Table 2.
Perioperative Conditions of the Patients

	Operative Time (min)	Blood Loss (mL)	Stones (n)	Stone Size (cm)	Abdominal Drainage (mL)			Time to Removal of Drainage Tube (d)	Postoperative Stay (d)
					d 1	d 3	d 5		
Mean	104.4	26.4	2	0.7	36	15	0.7	5.9	8.04
SD	41.76	40.8	2	0.4	74	69	3.2	5.7	2.13
Maximum	285	200	9	3	150	700	20	18	14
Minimum	45	0	1	0.2	0	0	0	2	3

N = 194.

Figure 7. a, Preoperative and b, postoperative MRCP.

incision was made in the CBD for choledochoscopic exploration and extraction of stones. Bile leakage occurred in 2 patients, without obvious abdominal pain, distention, or signs of peritoneal irritation. The maximum bile drainage in these 2 patients was 150 and 200 mL. After the patients fasted and underwent fluid infusion, the bile leakage stopped, 9 after the operation in one and 13 days in the other. In 2 patients, postoperative abdominal pain and distension abated spontaneously after 48 hours. The average postoperative hospital stay of the 194 patients was 8.0 days (SD 8 ± 2.1 days).

Owing to the low position of the valvular septum around the confluence, 92 patients (47%) had unsuccessful intrahepatic duct exploration by choledochoscope. A residual hepatic duct stone was found in 1 patient, who had intermittent abdominal pain and jaundice on postoperative days 5 and 8, respectively. MRCP of this patient showed the residual stone located in the CBD (**Figure 8a**). Both the abdominal pain and jaundice ceased on postoperative day 9 after the stone was discharged spontaneously (**Figure 8b**). Follow-up of 176 patients (90%) showed no recurrent CBD stones or strictures. Fifty patients were observed for 6 months, 60 for 6 to 12 months, and 66 for more than 12 months.

DISCUSSION

Current Development of Minimally Invasive Surgical Techniques in the Treatment of Secondary Choledocholithiasis

Duodenal endoscopic extraction of stones has been reported in the treatment of common bile duct calculi, both

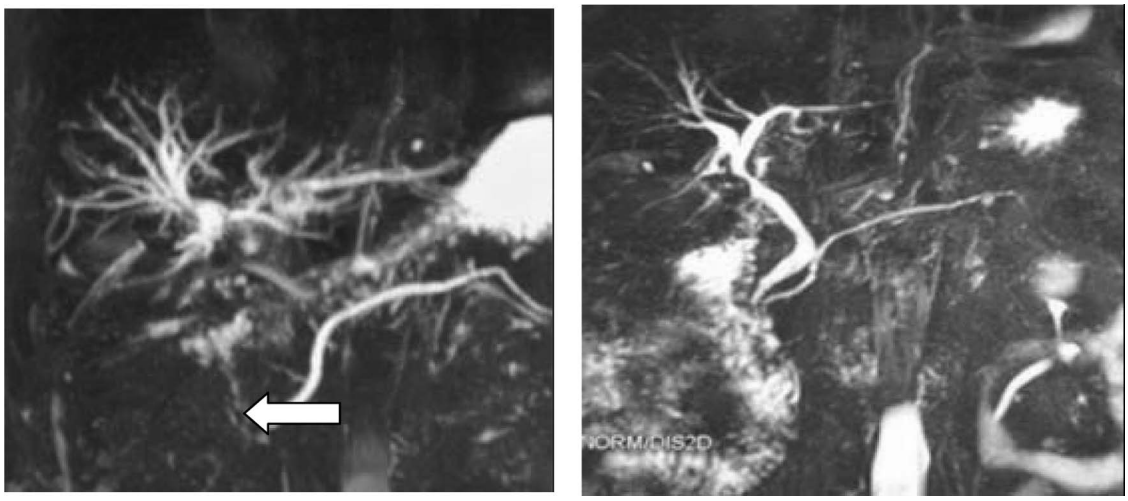

Figure 8. a, Residual stone in CBD. b, MRCP after the stone spontaneously dislodged.

at home and abroad. The procedure must be selected according to the size of the stone. Endoscopic papillary balloon dilation (EPBD) is used for stones less than 5 mm, and endoscopic sphincterotomy (EST), with a net basket and holmium laser lithotripsy, is applied for stones more than 5 mm or incarcerated stones.

Duodenal endoscopic stone extraction has certain requirements: smaller stones, fewer stones, and location close to the duodenal papilla. The success rate is about 80%. In EST, it is very important to avoid cutting the duodenal papilla and impairing the structure and function of the sphincter of Oddi. Annoying recurrent retrograde infections in the CBD happen often. Therefore, we usually perform a laparoscopic choledochotomy, no matter how many stones, their size, or the presence or not of duodenal papilla lesions. The operation is simple. Even if stones cannot be completely removed intraoperatively, a T tube may be placed, to remove the residual stones postoperatively by choledochoscope. Disadvantages are the need for surgery, increased trauma, longer operative time, and more surgical participants compared with stone extraction by duodenal endoscopy.

Choledochotomy with T-tube drainage has been the classic surgical treatment for secondary bile duct stones. Since 1997, our hospital has performed laparoscopic treatment of CBD stones, and 1385 laparoscopic choledochotomies with T-tube drainage have been completed through April 2012. Compared with traditional laparotomy, laparoscopic choledochotomy with T-tube drainage has dramatically decreased surgical trauma. New problems have aroused concerns, however, such as discomfort of patients caused by the prolonged need for the T-tube, peritonitis caused by bile leakage after removal of the tube, and T-tube complications such as accidental slippage out of the CBD.[1–5] EST can be used as an alternative to extract stones from the CBD, but the sphincter of Oddi, along with its normal function can be badly injured. For a long time, surgeons have been looking for a procedure for the removal of CBD stones in one operation, with less damage to the sphincter and fewer complications. In 1932, Mirizze introduced the technology of intraoperative cholangiography. Later, the choledochoscope was widely used intraoperatively and decreased the incidence of residual biliary stones greatly.[6] Laparoscopic common bile duct exploration avoids intraoperative radiologic injury to patients and operator, allows removal of the CBD stones, and shortens the postoperative hospital stay.[7–10] Above all, transcystic exploration avoids CBD injury, reduces the incidence of postoperative bile leakage and CBD stricture, and shortens the operative time and postoperative hospital stay.[5,10–11] For the patients who are inappropriate for transcystic extraction of stones, it is still necessary to convert to choledochotomy to extract the stones.[1–3,5,10] If there is neither residual calculi nor edema and stricture after laparoscopic common bile duct exploration, it is safe and effective to perform primary closure of the CBD.[7,12,13] According to reports in the literature, primary closure of the CBD is generally by full-thickness continuous suture.[1,12,13] However, in the case of postoperative high bile duct pressure, bile leakage from a suture pinhole may occur. A preoperative endoscopic nasal biliary drain or an intraoperative bile duct duo-

Figure 9. Diagram of transcystic choledochotomy.

denal drainage tube is usually placed, to prevent bile leakage.

Based on the current treatment of secondary cholangiolithiasis, we have described laparoscopic transcystic choledochotomy with primary double-layer suture. By making full use of the natural dilatation around the confluence between the cystic and hepatic ducts found in most patients, the surgeon can easily insert the choledochoscope into the CBD through the natural orifice in the lumen of the cystic duct or by a combined continuous incision in the cystic duct and CBD (**Figure 9**). The use of primary double-layer suture of the mucous and seromuscular layers can avoid the placement of a T-tube drain, decrease the occurrence of bile leakage, and avoid discomfort from the presence of the T-tube. Among the 194 patients in this study, postoperative bile leakage occurred only in 2 (1%). According to a report by Cai et al[14] the postoperative rate of bile leakage for laparoscopic choledochotomy with T-tube drainage or primary CBD closure was 4.50% and 4.00%, respectively.[14] In another study on laparoscopic choledochotomy with primary CBD closure, Decker et al[1] reported a bile leakage rate of 3% (3/100).[1] A further two original studies on laparoscopic transcystic CBD exploration reported a rate of 7.4% (2/27) and 3.39% (2/59), respectively.[5,11] We found during the operation that the CBD at its confluence with the cystic duct had a greater diameter than other points along the duct. In this article, the site of the CBD incision was in this enlarged portion. Thus, the suture of the CBD and cystic duct generally had no effect on the diameter of the CBD and made primary closure feasible, decreasing the possibility of postoperative stricture of the CBD dramatically. Postoperative MRCP in 55 patients in this study showed no abnormal change in the CBD caliber, compared with that seen in the preoperative scans.

Indications for Laparoscopic Choledochotomy and Extraction of Stones with Primary Closure

At present no unified surgical indication has been reported for choledochotomy with primary closure.[2,5] In addition to the surgeon's proficiency in performing laparoscopies, it has been reported that the CBD can be continuously sutured if neither tissue fragments nor stone sludge is directly viewed in the CBD and if the ampulla of Vater is found to have no stricture.[5] Moreover, it has been recommended that a T tube should be placed if the distal bile duct has high biliary pressure, if a postoperative cholangiogram is deemed essential, or if residual stones must be extracted postoperatively.[3,15]

Based on our laparoscopic experiences, we suggest the following indications for laparoscopic CBD exploration with primary closure: (1) definite diagnosis of CBD stones with a CBD diameter of more than 5 mm. In general, the CBD diameter should be more than 8 mm, to allow primary closure. However, by making use of the improved procedure, the incision site of the CBD is the area of natural dilatation around the confluence between the cystic duct and the CBD, along with the natural lumen of the cystic duct. Thus, the length of the incision in the CBD, the postoperative incidence of CBD stricture, and bile leakage are decreased. (2) Both intrahepatic and extrahepatic duct stones must clearly have been extracted. The use of a lithotripter makes it possible to have primary CBD closure in the presence of large stones or incarcerated ampullary stones, but the gravel must be removed completely. (3) No edema or stricture of the CBD, ampulla, or duodenal papilla must be present in intraoperative inspection by choledochoscope. Irrigation water must pass smoothly through the CBD and into the duodenum. (4) The surgeon has proficient experience in laparoscopic choledochotomy, suture, and manipulation of the choledochoscope. It is important to minimize stimulation of the ampulla or duodenal papilla with the choledochoscope; both are risk factors for bile leakage. One patient in our group had a 3.5 × 1.5-cm cylindrical stone in his 1.7-cm diameter CBD. Transcystic choledochotomy with primary closure was successfully completed through a 1.1-cm CBD incision. No postoperative bile leakage occurred.

Features and Techniques of Laparoscopic Transcystic Choledochotomy

The use of the cystic duct makes it possible to shorten the CBD incision, because the longitudinal incision of the cystic duct offers a passage for the choledochoscope to enter the CBD. The caliber of the choledochoscope rou-

tinely used was 0.45 cm, and the diameter at the confluence between the cystic duct and CBD in all the patients was 0.3 to 0.8 cm. In transductal choledochotomy, the CBD incision was 1.0 to 1.5 cm (average, 1.2 cm). However, by laparoscopic transcystic choledochotomy, the CBD incision was 0.1 to 1.1 cm (average, 0.5 cm). Moreover, less injury of the CBD ensured a lower risk of bile leakage or bile duct stricture.

The cystic duct should be entered through a ventral longitudinal incision. At the confluence, the incision should be made along the longitudinal axis of the CBD, with care taken to avoid opening the CBD transversely.

The shorter the CBD incision, the more difficult it is to perform the choledochoscopic exploration in the direction of the hepatic duct. Another factor affecting exploration in the direction of the hepatic duct is the existence of the valvular crescent septum at the junction of the cystic duct and common hepatic duct wall. For CBD exploration, it is easier for the choledochoscope to pass the septum, but it is more difficult to bypass the septum upwardly for intrahepatic exploration. In this study, intrahepatic duct choledochoscope exploration failed in 92 patients (47%), and 1 patient had postoperative residual stones. Therefore, it is essential to determine the locations of stones by preoperative CT or MRCP.

The caliber of the CBD was seldom narrowed by this novel procedure of cut and suture, because the CBD incision was shorter (average, 0.5 cm). In addition, the CBD is capable of self-adjustment and can regulate its caliber in accordance with the bile duct pressure. Moreover, we left a margin of 1.5 to 2 mm from the stitches to the edge of the incision in the CBD when closing the CBD. These efforts ensured that there would be no postoperative stricture in the CBD during follow-up. To determine whether postoperative bile duct stricture occurred, a postoperative MRCP was performed. The comparative results between preoperative and postoperative MRCP in 55 patients objectively proved the effectiveness of this new procedure in avoiding postoperative CBD stricture.

The process of laparoscopic primary closure of the bile duct has rarely been reported in the literature . CBD full-thickness suture has been performed in most reported transductal choledochotomies.[1,5,12,13] Interrupted suture is rarely reported, perhaps because of the complexity of suture by laparoscope.[10–11] However, the method of primary closure is known to be very important, in that it may influence the postoperative incidence of bile leakage and bile duct stricture.[16,17] In this study, an improved technique for primary suture was used. First, continuous suture of the mucosa from the distal CBD to the distal cystic duct with 5-0 absorbable sutures was performed, to close the mucous layer tightly with good mucosal apposition. Second, Lembert's seromuscular suture technique was used, with care taken to avoid penetrating the mucosal layer and causing bile leakage. The distance between stitches was commonly 2 mm in the muscular suture. If the CBD wall was thin and bile was seen leaking from a pinhole during the operation, the hepatoduodenal ligament was sutured by the Lembert method. The abdominal drainage tube can be removed 3 to 5 days postoperatively if no bile is discharged from the drainage tube and if the patient has no abdominal pain, fever, or jaundice. There is evidence that T-tube placement compromises the advantage of the minimally invasive technique and increases the risk of complications and length of hospital stay. Thus, laparoscopic CBD exploration with primary closure is recommended.[2,7,18] Comparatively, primary closure of the CBD may shorten the hospital stay, reduce hospitalization expenses, and increase patient comfort, while avoiding the postoperative complications of bile leakage and peritonitis.[2–3,7,18–20] A transcystic drainage tube or temporary bile duct stent can be placed intraoperatively, if necessary. Ha et al.[4] reported a study of 36 patients with choledochotomy and extraction of stones with primary closure. Paralytic ileus and subhepatic effusion occurred in 2 patients, with no other complications. The study also supported that primary closure is feasible and can shorten the hospital stay and reduce medical costs.[4]

CONCLUSION

Laparoscopic transcystic choledochotomy and extraction of stones with primary double-layer closure decreases surgical injury, incidence of bile leakage, hospital stay, and admission costs. It is essential for the surgeon to have a good mastery of both the surgical indications and the laparoscopic surgical technique.

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