Instrumentation and Techniques for Laparoscopic Common Bile Duct Exploration

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The surgical management of biliary stone disease has long since included ERCP and endoscopic sphincterotomy (ES) for the diagnosis and treatment of common bile duct (CBD) stones. Indications to ERCP/ES have progressively expanded from the diagnosis and treatment of retained CBD stones after cholecystectomy to the management of severe cholangitis and acute pancreatitis in high-risk patients to the treatment of all patients with gallstones and CBD stones as part of an integrated endosurgical sequential approach.

By the end of the 1980s (when laparoscopic cholecystectomy became popular) in most surgical centers routine ES and open cholecystectomy were still considered the treatment of choice for these patients. Both retrospective and prospective randomized studies, comparing the combined endosurgical treatment versus surgery alone in elective patients, have failed to demonstrate any significant advantage of the former in lowering morbidity and mortality, but rather a higher incidence of procedure-related morbidity after ES.[1-4] The advent of laparoscopic cholecystectomy (LC), introducing the need on behalf of the surgeon to learn a completely new eye-hand coordination with its inherent difficulties in performing laparoscopic intraoperative cholangiography and cholecystectomy, together with the initial lack of specifically designed laparoscopic instruments, further discouraged most surgeons from following the surgical option in the treatment of CBD stones. This inevitably led to a dramatic increase in the number of ERCP and ES performed.[5] However, the preoperative prediction of CBD stones is poor and leads inevitably to a high number of false-negative, unnecessary ERCP.[6] Moreover, as already demonstrated before the advent of LC, ERCP/ES is not completely without short-term risks (10% morbidity, 10% failure rate, 1% mortality[7]) which are additive with the

risks of any surgical procedure in those patients–the majority–undergoing cholecystectomy (laparoscopic or open). A higher long-term incidence of recurrent CBD stones has also been reported (with the occurrence of stenosis and bactibilia) after endoscopic or surgical sphincterotomy than after choledocholithotomy,[8] causing some concern in considering ES as the treatment of choice in younger patients with a long life expectancy. It should also be considered that ES may require more than one endoscopic attempt to achieve complete stone clearance, with consequent increase in the number of days the patient spends in the hospital. When this is added to the in-hospital stay for laparoscopic cholecystectomy, a prolonged total in-hospital stay is derived.

Given these preliminary considerations, the hypothesis that we made was that, at the present level of technological advancement and laparoscopic expertise, the diagnosis and treatment of CBD stones in patients undergoing LC could be carried out within the same operative setting. The ideal approach that was pursued in every patient with biliary stone disease aimed at avoiding preoperative ERCP (to reduce the incidence and risks of unnecessary preoperative ERCP, unless jaundice was present), attempting to remove all ductal stones "from above" through the opened cystic duct without dividing the sphincter of Oddi, and then closing the cystic duct, with a postoperative course that was to be the same as for LC only. Therefore a study on the feasibility of laparoscopic single-stage management of gallstones and CBD stones in a series of 140 unselected, consecutive patients was initiated, evaluating its safety and short-term results. The aim of this report is to describe the instrumentation and the surgical technique required for laparoscopic CBD exploration during LC.

MATERIALS AND METHODS

All patients observed with biliary stone disease were evaluated for possible inclusion in this study. Blood tests and ultrasound scan, together with collection of the history and physical examination, were the only preoperative examinations performed. Common bile duct radiologic imaging for demonstration of stones was routinely performed intraoperatively, as shown in the clinical design of the study depicted in Figure 1, whereas preoperative ERCP was reserved only for jaundiced patients to exclude the presence of cancer. The inclusion criterium for each patient to be included in the study was the intraoperative choledochoscopic or radiologic unequivocal demonstration of CBD stones.

In the period between April 1991 and August 1995, 1272 consecutive patients with biliary stone disease were seen in our service. Overall, ductal stones were present in 140 patients out of 1272 (11%) (81 females, 59 males). The mean age was 63.9 years (age range: 12 to 94 years) with 60 patients being older than 70 years (42.8%). Ductal stones were preoperatively suspected, or proven, in 82 patients out of 140 (58.5%), based on history and/or laboratory tests and/or ultrasound scan. In 29 patients of this group, one or more preoperative ERCP/ES had been attempted elsewhere and had been unsuccessful for one reason or another (papillary diverticulum, large ductal stones, inability to cannulate the papilla, etc.), the patients being referred to us afterwards for surgical treatment. Ductal stones were unexpectedly discovered by routine intraoperative cholangiography during LC in 58 of 140 patients (41.4%).

Twenty-eight patients had previously undergone upper abdominal or other major lower abdominal surgery, including open cholecystectomy (1), partial gastrectomy (8), epigastric hernia repair (1), right hemicolectomy (6), hysterectomy (8), and left colectomy (5).

Port-site position for laparoscopic CBD exploration was the same as for LC and is shown in Figure 2. Note that the position of the so-called (for convenience) right midclavicular port, which was positioned under laparoscopic vision with a grasper from the epigastric port raising the liver, was in fact slightly more medial and corresponded to the closest and most perpendicular point with respect to the CBD. Routine intraoperative cholangiography, as previously described,[9] was performed with a cholangiogram clamp (Karl Storz,

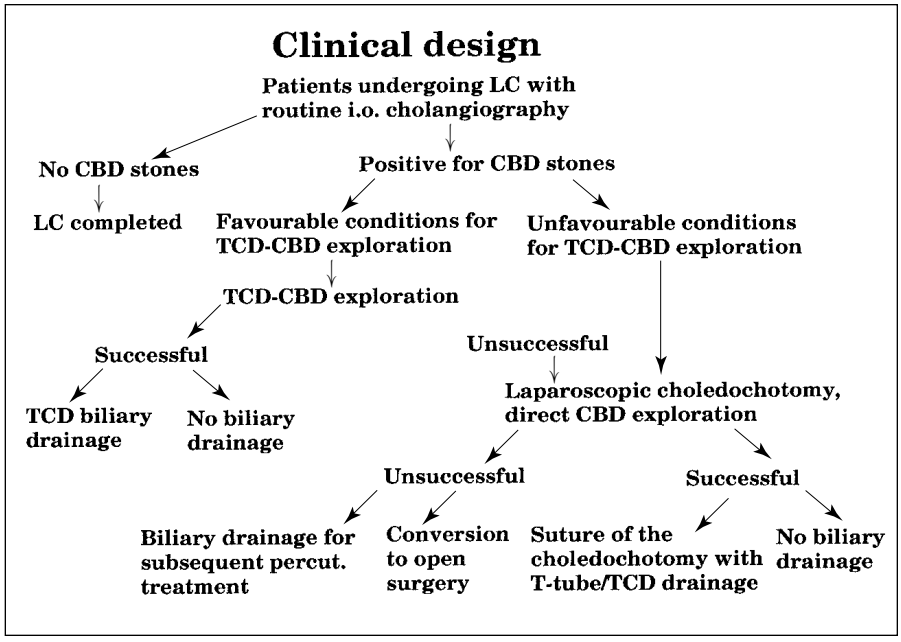

Figure 1. Clinical design of the study.

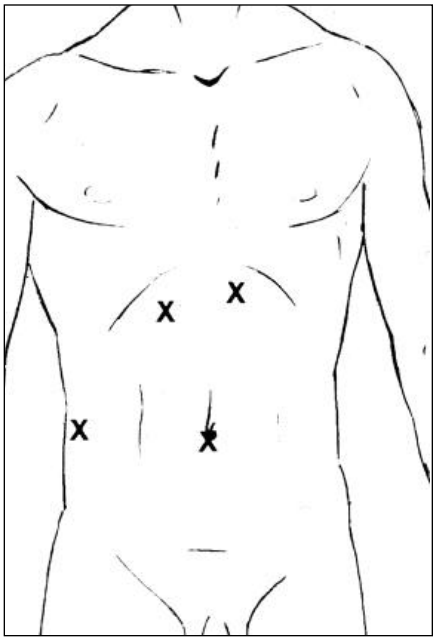

Figure 2. Port-site position.

Tuttlingen, Germany) and a 4 or 5 Fr. ureteral catheter (W. Cook Europe APS, Denmark), after complete preparation of the gallbladder infundibulum and of the cystic duct from the neck of the gallbladder down to the point where the cystic duct met the lateral aspect of the common bile duct. The cholangiogram clamp and catheter were introduced from the midclavicular port and cannulation of the cystic ductotomy was facilitated by a 10-mm grasper (MIC 500, Ethicon Endo-Surgery, Cincinnati, Ohio) introduced from the epigastric port, placing the cystic duct along the same axis with the cholangiogram catheter and providing countertraction to the infundibulum as the catheter was pushed inside the duct (Fig. 3). A dynamic radiologic study of the entire biliary tree was then obtained either with a digitally enhanced fluoroscope (OEC Diasonics, Series 9400, Salt Lake City, Utah) or with a standard fluoroscope (ATS, Bergamo, Italy) by injecting a solution of contrast medium containing 125 mg/mL of iodine. Hard copies were also obtained for documentation.

Transcystic Duct Approach

When ductal stones were proven by intraoperative cholangiography, the transcystic duct access to the common bile duct (TCD–CBD) was always attempted first, as this was considered to be the ideal treatment. All CBD exploration instruments were introduced through the right midclavicular port. To provide a better access to the CBD, the cystic duct was dilated with a balloon ureteral dilator catheter (W. Cook Europe APS, Denmark, No. 79674). Only half the length of the balloon (2 cm) was introduced through the cystic duct opening while the remaining half was kept under laparoscopic vision. The balloon was inflated to a diameter of 6 mm with a syringe containing saline. A dedicated manometer to measure the cystic duct dilation pressure was not necessary since cystic duct dilation could easily and safely be accomplished by simply filling the balloon with saline to its maximum diameter (6-mm) and keeping it filled under manual pressure for a few seconds. The cystic duct was then cannulated with a closed flat-wire stone extractor catheter (W. Cook Europe APS, Denmark, No. 14720 or 14740) introduced from the right midclavicular port through a 10-mm metal cannula with rubber sealing to prevent gas loss. The catheter was gently pushed inside and along the CBD to reach the papilla and was then opened under radiologic control. After our experience increased (after the first 50 patients), radiologic control was omitted to reduce patients' and surgeons' exposure to X-rays, since we learned to recognize, having developed the necessary tactile sensation, when the tip of the catheter was still inside the common bile duct or when it had passed through the papilla. The details of the exploration maneuver with basket, that was performed without radiologic or endoscopic control after cystic duct balloon dilation, are as follows:

1. The catheter was pushed *gently* inside the common bile duct for a length of 6 to 8 cm, as measured by the markings on the external surface of the sheath of the catheter, until a resistance was appreciated (sphincter tone).
2. *Gentle pressure* was applied on the catheter to overcome the papillary tone.
3. If the catheter did not pass easily through the papilla (i.e., if the resistance offered by the papillary tone was not overcome by a gentle pressure), it meant that the tip of the catheter was just above the papilla. The outer sheath of the catheter was then pulled backwards, thereby opening the basket, and the catheter was withdrawn from the common bile duct while the internal wire of the catheter was rotated at the same time along its axis, to facilitate the entrance of the stones inside the basket. *The basket was never opened against resistance.*
4. If the catheter passed easily across the papilla, this was recognized by the fact that 15 cm of its length could be introduced inside the cystic duct/common bile duct, without encountering any significant resistance. The basket was then opened and withdrawn until it met the papilla on the duodenal side, which was recognized because a resistance to traction was appreciated and the duodenum was seen being pulled up under direct vision. At this point, the basket was closed, withdrawn by 1 cm and opened again, now being inside the common bile duct, from which it was removed as described above.

Transcystic duct CBD exploration was repeated until all ductal stones identified during intraoperative cholangiography were removed with the basket (Fig. 4). To verify that all ductal stones had indeed been removed, transcystic choledochoscopy was performed. Either a 3.1-mm choledochoscope (URF Type P2, Olympus Corporation, Tokyo, Japan) or a 2.7-mm choledochoscope (Karl Storz, Tuttlingen, Germany) with saline irrigation, connected to a camera and monitor was employed, depending on which one was available at the moment. Any residual ductal stone that was identified by choledochoscopy was removed under endoscopic control by exploring the CBD with a 3 Fr. flat-wire basket (W. Cook Europe APS, Denmark, No. 14730) passed through the working channel of the choledochoscope. The tip of the closed basket was advanced under endoscopic vision below the ductal stone and opened distally to it. The open basket was then slowly pulled out while rotating its shaft along its axis, allowing the stone to pass across the four flat wires. Once the stone had entered the basket, it was carefully closed, trapping the stone against the extremity of the choledochoscope. The entire assembly (scope with basket and stone) was then pulled out of the CBD and then outside the peritoneal cavity.

Sometimes ductal stones were difficult or impossible to remove, either because they were too large or because they were impacted in a pseudo-diverticulum within the CBD wall and were unable to be surrounded by the four-wire basket. In these cases alternative energy sources were employed, the electrohydraulic lithotriptor (Circon ACMI, Stamford, Conn.) or the Alexandrite pulsed-dye laser lithotriptor (Medecom, Tettnang, Switzerland). Lithotripsy was always performed under endoscopic vision by passing the probes through the working channel of the choledochoscope and bringing their distal extremities directly in contact with the stone, always keeping them at a safe distance from the ductal walls. The lithotriptors were then activated as many times as necessary to release bursts of energy in order to break the stones into smaller fragments. The electrohydraulic lithotriptor can be very dangerous and seriously damage the CBD wall, causing bleeding and/or perforation, unless activated cautiously because an electric spark is generated at the distal end of its probe. The electrohydraulic lithotriptor was operated in the "soft" mode, with an energy output level of not more than 60 V and for not more than 60 seconds. The pulsed-dye

laser Alexandrite lithotriptor was used with less fear of damage, but still avoiding placing the tip of its probe in contact with the CBD walls, since it does not employ electrical energy but light energy. After lithotripsy, the cloud of stone fragments produced was washed away by saline irrigation out of the duct through the cystic ductotomy and through the papilla. Saline irrigation to flush the CBD free of stone fragments was delivered with a transcystic large bore catheter (up to 12 Fr. in diameter). Occasionally, when stone fragments remained, the papilla was gently dilated up to a diameter of 4 or 5 mm using the same balloon ureteral dilator catheter and syringe that had been used to dilate the cystic duct (W. Cook Europe APS, Denmark, No. 79674) to facilitate the flushing of stone fragments into the duodenum.

The possibility of performing a transcystic duct exploration of the common hepatic duct depends on the anatomy of the cystic duct–CBD junction and may be feasible only when the cystic duct is wide and joins the CBD on its lateral aspect. Therefore a choledochotomy usually provides a more direct access to the common hepatic duct and intrahepatic ducts and may be preferable to remove stones located at this level.

Once transcystic duct CBD exploration was completed, we needed to decide whether a soft Silastic transcystic biliary drainage tube was warranted or not. The possibility of avoiding positioning a biliary drainage tube is appealing since its absence allows the patient to be discharged 24 to 36 hours after the operation, as commonly done after laparoscopic cholecystectomy. The indications that we set for the use of biliary drainage were the presence of fibrin debris inside the CBD and/or the instrumental balloon dilation of the papilla and/or the presence of retained CBD stones known to be left behind. In the latter case we decided that stones or fragments of stones could be knowingly left inside the CBD when it was impossible to remove them in a reasonable amount of time, provided a biliary drainage could be positioned to maintain an access to the biliary tract for stone removal at a later time (at least four or five weeks later) along the biliary drainage sinus tract.

When a transcystic biliary drainage tube was positioned, it was secured in place with a 4-0 absorbable suture (Ethicon, Inc., Somerville, N.J.) to prevent accidental displacement. The suture was passed through the cystic duct wall, through the full thickness of the biliary drainage tube, was looped twice, and then tied around both structures to prevent bile leakage.

Choledochotomy

In case the TCD–CBD exploration was unsuccessful due to unfavorable anatomical conditions, a laparoscopic choledochotomy was performed. This occurred when CBD stones were larger than the cystic duct or when the cystic duct joined the CBD very distally in the proximity of the papilla or on its medial aspect, or when several stones were located in the common hepatic duct. Occasionally this was the procedure of choice soon after intraoperative cholangiography, when this revealed a particularly unfavorable anatomical situation, with the aim of reducing the operative time. If the decision to perform a choledochotomy was made, the peritoneum overlying the anterior wall of the CBD was divided, and a two-thirds transverse incision of the anterior ductal wall was carried out (Fig. 5). In our opinion a transverse choledochotomy, conducted on the anterior ductal wall, well clear of the two main arterial trunks which run longitudinally on the sides of the CBD, was preferable to a longitudinal one because it reduced the risk of postoperative stricture. In fact, it was limited by the width of the anterior ductal wall, and it was sutured transversely, according to a fundamental rule of basic surgical technique.[10] Ductal stones were then removed, exploring the bile duct directly with the same sequence of maneuvers described above.

Unlike transcystic CBD exploration, the use of tube biliary drainage tube was considered mandatory in almost all patients who had undergone choledochotomy and direct CBD exploration, since the presence of fibrin debris inside the CBD in these patients, who often had large, multiple stones, was more common. The preferred type of biliary drainage was usually a tailored T-tube but could also be a transcystic duct catheter, secured to the cystic duct as previously described. We developed an instrument designed to facilitate the laparoscopic introduction of the transverse branches of the T-tube inside the CBD through the choledochotomy, as described in a previously published article.[10]

The method employed two sets of telescopic cannulas of two different sizes, to accommodate a larger or a smaller T-tube, and each set was made of an internal and an external cannula. The internal cannula contained the long limb of the T-tube while the external cannula, sliding over the internal one, brought the two transverse branches of the T-tube close to each other. The cannula set with T-tube was introduced from the midclavicular port and was manipulated from outside the peritoneal cavity to introduce the tip of the transverse branches, kept close to each other inside the

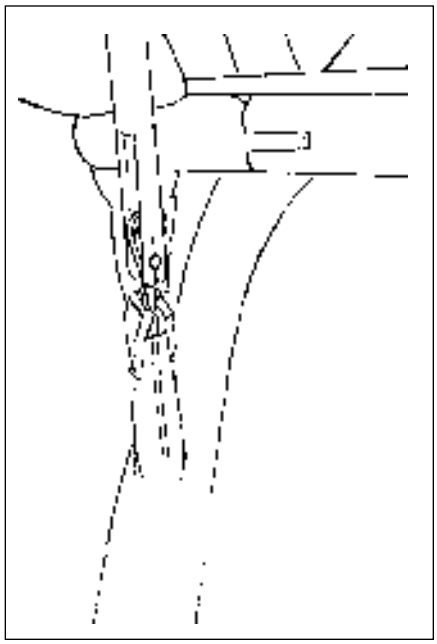

Figure 3. Transcystic duct cholangiography.

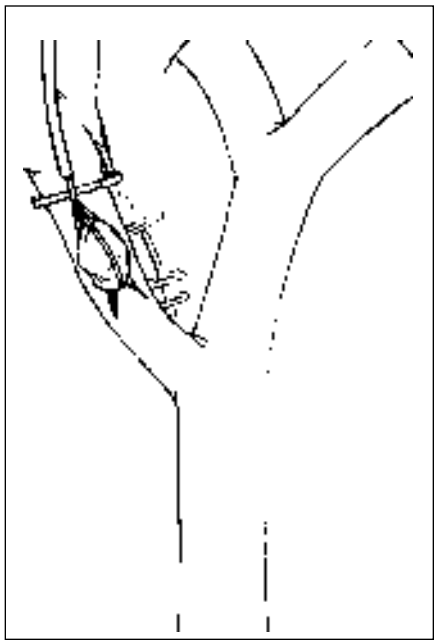

Figure 4. Transcystic duct basket stone retrieval.

choledochotomy (Fig. 7). By gently pushing the internal cannula and sliding the external one back from outside the abdomen, the transverse branches of the T-tube were pushed out of the external cannula and inside the common duct, where they spontaneously diverged, reaching the correct position, as shown in Figure 8. The choledochotomy was then closed with an original suture technique.[11] A 7-cm long 4-0 PDS II absorbable suture on straight needle (Ethicon, Inc., Somerville, N.J.) with an absorbable Absolok clip (Ethicon Inc., Somerville, N.J.) fixed by a knot at its distal end was employed for continuous suturing of the transverse choledochotomy. After two or three stitches were passed, a second Absolok was applied on the thread and was fixed in place by a silver clip (Wolf Corp., Knittlingen, Germany) (Figs. 9, 10).

At this point laparoscopic cholecystectomy was completed in the usual manner, and the gallbladder was removed from the peritoneal cavity. The free end of the biliary drainage tube was also exteriorized.

The procedure was always terminated with a completion cholangiogram which was performed from the cystic duct (when a biliary drainage tube had not been positioned), from the transcystic duct biliary drainage tube, or from the T-tube. The cholangiogram was performed mainly to verify the complete clearance of ductal stones but was also useful in checking the correct positon of the biliary drainage tube and the absence of liquid leakage from the CBD suture, if present. An indirect measure of the papilla's patency and of free bile flow was obtained intraoperatively (as well as postoperatively at the patient's bedside) by connecting the biliary drainage tube to a saline-filled syringe without plunger. When the syringe was gradually elevated over 20 cm above the patient's abdomen, the liquid meniscus started to sink if bile flow through the papilla was unobstructed.

Finally, a subhepatic 5-mm Silastic drainage tube was introduced from the midclavicular port in all patients. When a biliary drainage tube was present, the subhepatic drainage tube exited parallel and lateral to it, and they were both secured to the skin.

Patients who underwent transcystic duct CBD exploration without a biliary drainage tube were discharged 24 to 36 hours after the operation, as commonly done in patients who underwent simple LC. Patients who had a biliary drainage tube positioned during surgery underwent direct postoperative cholangiography on the fourth postoperative day to check again for the leakage and for residual stones. If this was negative, the subhepatic drainage tube was removed, the choledochotomy closed, and the patient placed under medication and dismissed.

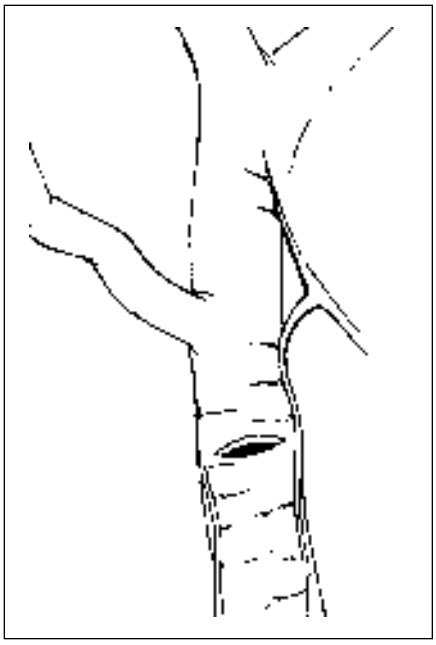

Figure 5. Transverse choledochotomy on two-thirds of the anterior ductal wall preserving the arterial blood supply.

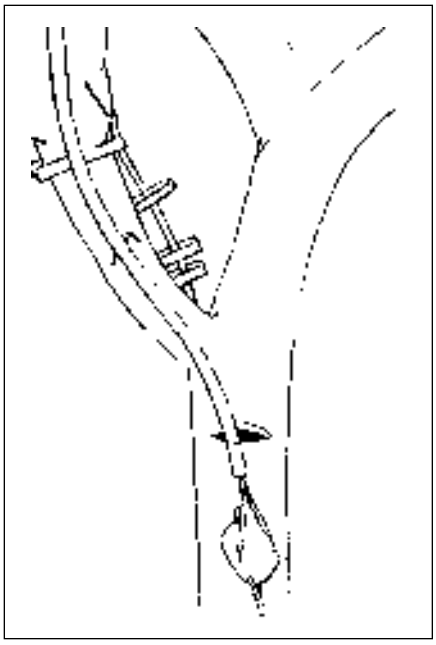

Figure 6. Direct CBD exploration and basket stone retrieval.

RESULTS

Single-stage laparoscopic management of gallstones and CBD stones was completed in 136 patients out of 140 unselected, consecutive patients (97.1% success rate) with a mean operative time of 128 minutes (range: 45 to 210 minutes). Conversion of the procedure to open surgery occurred in four cases (2.8%), two of them being among the first five patients of the entire series. In three patients the reasons for conversion were the presence of impacted and/or large, multiple stones occurring at a time when alternative energy sources were not available at our institution. At the present time, these patients would probably not require conversion to open surgery. In one patient a dilated CBD resembling a choledochal cyst was present and conversion was considered appropriate due to difficulties in recognizing the anatomy.

TCD–CBD exploration was completed in 92 patients out of 136 (67.6%). No biliary drainage was necessary in 64 cases (47%), whereas it was employed in the remaining 28 patients. Of the group of 92 patients who underwent TCD–CBD exploration, a single stone was present in 26 patients, 2 to 3 stones in 47 patients, 4 to 5 stones in 14 patients, and 6 to 7 stones in 4 patients. One patient with a short, wide cystic duct presented with a very large number of small ductal stones which were removed under choledochoscopic vision through the cystic duct. Over 70 stones ranging between 1 and 4 mm in diameter were retrieved until the choledochoscope eventually broke down due to overuse. Due to this technical problem, two stones were known to be left behind in this patient, and a transcystic duct cannula was positioned for subsequent percutaneous treatment. Stones larger than 5 mm were present in 16 patients, requiring a longitudinal prolongation (2 to 3 mm) of the cystic duct incision in 9 patients to allow for removal of the stones.

Laparoscopic choledochotomy was required in 44 patients out of 136 (32.3%) due to anatomical conditions preventing transcystic duct management of the ductal stones. At the end of the procedure, a biliary drainage tube was used in 42 patients, 36 of whom

had a tailored T-tube placed through the choledochotomy. A transcystic duct drainage tube was employed in five patients whereas in one, a naso-biliary catheter preoperatively positioned at ERCP was left in place. In only two cases a biliary drainage tube was not positioned after choledochotomy, and this was closed with the running suture technique described above.

Basket retrieval of ductal stones was the most successful method of clearing the CBD of stones through either the transcystic or the direct choledochotomic route in all 136 patients. Lithotripsy for impacted stones was also employed in 10 patients (electrohydraulic in 6, Alexandrite pulsed-dye laser in 4). Embolectomy balloon manipulation was also useful in 4 patients combined with basket manipulation to retrieve larger stones. Papilla dilation was carried out in 28 patients.

Retained ductal stones occurred in seven patients (5.1%). In three patients these were knowingly left behind and were confirmed at intraoperative completion cholangiography. In two of these patients a single stone was lodged in a prepapillary pseudo-diverticulum, in a lateral position with respect to the main axis of the CBD, and this prevented safe contact of the electrohydraulic lithotripsy probe with the stone. In one more patient, the stones' retrieval had to be interrupted by a technical problem (choledochoscope breakdown). The retained stones in these three patients were deliberately left behind to avoid prolonging the operative time; subsequent percutaneous treatment was administered. A biliary drainage tube was positioned and secured in place. False-negative or doubtful images at intraoperative completion cholangiograms were responsible for the single residual stone in the remaining four patients.

Residual stones were successfully treated percutaneously through the biliary drainage sinus tract four to five weeks postoperatively in five patients, combined with ESWL of the retained stone in one patient, due to a very peculiar location of the stone inside a pseudo-diverticulum in the wall of the CBD. In this case ESWL was extremely useful in mobilizing the stone. Endoscopic sphincterotomy was successfully carried out in two patients, in one after failure of the percutaneous expulsion of the retained stone due to the excessively acute angle between the T-tube at its entrance inside the biliary tract and the CBD.

Hyperamylasemia with mild pancreatitis occurred in 3 out of the 28 patients who underwent papilla dilation, and is considered in our experience to be a specific complication of that maneuver. A biloma which spontaneously drained through the subhepatic drainage tube (2 cases), port-site infection (2 cases), and an umbilical hematoma requiring drainage (1 case) were the other minor complications that were observed.

Major complications included bile leakage in three and hemoperitoneum in another three patients. Two cases of clip displacement involving the cystic duct stump and one case of displacement involving a transcystic duct biliary drainage tube, which had been secured only with a pretied loop suture, both occurred after TCD–CBD exploration. Successful treatment of the bile leakage was by ERCP and naso-biliary drainage in all three patients. Hemoperitoneum treated *conservatively* occurred in one patient and was related to the division of several upper abdominal adhesions in a patient who had previously undergone partial gastrectomy. In two patients, hemoperitoneum required an emergency operative reintervention, by relaparoscopy in one which demonstrated multiple port-site bleedings in a patient with no preoperative laboratory evidence of coagulation disorders. In the second patient bleeding from the right branch of the hepatic artery occurred on the fifth postoperative day and required open surgical control of the bleeding. This patient had undergone a very difficult laparoscopic choledochotomy and CBD exploration, due to the presence of several adhesions from gallbladder empyema and cholangitis in an elderly patient who had a transpapillary biliary stent endoscopically positioned two years before in another department for what was erroneously diagnosed at that time as a biliary tract cancer. The patient was lost to follow-up for two years and was referred to us with jaundice and cholangitis after several failed endoscopic attempts at removal of the proximally dislodged biliary stent which was completely buried in stone material.

A single case mortality was observed in an 81-year-old, physical status ASA IV patient who was referred with persistent cholangitis after multiple failed attempts at ES performed in another department. The patient died from cardiogenic shock on postoperative day 3 after successful laparoscopic treatment.

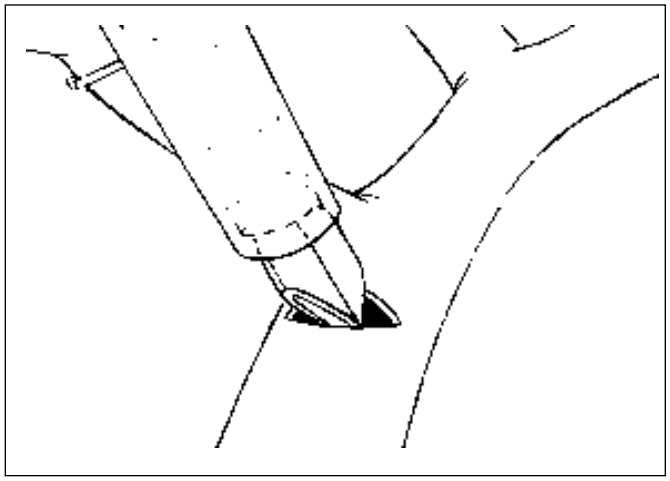

Figure 7. Transverse branches of the T-tube introduced through the choledochotomy.

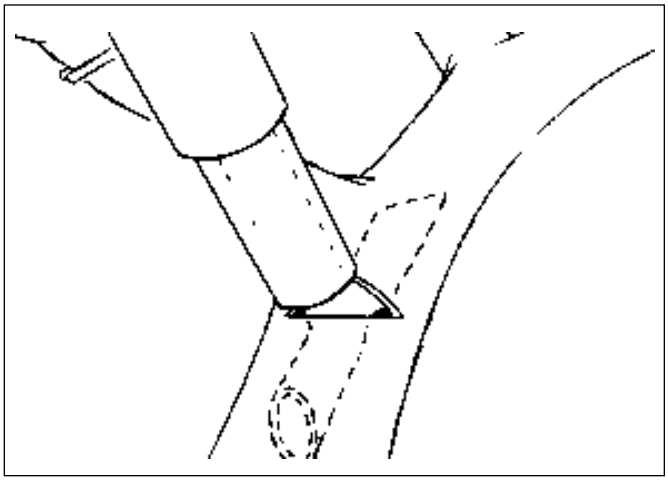

Figure 8. After sliding backwards the external cannula, the transverse branches of the T-tube spontaneously diverge inside the CBD reaching the correct position.

DISCUSSION

A definite increase in the incidence of preoperative or postoperative ERCP and ES has recently been observed after the advent of LC.[5] Sequential endosurgical treatment is not associated with better results as compared to open surgery alone in elective patients.[1,2,3,4] Moreover, recurrent CBD stones have been reported to occur more frequently after ES than after supraduodenal CBD exploration.[8]

A study to evaluate the feasibility, success rates, safety, and short-term results of single stage laparoscopic management of gallstones and CBD stones was therefore initiated with no selection of patients and no attempt at preoperative identification of ductal stones. ERCP was performed only to exclude the presence of cancer in jaundiced patients; a recommendation was made to the endoscopists to refrain from performing ES if stones were discovered at diagnostic ERCP.

Instead, routine dynamic cholangiography was included in the clinical design for the following two reasons: (1) Unsuspected ductal stones cannot be overlooked, and routine intraoperative cholangiography reveals them in a significant number of patients with no increased risk for the patient, as we have demonstrated in a previous study.[9] Unsuspected ductal stones were present in 41.4% of patients in the present series, confirming our personal observation as well as that of other authors.[12,13] Since no data are available on the natural history of unsuspected ductal stones, which may become symptomatic much later in life when the patient is at greater risk for any procedure,[14] our policy was to diagnose and remove all ductal stones. (2) Cystic duct cannulation for cholangiography in every single patient undergoing LC provides the best exercise for routine intraoperative cholangiography itself (97% success rate in our previous experience[9]) as well as for TCD–CBD exploration.

As already described,[9] two steps are important to obtain cystic duct catheter cannulation for cholangiography as well as for TCD–CBD exploration: (1) complete cystic duct dissection from the infundibulum of the gallbladder to the junction with the CBD, and (2) choosing the correct position for the midclavicular trocar, which is placed in the closest and most perpendicular location with respect to the CBD, to be able to exert an optimal *vis a tergo* (push) on the catheter employed.

TCD–CBD exploration is obviously preferable to direct CBD exploration because a choledochotomy is avoided and the cystic duct may often be closed at the end of the procedure without positioning a biliary drainage tube, with a postoperative course that is similar to that of patients who underwent LC only. The cystic duct, which is usually patent due to increased pressure in the biliary tree, is easily dilated with a balloon ureteral dilator catheter under laparoscopic vision. All CBD exploration maneuvers, including lithotripsy, must be performed very gently and cautiosly, but the necessary skills for surgeons who have an adequate experience with LC (at least 100 procedures performed as first surgeon) can be rapidly acquired with the proper tutored training on phantom models during dedicated courses endorsed by the major societies of endoscopic surgery (SAGES, EAES). Due to the electrical spark that is generated at the extremity of the probe, the electrohydraulic lithotriptor must be operated more cautiously than the Alexandrite lithotriptor but is faster than the latter in fragmenting the stone.

Even though the ideal treatment would be TCD–CBD exploration without a transcystic biliary drainage, in our experience it should nevertheless be employed whenever a postoperative obstacle to bile flow is anticipated (that is, when fibrin debris, residual stones, or papillary edema are present), and it is best secured by a transfixion suture to the cystic duct to prevent its accidental displacement, as occurred in one of our patients. Four or five weeks after the operation, when the biliary drainage tube is removed, the suture is hydrolyzed enough to be easily broken down by the traction applied on the biliary drainage tube.

When multiple, larger than 8-10 mm CBD stones are present, or when the cystic duct–CBD junction is low or is on the medial aspect of the bile duct, TCD–CBD exploration may be unsuccessful. This occurred in approximately one-third of our patient population (32.3%). Following our clinical design, in these cases a laparoscopic transverse choledochotomy is performed, with the aim of obtaining definitive treatment of the biliary stone disease at the same session. Laparoscopic choledochotomy provides an easy access to the common bile duct and to the common hepatic duct. As is our custom in open surgery, a transverse rather than a longitudinal choledochotomy is preferable in our experience because it is limited by the

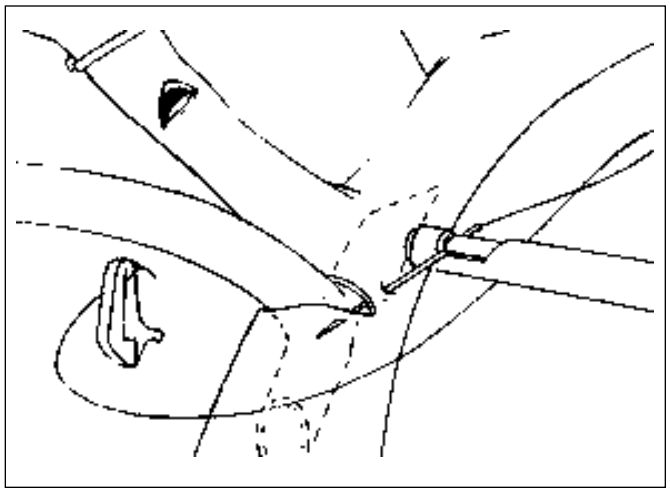

Figure 9. Technique of suture of the choledochotomy.

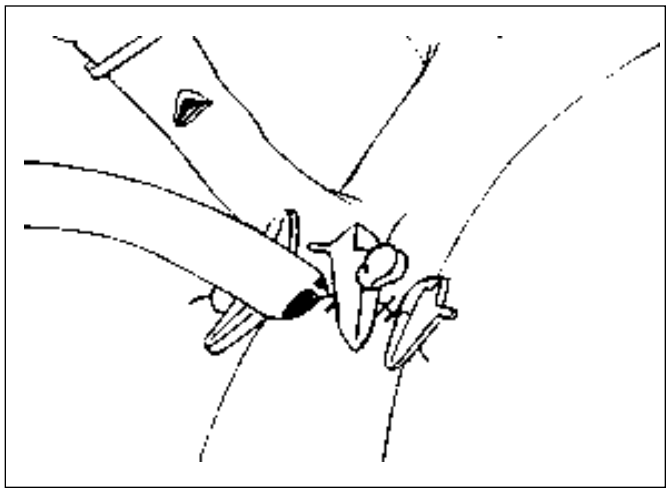

Figure 10. Suture of the choledochotomy completed.

width of the bile duct, and may therefore reduce the risks of postoperative biliary stricture. Following choledochotomy, direct CBD exploration on the major bile duct as well as on the common hepatic duct follows the same sequence of maneuvers as for TCD–CBD exploration. Hyperamylasemia with mild pancreatitis was observed only in patients who underwent papilla dilation (3 out of 28) and resolved conservatively. In our opinion this maneuver finds an indication in only a few cases and should be avoided because it is potentially dangerous.

Patients with larger stones frequently have more fibrin debris and sludge in the bile duct so a biliary drainage is recommended after choledochotomy to prevent cholangitis from postoperative increase in biliary pressure. The techniques of T-tube insertion and CBD suture that we described in previous articles[10,11] have the advantage of reducing the operative time and the surgeons' efforts.

Another major complication was the displacement of clips closing the cystic duct stump, a problem that has been encountered and described also after LC.[15]

The single case mortality observed occurred in an elderly, high-risk patient with persistent cholangitis, referred to us for surgical treatment after several failed attempts of endoscopic treatment of large, multiple ductal stones, and occurred for complications directly related to CBD exploration.

In conclusion, in our experience single-stage laparoscopic management of gallstones and CBD stones was not only feasible, but was a safe and effective method for dealing with two problems during the same operative setting, with results that are not inferior to published results of ES from expert centers.[16] The aim is to avoid an extensive preoperative diagnostic work-up and to obtain definitive treatment of both biliary problems through the cystic duct with a postoperative course that is ideally the same as after LC only. TCD–CBD management was feasible in more than two-thirds of our patients (67.6%). The fact that in our series laparoscopic choledochotomy had to be performed in a fairly large number of cases (32.3%), higher than what has been reported by other authors,[17] may reflect differences in patient population. In fact, 42.8% of our patients, who were between 70 and 94 years of age, were suffering from long-standing symptomatic biliary tract stone disease, and were referred for surgical treatment by their general practitioners at a later time in the natural history of the disease, probably due to the patients' advanced age.

A specific training of the surgical staff is required to employ such a high concentration of technology. Several educational courses on phantom models have been activated in our department to provide an adequate theoretical and practical preparation for the surgeons, with the aim of increasing the individual surgeon's ability to explore instrumentally the common bile duct with choledochoscopes and baskets and to instruct on the correct use of lithotriptors on models. STI

ACKNOWLEDGEMENT

The authors are grateful to M. M. Muti, M.D., for drawing the illustrations.

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