Laparoscopic Common Bile Duct Exploration and Hand Sutured Closure of the Choledochotomy

Paul S. Strange, M.D.
Chief of Surgery
St. Francis Hospital
Indianapolis, IN

Zoltán Szabó, Ph.D., F.I.C.S.
Director
Microsurgery & Operative Endoscopy Training (MOET) Institute
San Francisco, CA

In the years since 1987, when Mouret introduced laparoscopic cholecystectomy in France, this approach has become the preferred method for management of symptomatic gallbladder disease. However, the treatment of calculous disease other than the gallbladder is not generally practiced by the laparoscopic approach. The treatment of common duct stones is largely managed by preoperative Endoscopic Retrograde Cholangio Pancreatography (ERCP) or choledochotomy and exploration through a laparotomy incision. The authors believe that this lack of acceptance of laparoscopic treatment of common duct stones is because of the ready availability of ERCP and sphincterotomy in most centers countenanced by the difficulty of laparoscopic treatment.

Before the advent of minimally invasive surgery, the management of patients suspected of having common duct stones was a good deal simpler and more straightforward. Cholangiography was done showing common duct or hepatic duct stones, or a stone could be palpated. The problem was addressed in one setting and the patient was discharged free of their problem. Because of the difficulty of laparoscopic treatment of common duct stones and the desire to manage the entire problem with minimal access techniques, surgeons have to a great extent abdicated this portion of patients to their colleagues.

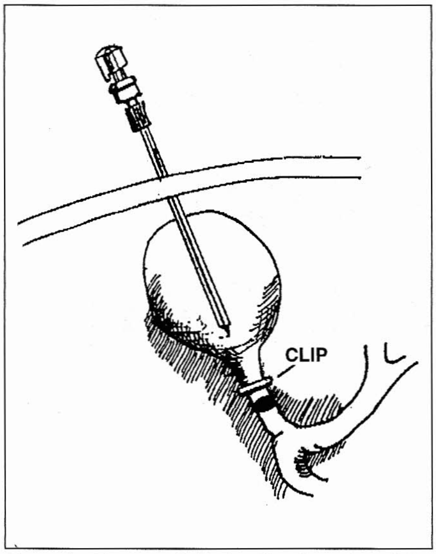

Figure 1a. Transcystic Exploration: Insertion of the needle with sheath.

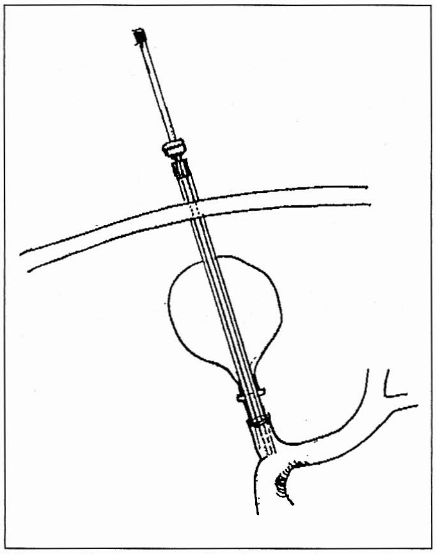

Figure 1b. Transcystic Exploration:Catheter insertion.

The majority of preoperative ERCP's done to rule out common duct stones prove to be normal. The reasons for this are many. Reliance on abnormal blood chemistries to estimate the probability of biliary obstruction is not as reliable as desired. Only 60 percent of patients with elevations of three abnormal liver chemistries will prove to have a common duct stone. Estimation of ductal size by sonography also suffers from the same lack of sufficient accuracy. Any fear that the patient may harbor a common duct stone will usually lead to a preoperative ERCP for evaluation and management. Conversely, a significant number of patients will be found to have common duct stones where none are suspected. Just like surgical common duct exploration, there is

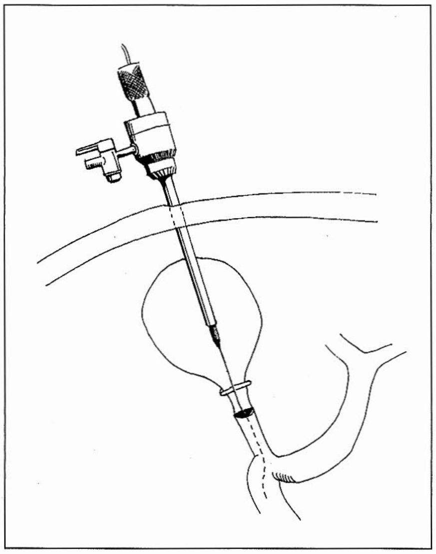

Figure 1c. Transcystic Exploration:Insertion of guidewire.

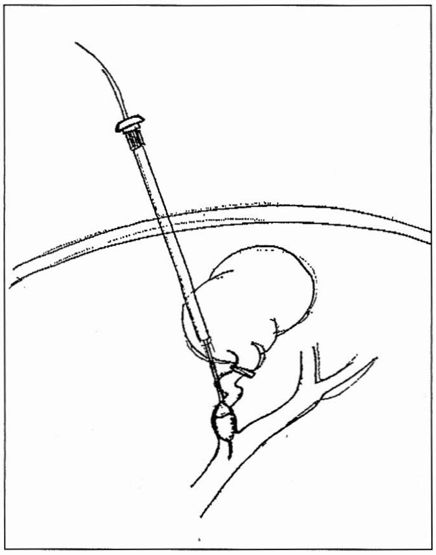

Figure 1d. Transcystic Exploration:Dilation with balloon.

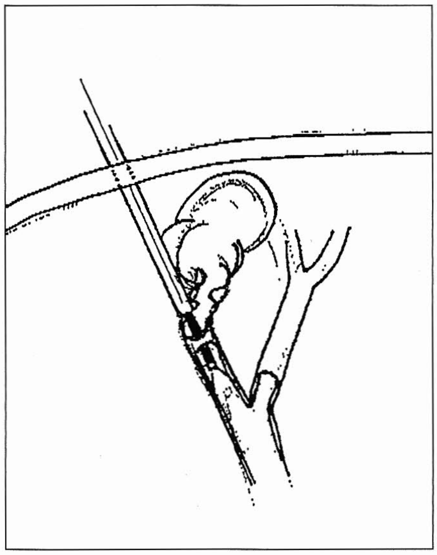

Figure 1e. Transcystic Exploration:Visual exploration.

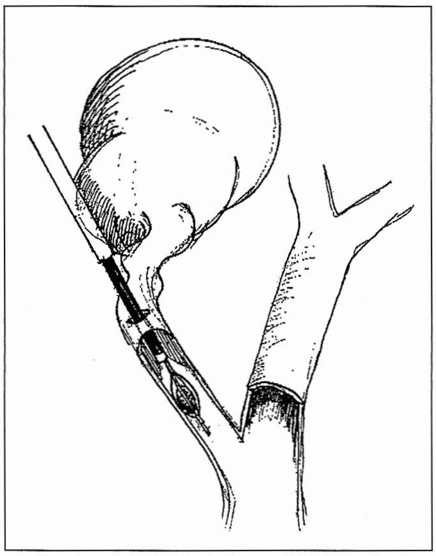

Figure 1f. Transcystic Exploration:Stone removal with basket.

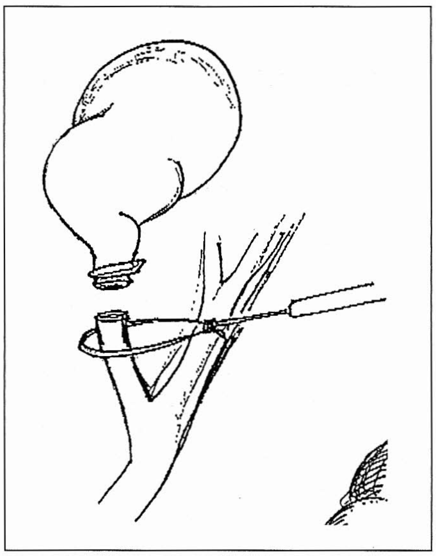

Figure 1g. Transcystic Exploration:Ligature.

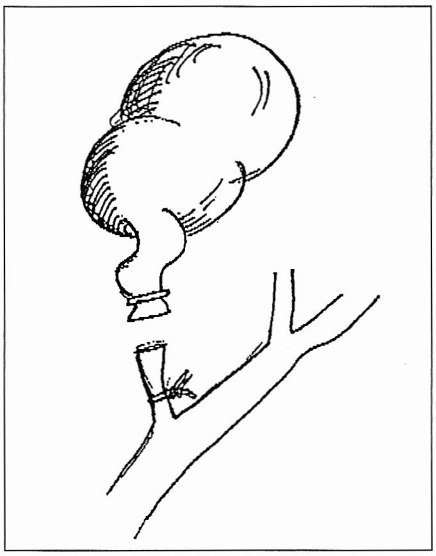

Figure 1h. Transcystic Exploration:Pretied loop ligature of cystic stump.

morbidity and mortality associated with ERCP and sphincterotomy. These are eleven percent and two percent respectively. There is also concern about the long term consequences of sphincterotomy performed in younger patients. However, a sphincterotomy less that 7 mm in length seems to preserve function of the sphincter of Oddi. It should be pointed out that initial treatment of suppurative cholangitis, evaluation for periampullary malignancy, and management of the elderly, high-risk surgical candidate properly fall within the realm of the endoscopist. However, a more efficient, cost effective, and traditional approach to uncomplicated biliary calculous disease is to deal with all possibilities in one setting.

COMMON DUCT EXPLORATION

There are two basic approaches used for laparoscopic common duct exploration. One method is exploration across the cystic duct, and the other is exploration with choledochotomy. In both methods, laparoscopic cholangiography is performed to determine the presence, number and location of stones. Use of a fluoroscopic C-arm unit with digital image enhancement capability is highly recommended. In addition, a second video unit will be needed for the choledochoscope.

TRANSCYSTIC EXPLORATION

Excellent and more detailed descriptions of this technique are available.[1] It is our primary purpose to describe exploration with choledochotomy and its closure.

Transcystic exploration (Figures 1a–1h) is performed through a dilated cystic duct. On occasion, it can be done through a duct that is sufficiently large to accommodate a small (9Fr.) choledochoscope. Usually, it is necessary to dilate the cystic duct with a balloon dilator.

Stones can be retrieved with a stone basket passed under fluoroscopic control. A dual lumen catheter can be used to pass the stone basket and simultaneously inject contrast material to aid in fluoroscopic guidance. If this is not successful, a small choledochoscope is passed through the cystic duct over a guide wire into the common duct. Stone baskets can be passed through the working channel of the scope to retrieve the stones under direct visualization.

This approach is limited to stones smaller than 7 mm and located in the distal common duct. It is best suited when there is a true lateral confluence of the cystic duct into the common bile duct. However, a true lateral position is present in only twenty percent of the cases. It can also be difficult to pass the scope through a long, tortuous cystic duct. Attempts to extract a stone larger than 7 mm may result in impaction of the stone and basket in the cystic duct. The best alternative, if the stone cannot be crushed with the basket, is to convert to an open procedure. This approach is not well suited for stones located in the common hepatic duct. It is frequently impossible and always difficult to deflect the scope upward into the common hepatic duct to retrieve stones in this location. Despite these limitations a success rate of 94 percent has been reported.

With suitable anatomy, it is not difficult to do. No internal drainage of the bile duct is required. Perhaps most appealingly, no suture closure is needed. It is recommended that the cystic duct stump be closed with a pretied loop or hand-sutured ligature. Dilation of the cystic duct may weaken this structure leading to an insecure closure with clips.

LAPAROSCOPIC CHOLEDOCHOTOMY

The technique which is most familiar to the general surgeon is common duct exploration through a choledochotomy. It permits extraction of large stones, access to all portions of the biliary tract, and it is possible to use the larger 5 mm choledochoscopes which have inherently better optical quality. Anatomic variations of the cystic duct are not a barrier to performance.

This technique is not as commonly used as the transcystic approach, and we speculate that the prospects of choledochotomy closure is a deterrent to many. Admittedly, precise laparoscopic suturing and know tying is a difficult skill to acquire. However, with proper training[2] and a commitment to many hours of practice, it is an attainable skill.

TECHNIQUE

Laparoscopic cholecystectomy is initiated with a standard four trocar technique (Figure 2.). When ductal exploration can be anticipated, the anterior wall of the common bile duct is carefully dissected

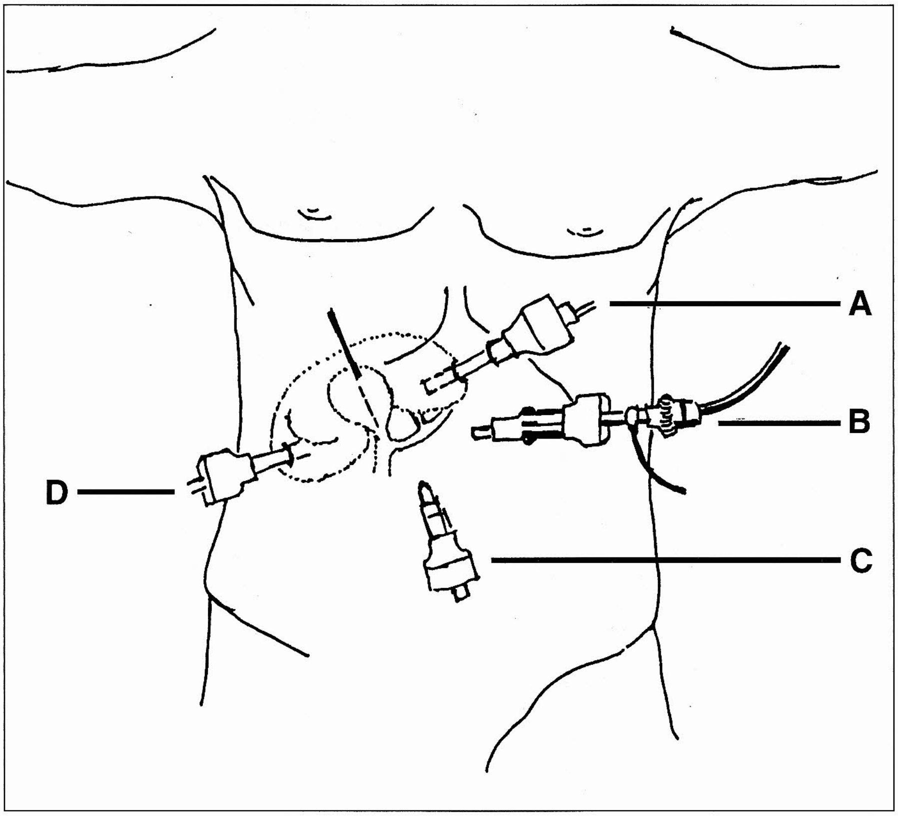

Figure 2. Standard four trocar positioning for suture closure of the choledochotomy. Positions A and C are the right and left hand ports respectively. Position B is the camera port. Position D is the assistant port.

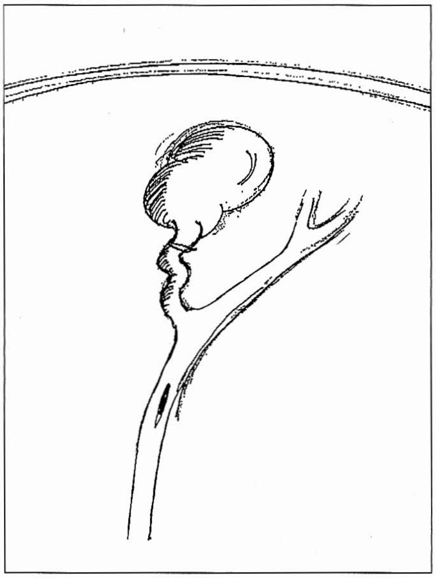

Figure 3. A 1 cm incision is made.

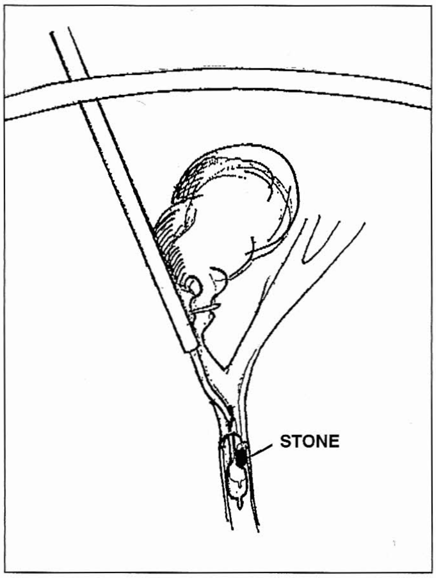

Figure 4. Fogarty balloon catheter stone removal.

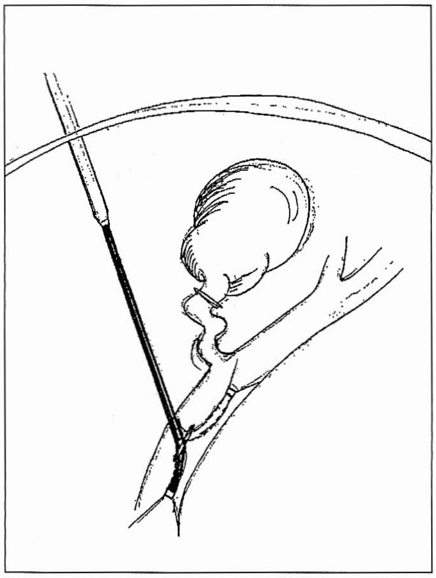

Figure 5. Inspection of the CBD proximally and distally.

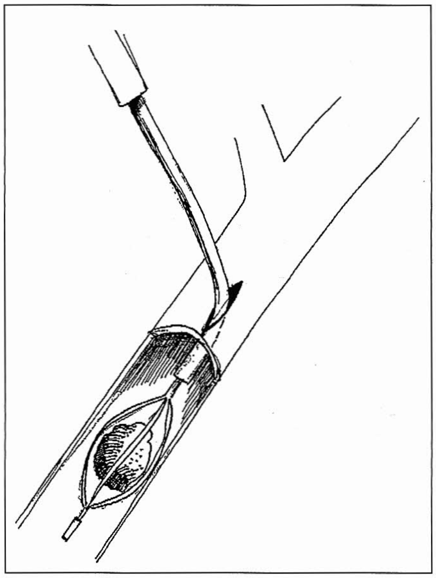

Figure 6. Stone removal with wire basket.

for approximately two centimeters to expose the duct before performance of the cholangiogram. The rationale for proceeding in this fashion is to lessen the chance of avulsion of the cystic duct when applying traction to expose the common duct. Although the need for routine cholangiography continues to produce opposing points of view, it is the author's (PS) standard practice. The authors believe that the incision used to introduce the cholangiogram catheter increases the chance of avulsion of the cystic duct and therefore the 2 cm dissection, we believe, reduces the risk significantly.

The cholangiogram is done through a self-sealing percutaneous needle in the right upper quadrant. Through this needle a #4 F Olsen-Cook cholangiocath catheter is introduced into the cystic duct through an incision made previously. With experience, the needle can usually be placed so the catheter lines up precisely with the long axis of the cystic duct. Fluoroscopic cholangiography is done with a C arm with digital image enhancement capability. If the cholangiogram is normal, then the cholecystectomy is completed in the routine fashion. If stones are present, their number, size and location are noted. If cystic duct anatomy and the nature of the stones indicate a low probability of success with the transcystic approach, a choledochotomy approach is used.

This is done by making a 1 cm incision (Figure 3.) on the anterior wall of the common duct with microscissors. A guide wire is passed through the percutaneously placed needle that was used to introduce the cholangiogram

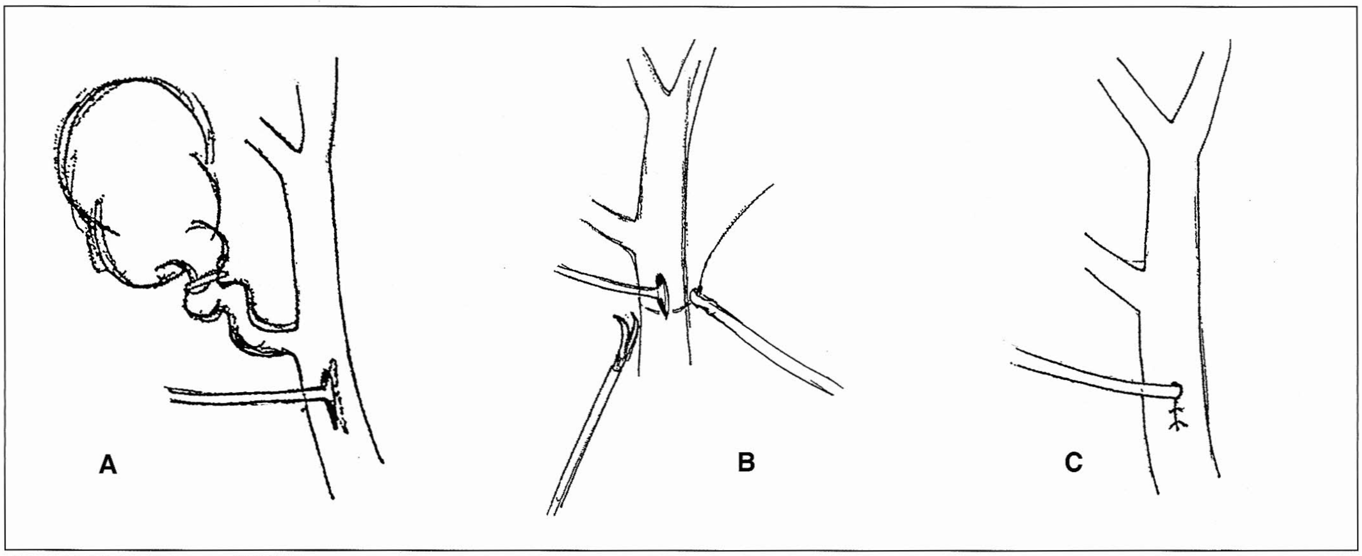

Figure 7. T-tube drainage of CBD.

catheter. A new 5 mm port is then placed over the guidewire using a Cook Critical Care (Bloomington, IN) dilator port device. Because the correct geometry had already been established for placement of the cholangiogram catheter, the choledochoscope (5 mm diameter) is easily threaded over the guide wire and through the new port. By advancing the port and the contained choledochoscope toward the choledochotomy, it is usually possible to thread the choledochoscope directly into the bile duct without manipulation with a grasping forceps. This prevents damage to the outer coating of the scope and should prolong its life. Distension of the inner lumen of the duct is accomplished with continuous saline infusion through the irrigation channel of the scope.

It may be possible to clear the duct of stones with flushing or passage of a Fogarty Biliary balloon catheter (Figure 4.). Confirmation of complete clearance of all stones should be accomplished by visual inspection of both the common bile duct and the common hepatic duct with passage of the choledochoscope proximally and distally (Figure 5.). The scope can easily be inserted in either direction through a choledochotomy. This is not easily done when the transcystic technique is used.

In the majority of cases in the author's (PS) experience, it is either necessary or more expedient to retrieve the stones by grasping them in a stone basket (Figure 6.) passed through the working channel of the choledochoscope. A Segura basket is used for stones estimated to be larger than 7 mm in diameter. Smaller stones are grasped with a helical basket manufactured by Cook Critical Care. After confirming the clearance of all stones and debris from the ductal system, the choledochotomy is closed with precisely placed and tied sutures.

Before describing the suturing technique used for closure, a brief discussion of ductal drainage is in order. It is the norm in the United States to drain the common duct with a T-tube after exploration (Figure 7.). The rationale being that alternative drainage is provided in case of spasm or edema at the ampulla induced by duct exploration. However, the duct is sometimes closed without ductal drainage (Figure 8.) after common duct exploration with no undesirable effect. Conversely, there is no percutaneous access to the ductal system should the patient prove to have a retained stone–ERCP, or reoperation would be the consequence. This point is deemed worthy of further investigation because it is sometimes troublesome to introduce a T-tube into the choledochotomy laparoscopically. It is also more bothersome to the patient postoperatively with a tube in the side and requires approximately two weeks of care as an outpatient.[3] It is also more cumbersome to close the choledochotomy with the T-tube present.

An attractive alternative is to drain the ductal system through the cystic duct (Figure 9.). Such a device is available in 8F and 10F sizes Cook Critical Care. In the author's (PS) experience, it facilitates closure of the choledochotomy and is more easily tolerated by the patient in the postoperative period. If the drainage could be solved by other means, a complete repair of the choledochotomy might be easier.

Such a solution could be the laparoscopic placement of a temporary biliary stent (Figure 10.) to provide ductal drainage, completely dispensing with external drains that prolongs the postoperative recovery. The other choice is to use the cystic duct, and an external drain. This, however, does not eliminate the inconvenience of an external tube. The need for any artificial drain method could be minimized by avoiding traumatization to the biliary drainage system.

This technique also avoids interference of a T-tube during closure of the choledochotomy and completely eliminated the patient discomfort associated with a T-tube. A possible drawback is the necessity for endoscopic removal when the stent has served its purpose. The authors recommend that the surgeon should continue using his or her usual practice concerning whether to drain or not to drain and what manner of drain to use until these techniques can more thoroughly evaluated. In any event, a closed suction Jackson Pratt subhepatic drain is always recommended when a choledochotomy is done.

When suturing laparoscopically, a proper setup is essential. Unless the needle driver and assisting driver are placed in proper relation to the area to be closed frustration and failure are certain Correct geometry is illustrated (Figure 2). It can be seen that the prop-

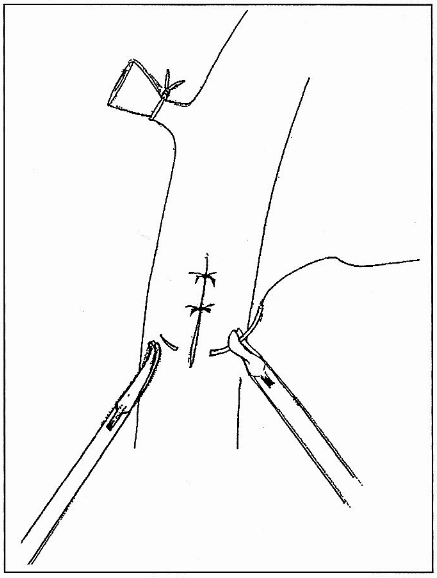

Figure 8. Choledochotomy closure without T-tube or trans cystic drain.

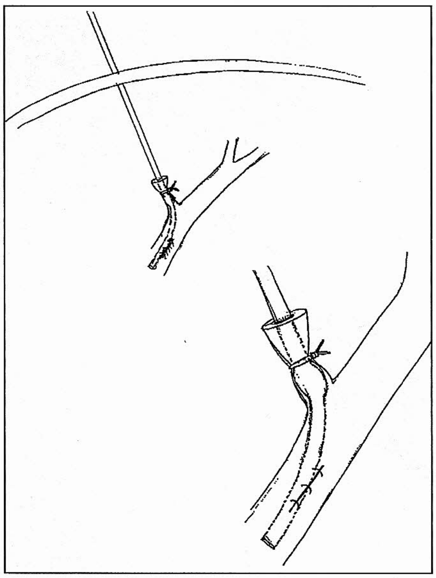

Figure 9. CBD drainage through the cystic duct stump.

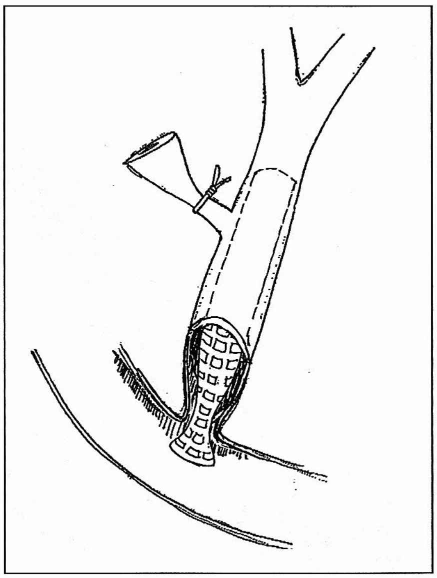

Figure 10. CBD drainage with intraluminal stent.

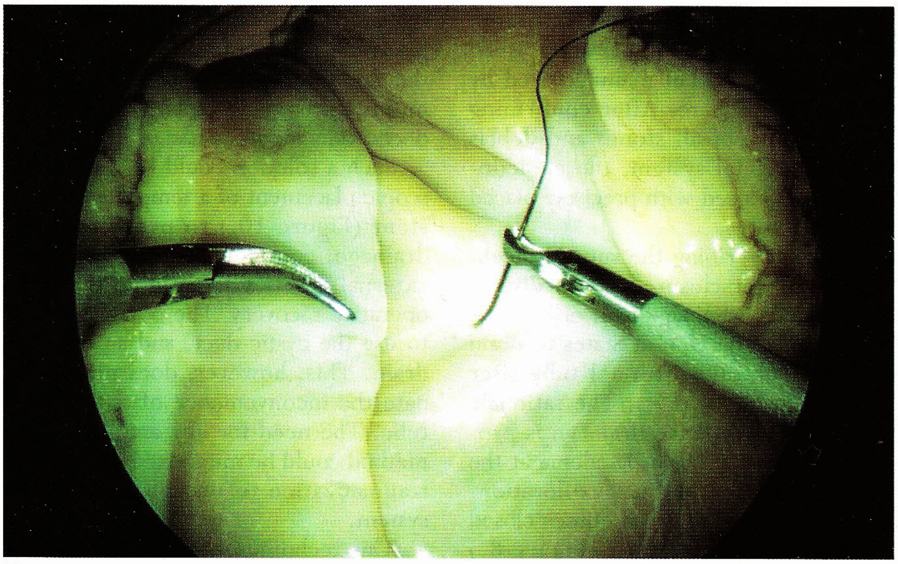

Figure 11a. The Szabo-Berci "parrot" needle driver (right) and "flamingo" assistant needle driver (left) (Karl Storz Endoscopy, Culver City, CA).

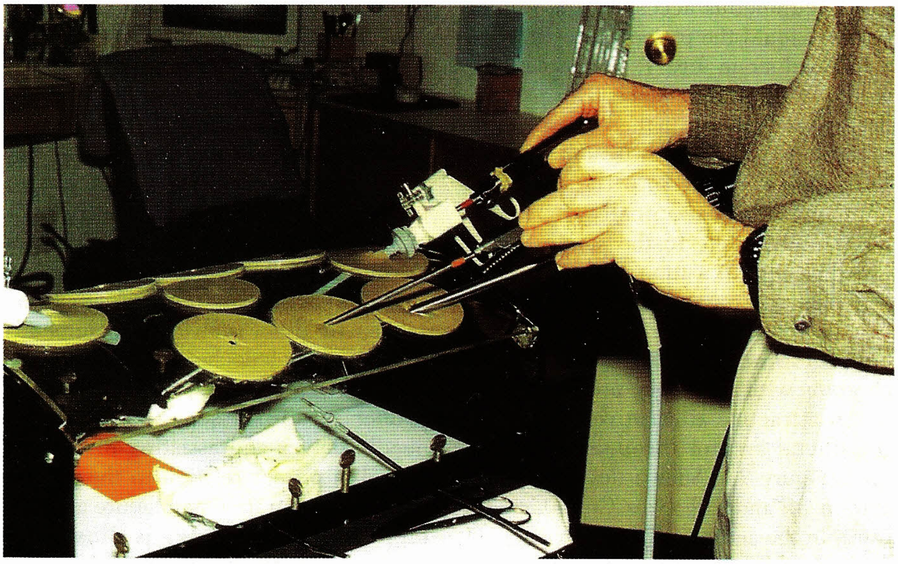

Figure 11b. Precision pencil grip for the coaxial handles of the Szabó-Berci needle drivers.

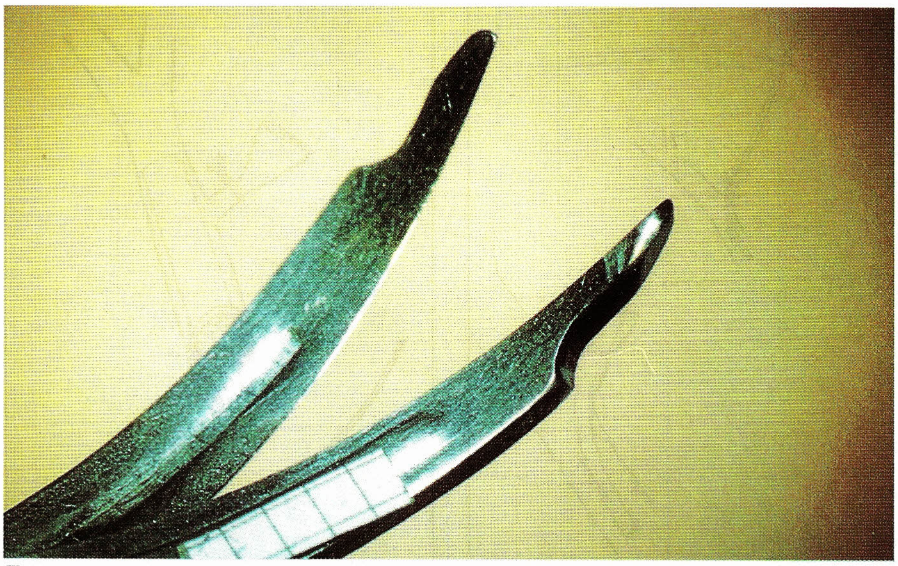

Figure 11c. Curved endoscopic scissors – Szabó-Berci modification for dissection of the CBD and choledochotomy incision.

er suturing setup is a triangle with the area to be sutured occupying the apex of the triangle. The port used for the needle driver is one corner of the base - right or left depending upon the surgeons dominant hand - and the assisting driver in the opposite corner of the base. The surgeon's eyes (the camera) are located along a line drawn from the apex perpendicular to the base centered between the suturing ports. With proper setup, approximately one half of the instruments is located in the abdominal cavity and one half out of the abdominal cavity.[9] This setup balances the instruments and reduces fatigue on the part of the surgeon. The surgeon will be relaxed with the arms in a comfortable position. The forearms are flexed at the elbows to form approximately a 90 degree angle with the upper arms.

The type of suture material, the type and shape of the needle and the length of suture used will be determined by the type of tissue to be approximated and the relative distance between the entrance point of the needle. When suturing the common duct in closing a choledochotomy, the two tissue edges are in close proximity to each other. A regular half circle needle works well. Others feel more comfortable with a ski shaped needle or a 3/8 circle needle. The needle can be easily fashioned into a ski shape by simply straightening the back two thirds of the needle using two regular needle holders.[4] An absorbable suture material should be used for the common duct to eliminate a nidus for stone formation from the suture material itself. The suture material should be cut so that 12-15 cm of tail is left. As one gains proficiency, the shorter length is preferred.

The Szabo-Berci "parrot" needle driver and "flamingo" assistant needle driver (Figure 11.) (Karl Storz Endoscopy, Culver City, CA) has been found to greatly facilitate correct needle entrance and exit point placement and intracorporeal knot tying. The needle driver has a spoon shaped "parrot" jaw and the assistant needle driver has a long curved "flamingo" jaw. It will also be noted that they both have axial control of the opening and closing of the jaws.

This allows the wrist and fingers to be held in a comfortable and natural position while operating these instruments. No more than finger tip control is needed for their proper use. It should be pointed out that the assistant needle driver - "flamingo jaw" - will not fit down a rigid 5 mm port. One must either use a flexible metal cannula (Karl Storz Endoscopy, Culver City, CA) or a 7 mm rigid port. The final piece of equipment needed is a 10 mm reducing sleeve fitted with a 5 mm rubber gasket (Weck Inc.). This is used to introduce and then remove the needle through the suturing port. If the needle and attached suture material are placed unprotected through the suturing port, the gasket will be cut. This will result in loss of the gas seal, and it will be difficult to maintain the pneumoperitoneum. Of course there is the issue of wasting gaskets for reusable ports or using an excessive number of disposable ports when it is necessary to replace one that leaks. A potentially more serious problem is the loss of a needle. It is a cardinal sin to lose a needle in the peritoneal cavity. Unless the needle is protected inside the reducer sleeve (Figure 12.) during periods of transit into and out of the peritoneal cavity, it can be caught on the flap valve of the access port and separate from the suture. It may then drop unnoticed into the abdomen. It is also imperative that the surgeon makes certain that the camera operator follows the needle at all times during periods of transit in and out of

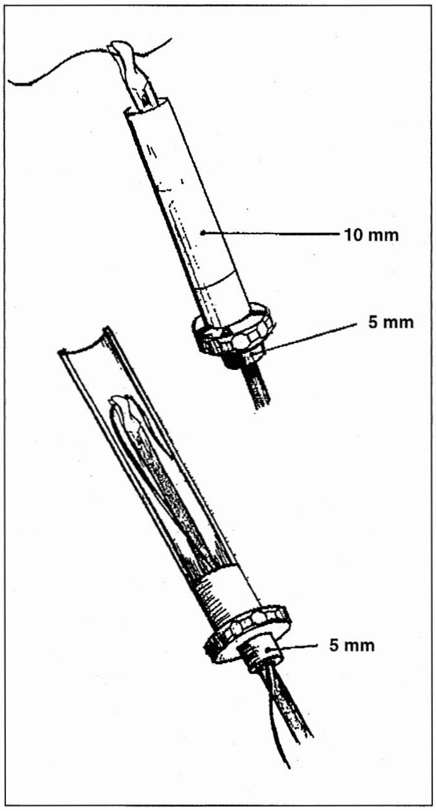

Figure 12. Suture introducer sleeve.

Figures 13a–13e. Sutured closure of the choledochotomy. **(continued on page 8)**

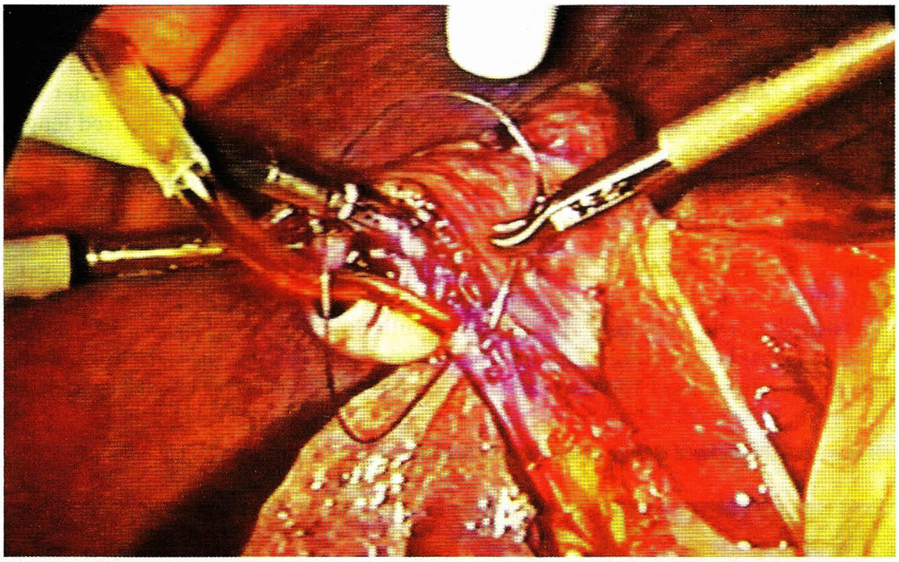

Figure 13a. Double bite loop for ligature knot around cystic duct and drain.

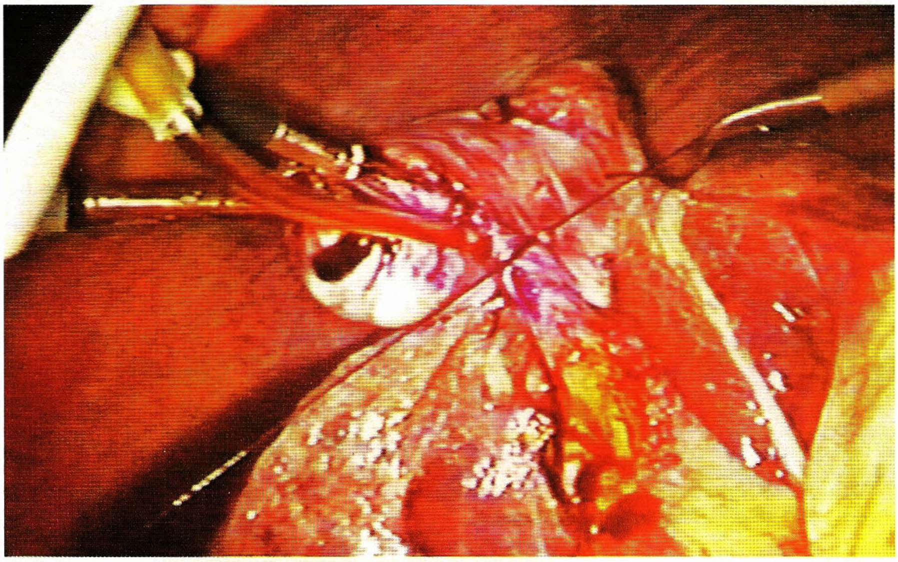

Figure 13b. Ligature knot of cystic duct with drain is tightened with surgeon's knot.

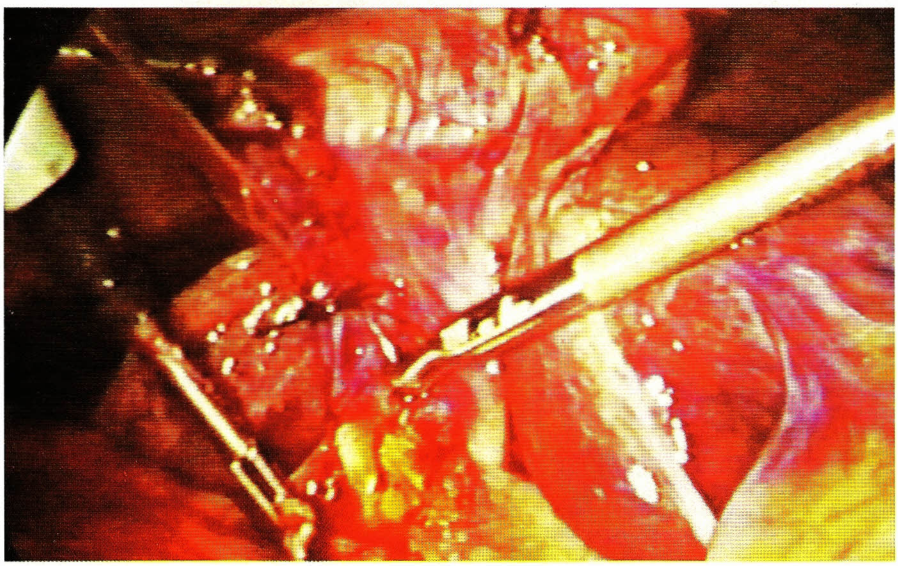

Figure 13c. Suturing choledochotomy: entrance and exit bites of cut edges.

the peritoneal cavity, If these precautions are observed, a needle should rarely if ever be lost.

We will specifically consider now the technique of laparoscopic closure of the choledochotomy incision. The commonly used suturing ports used in this setup are shown in (Figure 2). The primary needle driving port site is the epigastric port. The assistant driver site is usually the most medial of the original right subcostal ports. The remaining ports in the right subcostal region are used to provide exposure. Any one of the three can be used for the assistant needle driver, and then any of the other two will be used for exposure. Use the combination which provides the best setup.

A 4-0 braided absorbable violet colored suture is cut to the desired length (6-7 inches). The needle is usually left as a half circle, but can easily shaped into a ski needle if desired. The parrot jaw needle driver is then passed through the reduction sleeve and gently grasps the suture material then pulls it inside the loader. The entire apparatus is then passed through the epigastric port. The needle is released onto the anterior wall of the stomach or any suitable place. The parrot jaw needle driver and reduction sleeve are removed together, and the needle driver is withdrawn from this device and reinserted through the epigastric port which now has a 5 mm gasket in place. Suturing through the reduction sleeve creates excessive drag on the needle driver.

Usually, the needle can be placed in a desirable position so that it can be regrasped by the needle driver ready to be passed through the common duct. Occasionally, it is necessary to manipulate the needle in order to grasp it in the ready position. This is done by passing the assistant or flamingo jaw needle driver through the appropriate right upper quadrant port. The suture material is grasped and elevated so that the tip of the needle is vertical but in contact with whatever tissue it rested upon. By twisting the flamingo driver the suture material causes the needle to pirouette. It is held in the proper position, and the needle is grasped approximately half way along its shaft.[5]

The parrot jaw needle driver has a two position ratcheted locking mechanism with each successive ratchet applying greater holding force. The instrument can be unlocked by clicking a third time and releasing. It is not important that the needle be held with great force to prevent deflection of the needle as it is driven through tissue while suturing. In fact the instrument is not usually ratcheted. It can be seen that unless the needle is driven at a 90 degree angle to the plane of tissue resistance, it will invariably deflect. This means that the entire process must be repeated. Frustration and delay can be avoided by taking the time to insure that the needle and driver setup are perfect before attempting to pass the needle through tissue. By proceeding slowly and methodically, the goal is accomplished more quickly.

The luxury of three dimensions is not yet realistically available for laparoscopic surgery. The two dimensional visual field and working through long instruments at relatively great distances from their point of application are the factors responsible for the lack of general use of laparoscopic suturing by surgeons. However, there are ways in which these limitations can be minimized.[6] The first way is to touch the

Figures 13a–13e. Sutured closure of the choledochotomy. **(continued from page 7)**

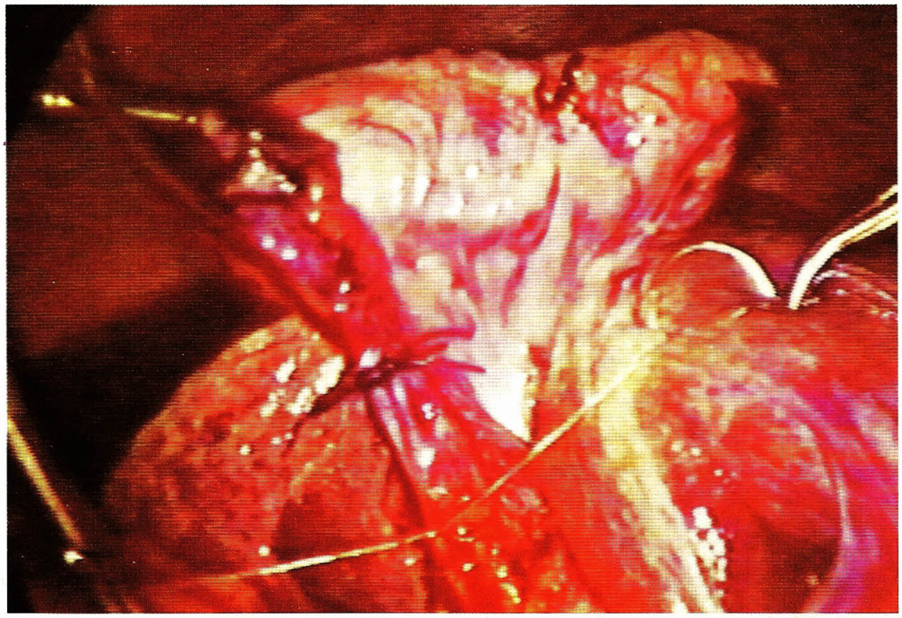

Figure 13d. Tightening knot for water tight closure.

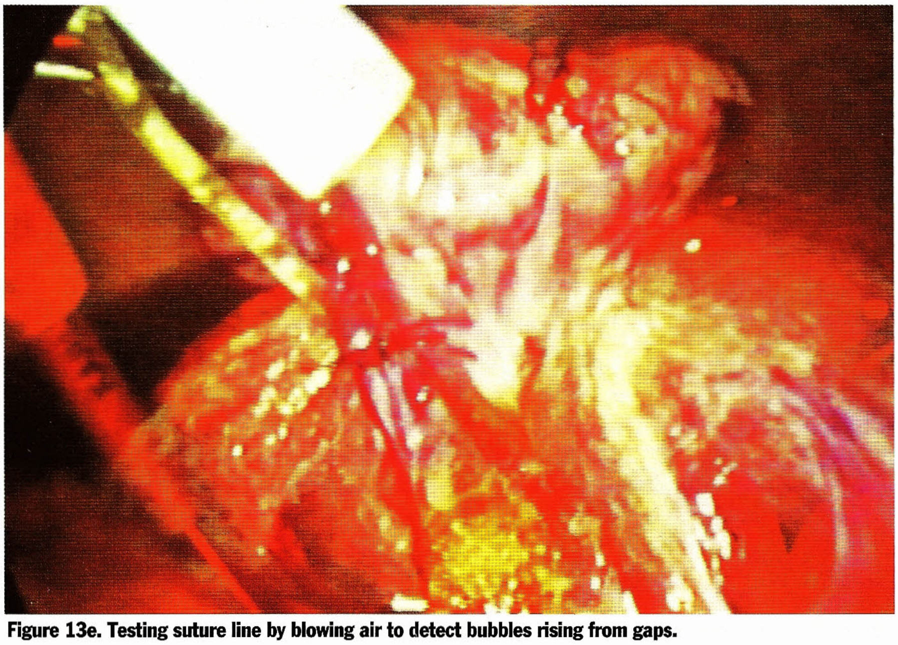

Figure 13e. Testing suture line by blowing air to detect bubbles rising from gaps.

suture, needle, or tissue before attempting to grasp the object. By touching an object, the position of the instrument relative to that object is confirmed.[10] Use of this technique will eliminate much of the futile groping when we try to estimate depth perception when it is not there. A second way to help overcome these limitations deals with confirming proper positioning of the needle by the driver. Once the needle is grasped in what is felt to be the proper position, bring the needle and driver close to the end of the laparoscope and then rotate to different positions. Looking at the position of the needle in the grasp of the driver from different angles will reveal its true position.[10] Finally, there is a greater need to coordinate camera position and movement when suturing than during general laparoscopic surgery. Mechanical laparoscope holders with driving mechanisms to move the camera in an X, Y, and Z axis fashion under the control of the surgeon are being developed (Karl Storz Endoscopy America, Culver City, CA; Computer Motion, Santa Barbara, CA).[7] This relieves the burden from the surgeon communicating complicated instructions to another person.

When the setup is maximized, then one can proceed to close the choledochotomy (Figure 13.). The edge of the tissue is gently but firmly grasped with the flamingo jaw instrument and placed on slight tension. Then the tissue at the point of penetration is touch with the tip of the needle. After making any necessary fine adjustment the needle is driven through. At this point, the needle can either be released and regrasped to drive the needle through the opposite wall of the common duct, or the needle can be driven through both sides with one pass. The needle is grasped with either driver and pulled completely through. At this point, the needle is released and not be grasped again. It is desirable to handle the suture only from this point on. When tying the knot, the needle is usually pulled out of visual range. If it is dangling harmlessly on the suture material, it cannot lacerate or penetrate tissue. If the needle is held firmly by one of the drivers when the knot is laid down, it could cause harm.

The suture is pulled through leaving a tail of 2 to 3 cm. The long portion of the suture is then pulled interiorly and looped back toward the short tail so that it looks like the letter C. The long tail[8] is touched and then grasped with the parrot jaw. The flamingo jaw instrument then placed on top of the suture and a loop made. The instruments are advanced together toward the short tail. If the flamingo is advanced without simultaneous movement of the parrot jaw instrument, the short tail can be pulled through. After touching and then grasping the short tail, the short tail is pulled through to create the first throw of a square knot. The throw is tightened by pulling the long side only. Pulling both sides equally, results in a tail which can be longer than the opposite side. This makes subsequent throws more difficult to accomplish. At this point, the short tail is on the side opposite to which it originally lay. It is dropped and the long tail is looped interiorly once again only this time the letter C appearance is reversed. The long tail is handed from the parrot to the flamingo. The parrot is placed over the suture and a loop is again made. After advancing with both instruments the short tail is pulled through with the parrot jaw instrument. The throw is laid down creating a square knot. If all has gone well, the layout will be same as the very beginning. The first step is repeated to created a third throw for security. At this point, the reducer sleeve is used once again to provide an atraumatic exit for the needle. The parrot jaw driver is introduced through the reducer sleeve. The parrot jaw driver, the secured needle and the reducer sleeve are withdrawn under direct video image. Two or three sutures are usually required, so the process is simply repeated for each additional suture. Once experience is gained one suture is adequate to minimize needle traffic through the ports. If a transcystic drain or T-tube has been used, it is externalized for completion cholangiography.

If the choledochotomy is closed without internal drainage or a stent is used, the port used previously for initial cholangiography is used once again for completion cholangiography. This port has a self-sealing cap, so the cholangiography will take place without loss of the pneumoperitoneum. The catheter is reintroduced into the previously used opening in the cystic duct for the completion cholangiogram. It is useful to flush the ductal system with saline prior to performance of this final cholangiogram to purge the duct of air which is invariably present. It also is used to test the integrity of the choledochotomy closure by checking for leakage at the closure site while flushing with saline under moderate pressure. When the surgeon is satisfied that the duct is clear, the cholecystectomy is completed. A subhepatic drain is placed and brought out through the most lateral right subcostal port.

SUMMARY

Techniques for laparoscopic common duct exploration are presented with emphasis on exploration through a choledochotomy. Laparoscopic suture closure of the choledochotomy is discussed in detail.

Mastery of these techniques and acquisition of the necessary judgement to determine which should be applied is challenging. With proper training and a dedication to acquisition of laparoscopic suturing skills the armamentarium of the surgeon will be greatly enhanced. The beneficiary will be our patients.

With greater skill and ability comes a need for greater judgement. There are now more options present for the surgeon and patient to consider concerning the management of gallbladder disease complicated by common duct stones. Not all common duct stones can be managed laparoscopically. How do we deal with this problem when it will inevitably arise during surgery? Do we convert to an open procedure? Refer the patient for a post operative ERCP and sphincterotomy - possibly a second anesthetic should the ERCP fail? All of these possible scenarios should be discussed with patients preoperatively to truly inform them and to learn their wishes.

We must never forget that out primary purpose is to make the patient well, not to display our prowess as laparoscopic gymnasts. This last thought is more eloquently stated by A. Cuschieri. "In the end, it does not matter how a surgical procedure is performed, but that it is done well and to the patient's benefit."

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