Original articles

Surgical Endoscopy

Surg Endosc (1991) 5: 103–108

Review of 300 consecutive laparoscopic cholecystectomies: development, evolution, and results

S. T. Ko and M. C. Airan

Department of Surgery, Mount Sinai Hospital Medical Center, Chicago Medical School, 15th Street and California Avenue, Chicago, IL 60608, USA

Summary. The present paper reviews 300 laparoscopic cholecystectomies with intraoperative cholangiograms that were performed by the authors. The development and evolution of this procedure are described along with the results. The guidewire technique used for operative cholangiography and the maneuver applied to control bleeding of the cystic artery are detailed. Five cases were converted to open operations. No serious complications were encountered. One common bile duct injury occurred during endoscopic retrograde cholangiopancreaticography performed on postoperative day 8 for diagnostic purposes.

Key words: Laparoscopic cholecystectomy – Intraoperative cholangiogram – Surgeon/co-surgeon – Development – Evolution – Complications

Langenbuch [10] reported his first cholecystectomy in Berlin in 1882, and Calot [4] reported the first French cases in Paris in 1890; thus cholecystectomy has remained the gold standard for the treatment of gallstone disease for 100 years. Laparoscopy has been extensively used by Semm [16] over the past four decades. In Lyon, France, Mouret combined the two techniques and carried out a laparoscopic cholecystectomy in 1987 (F. Dubois, personal communication). In Paris, Dubois et al. [6, 7] reported their series in 1989. Perissat et al. [13] of Bordeaux described their laparoscopic method using intraoperative lithotripsy for gallstones. In Scotland, Cuschieri and colleagues [5] reported their percutaneous treatment of gallstone disease in 1989. McKernan [11] is reputed to be the first surgeon in the United States to have performed a laparoscopic cholecystectomy (in 1988). In the United States, Reddick and Olsen [15], Berci et al. [2], and the present authors [9] have independently carried out laparoscopic cholecystectomy and intraoperative cholangiography. With the publication of these reports, laparoscopic cholecystectomy has recently become a most interesting and controversial surgical procedure. This paper is the result of the authors' combined experience with personal cases and in the teaching of hands-on courses and the practical tutelage of other surgeons. A total of 300 consecutive personal cases are reviewed, including only those in which the authors operated as a surgeon/co-surgeon team and excluding those in which either of the authors were tutoring other surgeons.

Offprint requests to: S. T. Ko, 701 South Main Street, Lombard, IL 60148, USA

Concept and development

Having witnessed a laparoscopic ovarian cystectomy performed by Semm [16] and the resection of a rectal tumor via rectoscope by Buess et al. [3], we decided to investigate the feasibility of laparoscopic cholecystectomy. Using six canine models, a four-puncture technique was developed. An optic port at the umbilicus and three accessory operating ports in the line used in incision of standard cholecystectomy were found to be adequate. The exposure of Calot's triangle was facilitated by grasping the fundus and Hartmann's pouch. Dissection of the cystic duct and cystic artery were carried out in a standard fashion. Ligation of the cystic artery and occlusion of the cystic duct posed some difficulty because of inadequate instrumentation in early cases. Self-made clips and an extracorporeal knotting technique were used to clip the cystic artery and occlude the cystic duct. All but one of the dogs survived the procedure and became active on the next day, the exception being one canine that died within 12 h postsurgery due to a failure of the animal laboratory facility. (A power failure occurred in the animal laboratory at the end of the procedure, resulting in complete collapse of the abdominal cavity due to loss of pneumoperitoneum. The trocar sleeve must have punctured the spleen unnoticed, causing exsanguination and death.)

After this successful animal laboratory experience, we used the instrumentation in three open cholecystectomies to investigate the application of this technique to patients. Three other subjects were selected and laparoscopic dissection of Calot's triangle was performed. The cystic artery was ligated with extracorporeal knots and the cystic duct was either clipped with self-made staplers or tied with extracorporeal knots. This work was then checked by minilaparotomy to ensure that no injury had occurred. Following these early six cases, we proceeded to do planned laparoscopic cholecystectomies. All patients were informed of this new technique and were also given an opportunity to undergo standard open cholecystectomy (the consent form always stated, "Laparoscopic cholecystectomy with intraoperative cholangiogram and possible open cholecystectomy"). The first successful procedure was done in August 1989 by the present authors, who reported their findings in December 1989 [9].

Evolution

As the instrumentation improved and our experience increased, the procedure was refined. Special maneuvers and techniques were developed. General anesthesia via endotracheal intubation was used, and special care was taken to prevent postoperative nausea and vomiting. End-tidal carbon dioxide was closely monitored during the entire procedure. Due to the need for changing the patient's position on the operating room table during the procedure, an antiembolic sequential compression device was applied routinely rather than selectively. Arms and feet were padded, and a nasogastric tube, a Foley catheter, and prophylactic antibiotics were routinely used.

Initial pneumoperitoneum was routinely achieved via the umbilical site using a Veres needle, but when condition's warranted, either alternate puncture sites or an open method was used. The technique used to insert the Veres needle varied, but we found that direct insertion of the needle into the midpoint of the umbilicus was safe. Because the umbilicus is a scar and is the thinnest part of the abdominal wall, the surgeon almost never needs to use the longer Veres needle to gain access to the peritoneal cavity. A Z-stab in the umbilicus using the dilator technique as described by Semm [16] was used for the insertion of an umbilical trocar to prevent air leakage. However, due to difficulties encountered in removing the gallbladder, both the Z-stab and the dilator techniques were abandoned. A beam-splitter was used to connect the scope during the procedure, and the surgical team viewed the monitor while assisting. After the first 12 cases, this technique was changed to complete electronic imaging such that the surgeon as well as the entire surgical team could view monitors while operating [1]. This not only provided an imaging improvement but also lessened the surgeon's visual fatigue and reduced the chance of contamination during the procedure. For proper visualization the angle of a 10-mm telescope was changed from 0° to 30° to facilitate the exposure of Calot's triangle, especially in obese patients.

Generally, the four-puncture technique was used, but five punctures were sometimes needed to control bleeding and enhance exposure in obese subjects and/or patients who exhibited severe adhesions. The locations of the puncture sites are very important for exposure of the vital structures and for facilitating the dissection and insertion of the ureteral catheter into the cystic duct. As a rule, the first puncture is made with a 10-mm or 11-mm trocar at the umbilicus. The second is made at the right anterior axillary line below the costal margin with a 5-mm trocar. The third puncture is made at the midclavicular line below the right costal margin with a 5-mm trocar. The fourth puncture is made below the xiphoid process and slightly to the right of the midline with a 10-mm or 11-mm trocar to avoid penetration of the falciform ligament. The exact location of punctures varies with the contour of the torso of the patient and the position of the liver in relation to the costal margin. The surgeon may chose to use disposable or nondisposable trocars; the latter are less expensive. The dissection techniques are similar to those used for the open procedure, and the same surgical principles are applied in the endoscopic technique, except that additional precautions must be taken to prevent air leakage and to maintain an air cushion for both visualization and prevention of injury to the surrounding organs.

Intraoperative cholangiography is the most difficult part of the procedure. In our early cases, we used a blunt aspiration needle to cannulate the cystic duct so as to obtain X-ray pictures, but the latter were of poor quality due to leakage and to the radiopacity of the needle. Cholangiocatheters were also used, but the success rate was very low, ranging from 30% to 40%. We developed a guidewire technique using a 0.038-mm guidewire with a soft, flexible tip in an indwelling 5-F ureteral catheter with an open-end tip for cannulating the cystic duct. The ureteral catheter with guidewire was passed through the 5-mm midclavicular port. The guidewire was introduced into the cystic duct after the latter had been incised with microscissors through the same midclavicular port. The catheter was then secured by a grasping forceps. The guidewire and cannula were then withdrawn, the contrast medium was injected, and intraoperative cholangiography was performed. We usually inject 20 ml full-strength contrast medium; due to this technique, the success rate for intraoperative cholangiography has dramatically improved. Later on, the cholangiogram clamp became available and the technique was refined, which eliminated the shadow cast by the Wisap grasping forceps (see Figs. 1–3).

We feel very strongly about obtaining routine intraoperative cholangiograms (IOCs) for the following two reasons. First and foremost, the purpose is to secure immediate information on the ductal anatomy and on the possible position of any clips used. The information on the length of the cystic duct helps in the application of clips at a safe distance from the common bile duct (CBD). Second, any injury to the CBD is revealed on the cholangiogram and the damage can be repaired immediately. However, information on the presence or absence of unsuspected stones in the CBD undoubtedly influences the subsequent management of patients.

During IOC, the position of the patient is of utmost importance. The subject is placed in Trendelenburg's position and is tilted to the left. The trocar sleeves and telescope should be aligned in the craniocaudal position to avoid blockage of the CBD and its entrance into the duodenum.

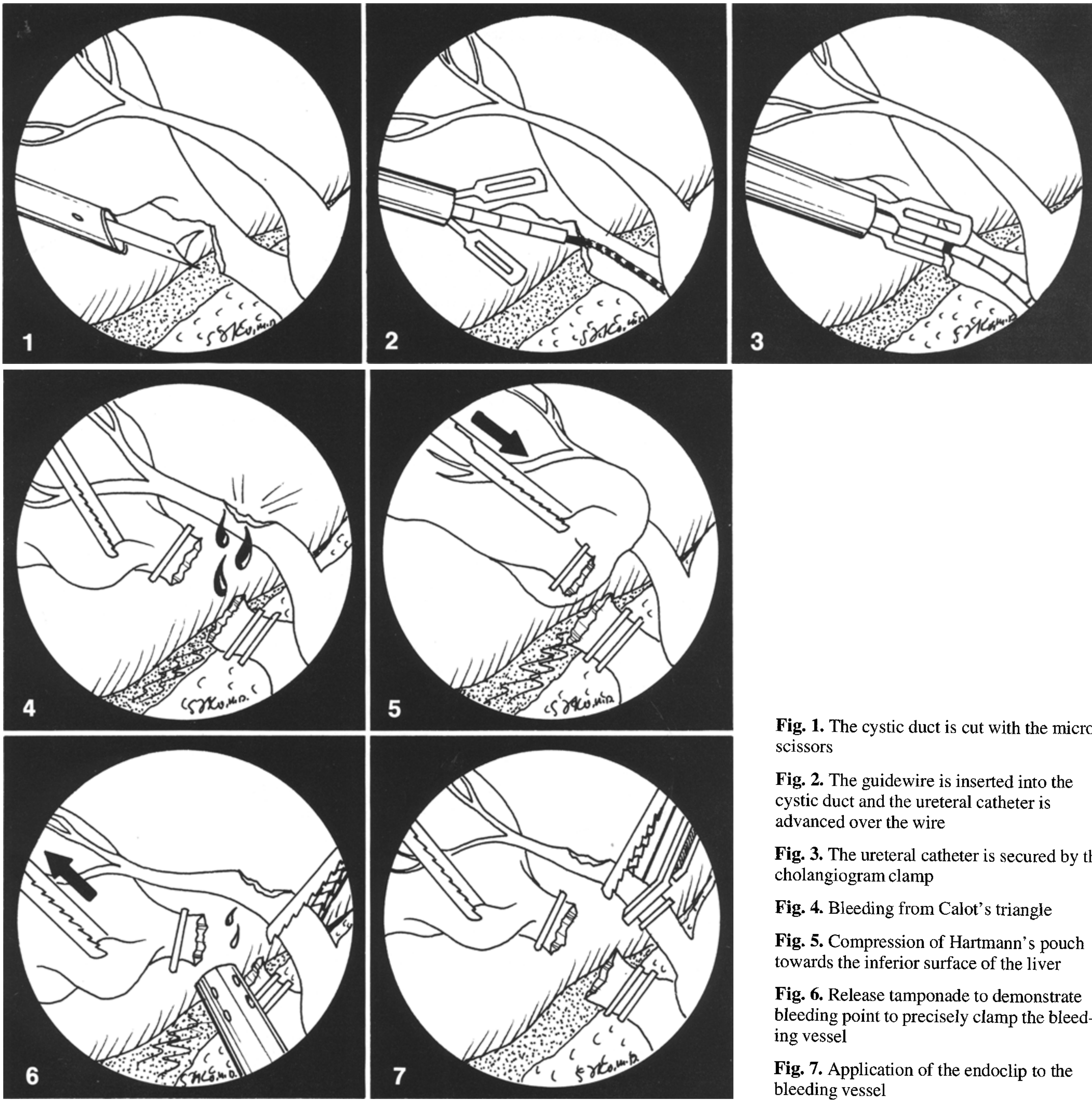

Fig. 1. The cystic duct is cut with the microscissors

Fig. 2. The guidewire is inserted into the cystic duct and the ureteral catheter is advanced over the wire

Fig. 3. The ureteral catheter is secured by the cholangiogram clamp

Fig. 4. Bleeding from Calot's triangle

Fig. 5. Compression of Hartmann's pouch towards the inferior surface of the liver

Fig. 6. Release tamponade to demonstrate bleeding point to precisely clamp the bleeding vessel

Fig. 7. Application of the endoclip to the bleeding vessel

With the catheter in place, 30 cc warm normal saline is used to irrigate the duct and contrast medium is then injected: the preliminary irrigation evacuates air bubbles in the duct. This guidewire technique has two advantages. First, it can act as a dilator and a stabilizer in difficult and small cystic duct cases. Second, the ureteral catheters are marked in centimeters, enabling the surgeon to know the exact length of catheter cannulated. Apart from these two advantages, this technique facilitates the management of unsuspected CBD stones.

The cystic artery can be inadvertently injured during the dissection of Calot's triangle, resulting in profuse bleeding. To control this, Pringle's maneuver [14] is used in the open method, which prevents injury to the surrounding structures. In laparoscopic surgery, a similar method based on the same principle is employed; however, using the grasping forceps that are holding Hartmann's pouch instead of the surgeon's finger and thumb, the gallbladder and the liver are gently compressed to secure hemostasis. As illustrated in Figs. 4–8, this is accomplished in the following manner:

1. The co-surgeon, who is holding the grasping forceps that is securing Hartmann's pouch, presses the forceps against the inferior aspect of the liver to control the bleeding. This mimics the finger-and-thumb technique of Pringle's maneuver as used in the open method.

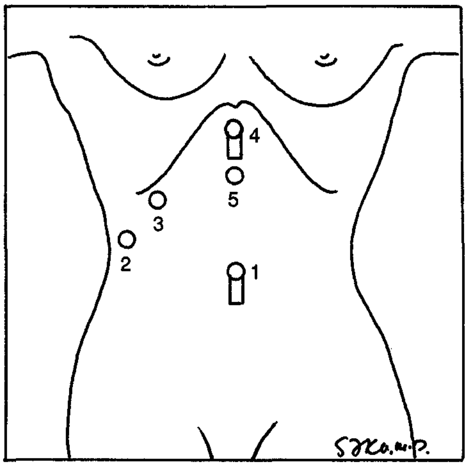

Fig. 8. The position of the fifth trocar

2. At the same time, the camera operator should quickly withdraw the telescope, clean it, and reinsert it into the abdominal cavity while the surgeon changes his operating instrument to a spring-loaded grasping forceps.

3. After the telescope has been reinserted, Calot's triangle is visualized to ensure that the previously described maneuver has indeed controlled the bleeding; if not, the patient must be explored immediately.

4. Once visualization has been reestablished, the surgeons' spring-loaded grasping forceps is kept near the bleeding site. The co-surgeon's grasping forceps is slowly released from its tamponading position to demonstrate the site of bleeding. If the bleeding is clearly visible, the surgeon can grasp the exact bleeding site with the spring-loaded forceps.

5. Should bleeding not be controlled in this manner, the co-surgeon must quickly reapply pressure with the grasping forceps to tamponade the bleeding and the surgeon should insert a fifth (5-mm) trocar 2 cm below the epigastric trocar site. The surgeon then inserts the spring-loaded grasping forceps through the fifth port. The maneuver then involves gradual release of the tamponading forceps to demonstrate the bleeding vessel using a suction cannula that has been inserted through the operating port near the bleeding vessel to identify it. The spring-loaded grasping forceps is then used to grasp the bleeding vessel and secure hemostasis. By suctioning and then grasping, precise localization of the injured artery can safely be accomplished without injuring the surrounding structures. Using this maneuver, we safely controlled such bleeding on four occasions and thus avoided the necessity of performing an open cholecystectomy. This Ko/Airan maneuver is a safe and useful method for the control of bleeding of the cystic artery during laparoscopic cholecystectomy.

Once the cystic duct and cystic artery have been dissected and controlled, the gallbladder is ready to be removed from the gallbladder bed. This dissection was originally done by insulated hook scissors and electrosurgical dissection and was tedious because the scissors dulled easily. Therefore, hook scissors were replaced by sharper-tipped scissors. Later on, hook and spatula dissectors became available and dissection was then performed using these newer instruments. During the dissection, the co-surgeon's duties are very important, involving the application of fundic traction as well as traction of Hartmann's pouch to open Calot's triangle. Dissection of the gallbladder from its bed also can be achieved using lasers. We used a contact YAG laser in six procedures and found no particular advantage for this procedure over the electrosurgical technique.

After the gallbladder has been removed from its bed, the camera at the umbilical port is moved to the epigastric port, the grasping forceps is inserted through umbilical port, and the gallbladder is extracted through the umbilicus. If the gallbladder contains large stones or the gallbladder wall is too thick and bulky, the umbilical incision can be enlarged cephalad so as to accommodate the size of the organ and/or stone mass.

Following removal of the specimen the abdominal cavity is irrigated with normal saline solution until it is clear. Suction drainage tubes were routinely placed in our initial 40 patients, but later we used drains selectively. Next, all puncture sites are injected with 0.5% Marcaine solution and closed subcutically with 5-0 vicryl sutures. To avoid future iatrogenic umbilical hernia, special care should be exercised in closing the fascia; we have used number 1 vicryl to close the umbilical fascial incison and to date have not encountered an iatrogenic hernia. In cases of preexisting hernia, repairs have been carried out similarly.

Results

The 300 consecutive laparoscopic cholecystectomies performed by the present authors from August 1989 through February 1991 are detailed in Table 1 in terms of the age, sex, and weight of the patients, their hospital stay, and the operating time. The results of these procedures, including the success rate and the incidence of unsuspected CBD stones, are listed in Table 2. The complications encountered are shown in Tables 3 and 4. Pathologic findings

Table 1. Details on 300 laparoscopic cholecystectomies

Age	Sex	Weight	Hospital stay		Operating time
12–85 years	F 252	102	Same day	3	40–270 min
	M 48		Overnight	290	
		500 lb	3 days	4	
			4 days	3	

Table 2. Results of 300 laparoscopic cholecystectomies

		Success rate
Attempted IOC	292	91.7%
Successful	268	
Unsuspected CBD stones	18/300	6.0%
Laparoscopic CBD exploration	1/300	0.03%
Cases converted to open procedures	5/300	1.6%
Complications	14/300	4.6%

Table 3. Complications in 300 cases

Intraoperative	Bleeding cystic artery (all controlled – did not open patients)	4
Postoperative	Surgical emphysema	2
	Umbilical wound infection	5
	Prolonged ileus (4 days)	1
Delayed complications	Fever of unknown origin (TbC culture positive for right-middle-lobe syndrome)	1
	CBD injury (on postoperative day 8 during ERCP – required emergency exploration and repair)	1

Table 4. Serious complications

Postoperative bleeding	0
Postoperative transfusions	0
Bile leakage, any cause	0
Bowel injuries	0
Bile duct injuries	0
Hepatic artery injury	0
Portal vein injury	0
Reoperation on postoperative day 8 (due to injury during ERCP)	1

Table 5. Pathologic review of 300 laparoscopic cholecystectomies

Noncalculous cholecystitis	8
Chronic cholecystitis with cholelithiasis	268
Adenomyosis	1
Localized smooth-muscle hypertrophy	1
Hydrops of the gallbladder	6
Subacute cholecystitis	5
Acute cholecystitis	6
Empyema of the gallbladder	4
Gangrene of the gallbladder	1

Table 6. Concomitant medical conditions

Diabetes mellitus (severe)	10
Pulmonary emphysema (severe)	12
Carcinoma of the lung	2
Coronary bypass	6
Cirrhosis of the liver	1
Chronic renal failure	3
Gallstone pancreatitis	2
Large umbilical hernia	3
Large hiatal hernia	2
Large inguinal hernia	3
Tuberculosis (pulmonary)	1
Severe arthritis with flexion contracture	1
Severe morbid obesity	1
Femoropopliteal bypass	2
Massive adhesions with no peritoneal cavity	1
Situs inversus (complete)	1

and concomitant medical conditions are listed in Tables 5 and 6, respectively.

Discussion

Inspite of the recent development of nonsurgical treatment for gallstone disease, cholecystectomy remains the standard therapy. Open cholecystectomy has been performed safely, resulting in very low mortality and morbidity [14]; however, standard open cholecystectomy requires a large incision, a longer hospital stay, a protracted recovery period, and severe postoperative discomfort. Laparoscopic cholecystectomy offers the advantage of minimal postoperative pain, a shorter hospital stay, and a brief recovery period and is cosmetically aesthetic. This technique is somewhat limited in patients with chronic adhesions and the incidence of ductal injury during the procedure is higher.

Laparoscopic cholecystectomy is heavily dependent on instrumentation, including a TV camera and monitors, a light source, an air insufflation machine, video recorders, an energy source for dissection (electrosurgery vs laser), and special surgical instruments. It is of utmost importance that every surgeon thoroughly understand the equipment before attempting to use it. The choice of using electrosurgery or laser treatment is best left to the discretion of the surgeon. We maintain that laser therapy offers no particular advantage and is more expensive and hazardous both to the patient and to the surgical team.

IOC has long been a point of argument: however, in laparoscopic cholecystectomy, IOC becomes more important because it provides crucial information on ductal anatomy and can confirm the absence of unsuspected CBD stones.

One of our patients reported to the emergency room complaining of epigastric pain and inability to pass gas. X-rays of the abdomen were unremarkable. Ultrasound examinaton of the right upper quadrant revealed a small (2 cm) collection of fluid around the gallbladder bed. On consultation, the gastroenterologist decided to obtain an endoscopic retrograde cholangiopancreaticogram (ERCP) because he suspected that the titanium clips on the cystic duct had dislodged. During the procedure, the guidewire perforated the supraduodenal portion of the CBD. An immediate papillotomy with stent placement was carried out, but the patient continued to deteriorate. Exploratory surgery revealed a 1-cm vertical perforation of the CBD located posterolaterally and at least 1 cm from the previous dissection site in Calot's triangle. A T-tube was placed through it for drainage. The cystic duct stump was intact and two clips remained in position. An IOC obtained during the original laparoscopic cholecystectomy indicated no abnormalities. The patient recovered.

Unsuspected CBD stones were found during surgery in 6% of our 300 cases and were managed in several ways, depending on the size and the number of stones. In some cases we crushed the calculi and flushed with heparinized saline solution simultaneously with the injection of glucagon. In some cases we used the guidewire technique, inserting the ureteral dilator first to expand both the cystic duct and Oddi's sphincter and then to push the stones into the duodenum. On two occasions, after dilating the cystic duct, we managed to insert the small choledochoscope through the cystic duct to extract the stone. In some cases, we left the stone alone because it was very small; postoperatively, the patients remained asymptomatic and we believe that the stones passed by themselves. In one subject, we found seven large stones in the CBD and converted this case to an open surgical procedure. On one occasion, we successfully performed a laparoscopic CBD exploration using T-tube insertion in a patient with known CBD stones. Improvement of the instrumentation has enabled us to do CBD exploration endoscopically. Certainly, this has enhanced the scope of the laparoscopic cholecystectomy with IOC.

The recovery of gastrointestinal (GI) tract function is another significant advantage of applying laparoscopic techniques in surgery. In spite of 3–4 h general anesthesia, peristalsis was almost invariably regained on the evening of surgery and patients could start oral intake either during the same evening or on the next day. The reason for this quick restoration of GI tract function remains unclear, but is probably related to minimal parietal body-wall trauma.

Contrary to current opinion, we believe that as this procedure becomes accepted, patients with concomitant illness such as severe pulmonary emphysema, severe diabetes mellitus, severe renal disease, cardiovascular disease, and morbid obesity will benefit most from laparoscopic cholecystectomy.

Finally, the natural history of biliary stone disease [8] indicates that as the instrumentation continues to improve and the surgeon's experience broadens, laparoscopic techniques will become the treatment of choice. At the same time, it must be emphasized that this method is unsuitable for the treatment of asymptomatic gallstones, as is open cholecystectomy. Such cases should be treated only if cholelithiasis becomes symptomatic. The advent of laparoscopic cholecystectomy should not change the indications for surgical treatment of gallstone disease.

Our review of 300 laparoscopic cholecystectomies with IOCs led us to draw the following conclusions:

1. Laparoscopic cholecystectomy is a safe technique in the hands of properly trained surgeons.

2. As carried out by an experienced surgeon/co-surgeon team, this procedure has reduced morbidity and mortality in patients treated for gallstone disease.

3. Laparoscopic cholecystectomy is indicated in patients with concomitant disease.

4. Definitive management of unsuspected and suspected CBD stones can be achieved through the laparoscope without the need of resorting to an open procedure.

5. The advent of safe laparoscopic cholecystectomy should not change the indications for surgical treatment of gallstone disease.

References

1. Berci G, Paz-Partlow M (1988) Electronic imaging in endoscopy. Surg Endosc 2: 227–233
2. Berci G, Sackier J, Paz-Partlow M (1990) Laparoscopic cholecystectomy, mini-access surgery: reality or utopia. Postgrad Gen Surg 2: 50–54
3. Buess G, Kipfmuller K, Hack D, Grissner R, Heintz A, Junginger T (1988) Technique of transanal endoscopic microsurgery. Surg Endosc 2: 71–75
4. Calot F (1890) De la cholecystectomie. Thesis 52, University of Paris
5. Cuschieri A, Al-Handrani A, Nathanson LK (1989) Percutaneous treatment of gallstone disease. Curr Surg Pract 1: 223–228
6. Dubois F, Berthelot G, Levard H (1989) Cholecystectomie par coelioscopie. Presse Med 18: 980–982
7. Dubois F, Icard P, Berthelot G, Levard H (1990) Coelioscopie cholecystectomy. Ann Surg 211: 60–62
8. Hermann RD (1989) The spectrum of biliary disease. Am J Surg 158: 171–173
9. Ko S, Airan M (1990) Technique and early experience of laparoscopic cholecystectomy and cholangiogram. Proc Inst Med Chicago 43: 23
10. Langenbuch C (1882) Ein Fall von Exstirpation der Gallenblase wegen chronischer Cholelithiasis. Heilung. Berl Klin Wochenschr 19: 725
11. McKernan J (1990) Laparoscopic cholecystectomy. J Med Assoc Ga 79: 157
12. McSherry CK (1989) Cholecystectomy: the gold standard. Am J Surg 158: 174–178
13. Perissat J, Collet D, Bellistri T (1990) Gallstones: laparoscopic treatment, cholecystectomy, cholecystotomy and lithotripsy. Surg Endosc 4: 1–5
14. Pringle J (1908) Notes on the arrest of hepatic hemorrhage due to trauma. Ann Surg 48: 541
15. Reddick D, Olsen D (1989) Laparoscopic laser cholecystectomy. Surg Endosc 3: 131–133
16. Semm K (1986) Operative manual for endoscopic abdominal surgery. Year Book Medical Publishers, Chicago