Chapter 8
Intraoperative Cholangiography (IOC): Important Aid in Biliary and Common Bile Duct Surgery

George Berci and Brian R. Davis

Introduction

Since Langenbuch introduced cholecystectomy in 1892, bile duct injuries have occurred with significant morbidity and mortality rates [1]. Kehr, the pioneer of biliary surgery, published a two-volume textbook in 1913 on gallbladder diseases and surgical treatments based on experience from 2600 cholecystectomies and 400 common bile duct (CBD) explorations. He invented the T-tube for CBD drainage [2]. Mayo

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and Halsted visited Kehr. Halsted, founder of the teaching system in American surgery, died from complication of biliary disease [3–5]. By 1930, increasing numbers of cholecystectomies with CBD injury created an urgent indication for intraoperative cholangiography (IOC). It was recommended by Mirizzi for indications to include:

A. Detection of occult CBD stones
B. To avoid negative exploration of dilated (empty) ducts
C. Recognition of anatomic anomalies to reduce the incidence of duct injuries [6] (Fig. 8.1)

Hicken et al. in 1936 (USA) tried to popularize IOC without success. The major impediment was technical shortcomings that included the following: (a) only three films were exposed, (b) the patients' position had to be lifted onto the table to insert and remove film, (c) and the anesthesiologist had to withhold ventilation for each exposure. Due to technical difficulties, it was not unusual that anatomy was misinterpreted or that films were poorly exposed. In addition, the operating time was extended [7].

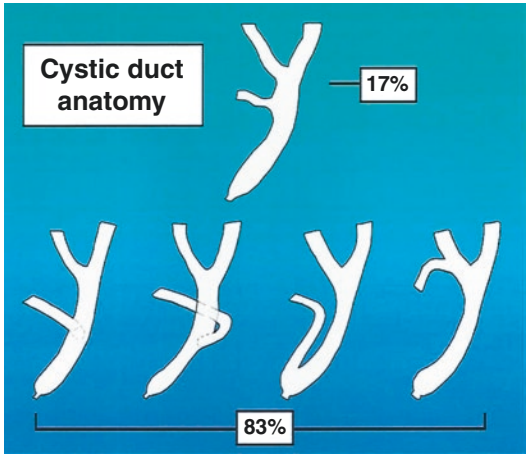

Figure 8.1 Variations of cystic duct anatomy include lateral duct drainage in 17% and in 83% drainage posterior, spiral, or parallel to the common hepatic duct or into the right hepatic duct

Introduction of video-fluoroscopy created significant improvements. Lackner et al. in 1957 ushered in a new era in IOC by introducing a mobile fluoroscope for immediate visual observation including single film exposure [8]. Improved IOC technique was demonstrated by Mallet-Guy in 1958, drawing attention to a mobile video cholangiography unit, which opened the way to today's modern, simplified IOC [9]. This technique was immediately adopted by orthopedic surgeons and other disciplines.

Hamlin and Berci introduced a mobile unit in 1975 for IOC that underwent further improvement. Results of this innovation were reported in 1981 [10]. A short learning curve was required to become proficient with the technique.

These steps during the performance of cholangiography are crucial to save operating room (OR) time and obtain a good result:

A. Interpretation of the complete cholangiogram by the surgeon to include proximal filling of the right and left hepatic ducts and distal drainage into the duodenum through the ampulla of Vater (Fig. 8.2).

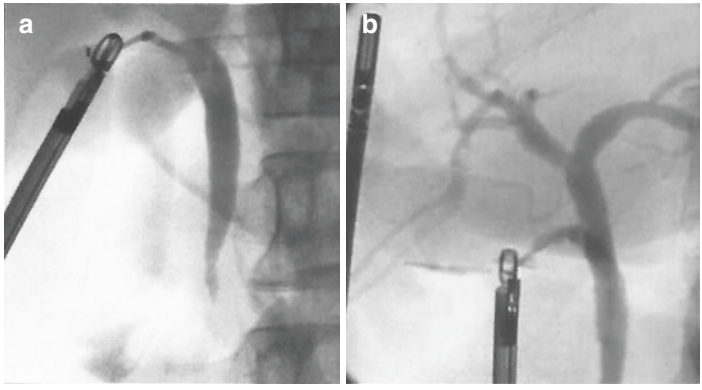

Figure 8.2 Critical components of a complete cholangiogram include (**a**) appearance of the distal CBD with the sphincter and contrast flow into the duodenum. (**b**) Hepatic ductal structure to include the left duct and right anterior and posterior ducts

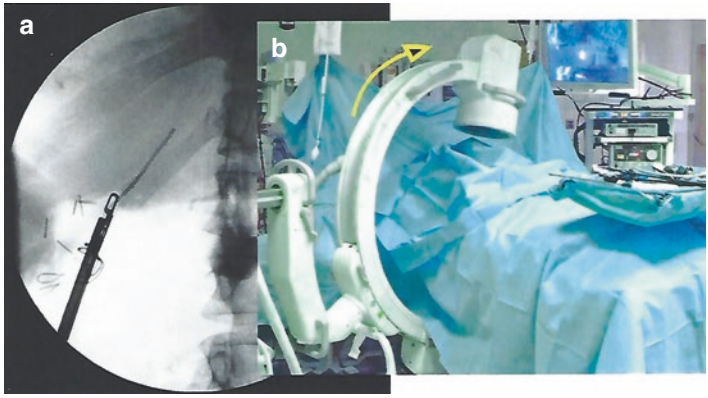

FIGURE 8.3 Critical aspects of cholangiogram technique include (**a**) catheter position in the cystic duct note the access point lateral to the spine. (**b**) Image amplifier rotated 15° to separate the catheter tip from images of CBD and spine

B. Cystic duct cannulation techniques include beveled cholangiogram catheters and disruption of the valves of Heister.
C. Rotation of the image amplifier 15° to separate the catheter tip from the CBD and spine (Fig. 8.3).
D. Pneumoperitoneum needle insertion into the gallbladder (GB) fundus for a cholecysto-cholangiogram as an alternative to cystic duct cannulation (Fig. 8.4).
E. Required instruments should be in the OR and checked by the surgeon and nurses before surgery starts.
F. Arrangements should be made so that the image amplifier is in the OR at the start of the surgery and the technician should be advised to return in time for the IOC.

Radiation Hazard

If basic recommendations are observed, there is no risk of radiation-induced injury to OR personnel if exposure remains under 5 milliroentgens per year. The anesthesiologist, sur-

FIGURE 8.4 Cholecysto-cholangiogram is visualized from insertion of a pneumoperitoneum needle into the fundus. Two clips are placed near the probable location of the cystic duct

geon's assistant, and scrub nurse should wear lead aprons or observe the cholangiogram behind a (translucent) lead screen placed at a distance of 5–6 ft [11].

Anatomy

Important anatomical variants have been detected in this early stage of IOC application. The cystic duct anatomy in 17% displays a short (dangerous) lateral drainage. The short cystic duct (CD) can be easily overlooked when the gallbladder is pulled laterally often leading to CBD injury (Fig. 8.5). Other anomalies include the parallel CD and CBD run, the spiral CD around the CBD, and drainage of the CD into the right hepatic duct (total 83%) (Fig. 8.1). Variant anatomy and inflammation play a significant role in creation of operative

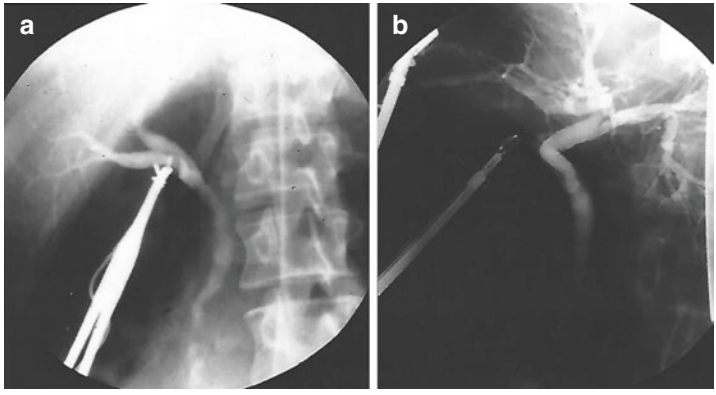

Figure 8.5 (**a**) The pictured short cystic duct that enters the right hepatic can lead to injury. (**b**) The pictured short cystic duct retracted laterally exposes the common hepatic duct to potential injury

injuries. (The reader is referred to Chap. 2 of this manual for a detailed description of the anatomy and its variants.)

Hamlin (1981) reported on approximately 500,000 cholecystectomies annually and that approximately 1000 patients suffered avoidable surgical injuries. Approximately 90% of ductal injuries were errors of surgical techniques [12]. In our first collections of cholangiograms, we reported 791 cases with 197 CBD explorations. Six to nine films were performed per case, and a total of 5,381 films were analyzed. Other institutions accepted the value of IOC and reported their results as well [13, 14].

Laparoscopic Cholecystectomy

Muhe introduced a new era of biliary surgery in 1986 by performing the first laparoscopic cholecystectomy followed by Dubois (1989), Perrisat (1990), Reddick, (1989), Cuschieri, Berci, (1990), Sackier (1990), and Phillips (1991) [15–21]. The introduction of a completely new surgical approach to replace a century-old procedure was rapidly accepted. This caused significant problems in training. Within months it became the procedure of choice, and media coverage was extremely well

organized. Reports indicated that patients were discharged on the first post-op day mostly pain free with the ability to resume normal activities within a week's time [22].

SAGES established training courses as did others advertised without certification. The incidence of complications was significant. Cuschieri reported in (1990) that "We shall witness an explosion of lap chole's. There is a risk that many surgeons will perform it without adequate training and control." It was also recommended that this procedure should be restricted to specialized centers that participate in prospective studies with accreditation [23]. Deziel et al. in 1993 reported a bile duct injury incidence of 0.6% out of 77,604 cases**.** This incidence of bile duct injury was extremely high compared to open cholecystectomies [24–26]. Recognition of the consequences of bile duct injury was delayed due to late onset of secondary biliary cirrhosis following reconstruction and stricture formation. The important role of IOC in prevention of CBD injury was overlooked [27–38].

Advantages of IOC include:

A. Demonstration of variant anatomy indicating areas of difficulty and dangerous dissection (Fig. 8.1).
B. Recognition of contrast extravasation alerts the surgeon of the possibility of a major bile duct injury with the potential need for immediate exploration, to repair duct injury, provide drainage, and call an experienced surgeon for assistance. This avoids complications of delayed diagnosis of the injury including increased morbidity and mortality rates (Figs. 8.6 and 8.7) (The reader is referred to Chap. 9 of this manual).
C. IOC can diagnose concomitant CBD stones with great accuracy allowing removal of calculi in the same surgical session. Incidence of occult CBD stones is 10% (Fig. 8.8).

With a volume of approximately 700,000 laparoscopic cholecystectomies annually, the incidence of bile duct injuries (BDI) is two to three times higher than in open surgery. BDI cannot be eliminated, but with improved education about IOC, we should be able to reduce its incidence and in some cases to reduce its severity when diagnosed at the time of the IOC.

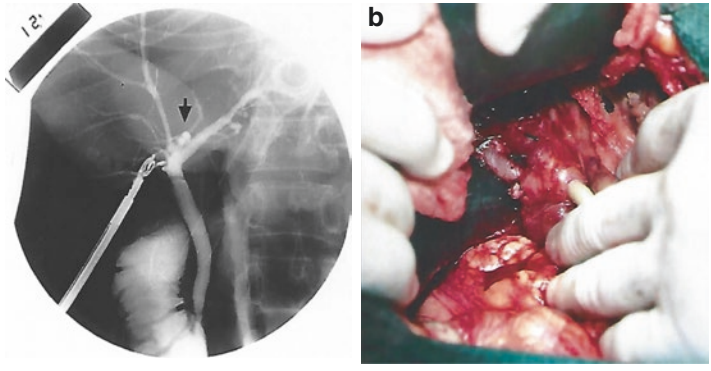

FIGURE 8.6 (**a**) Pictured is a short cystic duct with small contrast leak (arrow). (**b**) Repair of an injury in the CBD is shown with T-tube drainage

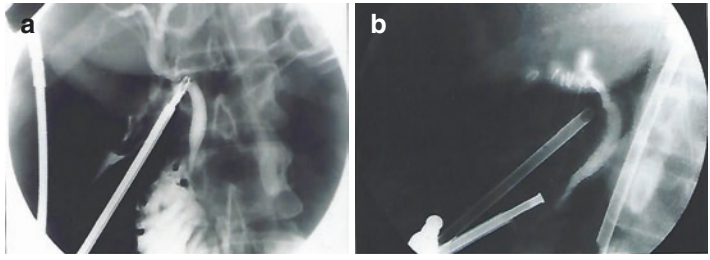

FIGURE 8.7 (**a**) Cholangiogram demonstrates significant extravasation of contrast and injury at the hepato-cystic duct junction followed by exploration and immediate repair without complications. (**b**) Cholangiogram demonstrates multiple clips occluding the right hepatic duct. Clips were removed on exploration, and final cholangiogram shows normal ducts

Common Bile Duct Stones

In 1940, Glenn reported 120 CBD explorations in which 50 demonstrated calculi [39]. Colcock (1964) reported on 1754 cholecystectomies with 503 explorations finding stones in

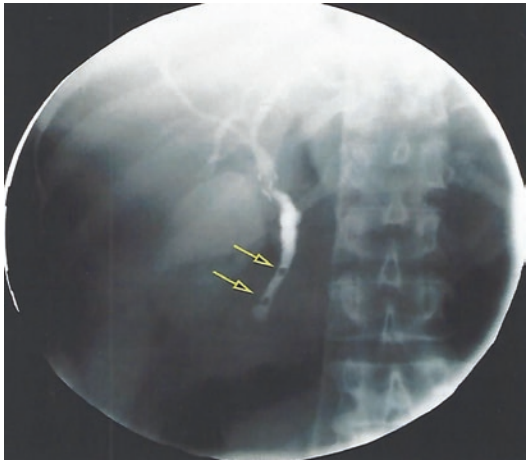

FIGURE 8.8 Cholangiogram demonstrates two small calculi (arrows). After administering intravenous glucagon, the small calculi were flushed through the sphincter

only 339 cases [40]. Detection of occult calculi created an important role for well-performed IOC [41].

Choledochoscopy was utilized in the open cholecystectomy era with the expectation that endoscopic inspection would improve stone detection accuracy. Wildegans (1960) introduced a modified angulated cystoscope with excellent results [42, 43]. Hopkins introduced a new optical system that was successfully employed in choledochoscopy [44]. Significant improvements included attachment of a small video camera to the choledochoscope allowing image projection onto a large screen. This provided an enlarged image for surgeons that facilitated coordination of movement [45]. Recent technologies to include smaller flexible scopes and distal-chip cameras shortened the learning curve to manipulate stones and record findings [46–48].

Out of 700,000 laparoscopic cholecystectomies performed annually, 10% harbor CBD stones. In a multi-institutional SAGES study of 226 patients, 12% harbored occult CBD stones found at IOC. IOC was performed in 99.5% of these

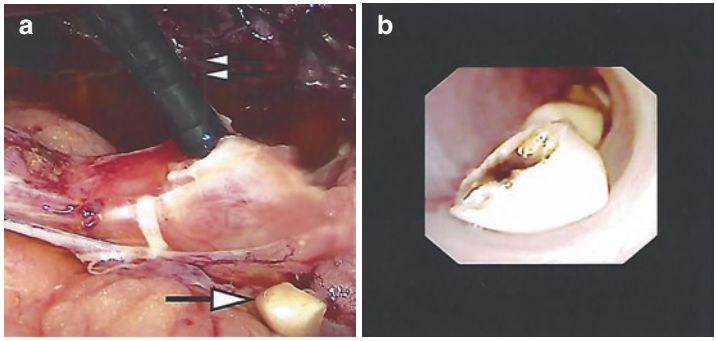

FIGURE 8.9 (**a**) The video-choledochoscope pictured (double arrow) is inserted into the cystic duct, and to the side of the duct is a single removed stone (arrow). (**b**) Pictured is the endoscopic view of calculi in the distal CBD

cases; in 83%, calculi were removed through a trans-cystic approach; and 17% were extracted through the CBD [49] (Fig. 8.9).

Today the majority of CBD stones found at time of surgery are removed during ERCP that means that the patient has a second anesthesia with a 4–5% incidence of pancreatitis. Extension of hospitalization for ERCP also increases health-care costs [50–53]. Surgeons that perform laparoscopic CBD exploration with stone extraction at the time of cholecystectomy have been the minority.

Conclusion

Laparoscopic cholecystectomy was introduced three decades ago, and it became widely accepted. However, serious complications were discovered already at the beginning of this era [54]. An editorial was published 8 years ago, signed by 16 surgeons drawing attention to the still existing problems. With 700,000 laparoscopic cholecystectomies annually, approximately 3000–3500 patients suffer from BDI complications requiring a second or third reconstructive procedure with

high morbidity [55]. The situation has not changed significantly in the past 30 years. Our recommendations include requiring adequate training to include imaging techniques, evaluation of findings, recognition of complications, and organized follow-up. These measures will result in better-educated and competent biliary surgeons with reduced complications.

Another aspect that should also be emphasized is the potential for astronomical savings in health-care cost. Approximately $1 billion dollars per year are spent on surgical re-explorations, insurance companies' compensation, and legal litigation fees from BDI. Costs of IOC that may include extended OR time (up to 1 h), increased surgeon remuneration, additional instrumentation, and radiology charges will still leave a significant profit margin for the supporting agencies.

It is time to recognize that we can improve the outcome of 700,000 laparoscopic cholecystectomies by reeducating surgeons to implement IOC and laparoscopic CBD exploration to improve patient care. Recommendations for increased utilization of IOC can be a factor in preventing BDI and assist in surgical removal of CBD stones.

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