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Selective Intraoperative Cholangiography and Single-Stage Management of Common Bile Duct Stone in Laparoscopic Cholecystectomy

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Abstract

Background: There are still debates and controversies in the detection and the management of common bile duct (CBD) stones in the era of laparoscopic cholecystectomy (LC). This prospective study was performed to evaluate a single-stage management of CBD stone during LC.

Methods: Between May 1998 and January 2000, 249 consecutive patients with gallstone and cholecystitis were enrolled in this study. The mean age was 52.5 ± 12.4 years. Male to female ratio was 106:143. All patients underwent abdominal sonography and the determination of the serum biochemical profile preoperatively. Patients presented with sepsis or with total bilirubin ≥ 6 ng/dL were excluded from the study.

Results: 244 (98%) patients underwent LC and 5 (2%) patients were converted to open cholecystectomy. Intraoperative cholangiogram (IOC) was only performed in patients who fulfilled our predetermined criteria. Among 90 patients who had IOC, only 23 patients had CBD stones that were removed either by transcystic duct stone extraction (61%) or CBD exploration (39%). The additional procedures to remove CBD stone did not prolong the hospitalization. There were four wound infections and one cystic stump leakage. One patient developed CBD stone during the follow-up period up to 37 months.

Conclusions: Our study indicates that routine use of IOC during LC is not necessary. In addition, single-stage approach for the management of CBD stone during LC is feasible and should be considered by laparoscopic surgeons.

Key words: Cholecystitis, Cholangiogram, Laparoscopy, Common bile duct stone, Gallbladder

The detection and removal of bile duct stones continues to challenge the biliary surgeons, especially in the era of laparoscopic cholecystectomy. Consensus had not yet been reached in the evaluation of common bile duct, although diagnostic procedures such as preoperative endoscopic retrograde cholangiopancreatography (ERCP),[1] routine intraoperative cholangiography (IOC)[2] or selective IOC[3,4] had all played different roles and provided respective efficiency in diagnosing common bile duct stones. There are growing concerns that preoperative ERCP or routine IOC might not be cost-effective since the positive findings are low.[5–7] In addition, certain procedure-related risks have been shown to be associated with ERCP and endoscopic sphincterotomy.[8] Similarly, selective IOC with stringent criteria will increase the yield of CBD stone but at the expense of missing certain findings.[9,10] Furthermore, once the presence of CBD stone is found, the subsequent management of the stone is also controversial. Some advocate a conversion to open CBD exploration while

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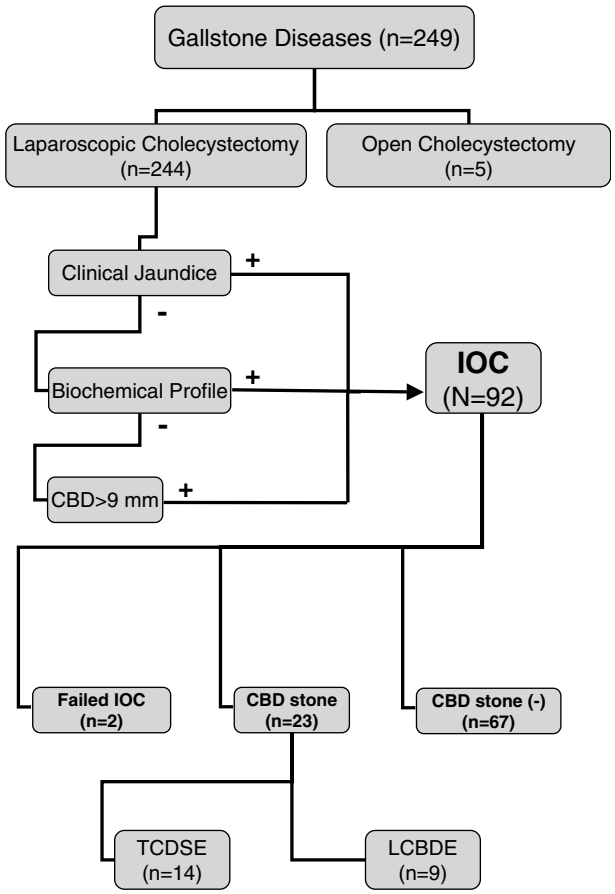

Figure 1. The algorithm for the management of gallstone disease with laparoscopic cholecystectomy. CBD, common bile duct; IOC, intraoperative cholangiogram, TCDSE, transcystic duct stone extraction; LCBDE, laparoscopic common bile duct exploration.

others have shown that CBD stone could be removed laparoscopically.[11,12] We performed this prospective study to 1) test the feasibility of selective use of IOC in laparoscopic cholecystectomy and 2) propose a single-stage approach in managing the CBD stone during laparoscopic cholecystectomy.

PATIENTS AND METHODS

Between May 1998 and January 2000, 249 consecutive patients including 94 patients with acute cholecystitis and 155 patients with chronic cholecystitis and acute symptoms were admitted to the Department of Trauma & Emergency Surgery at Chang-Gung Memorial Hospital (CGMH), Kaohsiung, Taiwan. The diagnosis of acute cholecystitis was based on clinical findings that included right upper quadrant abdominal pain less than 4 days, leukocytosis, temperature higher than 37.5 degrees, and peritoneal irritation (*e.g.*, Murphy's sign) on physical examination. Patients with chronic cholecystitis and acute symptoms were those who had previously diagnosed cholelithiasis and presented with acute exacerbation. The diagnosis of cholecystitis was confirmed by the abdominal sonography (GE Logic 400) showing the presence of gallstone and edematous change of gallbladder wall. In addition, each patient had blood drawn to determine the serum biochemical profile that included serum glutamic-oxaloacetic (aspartate) transaminase (SGOT), alkaline phosphotase (ALP), total bilirubin (T-Bil), direct bilirubin (D-Bil), and lipase. Patients were then admitted to the hospital and received intravenous fluid and antibiotics when indicated. Laparoscopic cholecystectomy was performed within 24 hours of admission.

Study Protocol

Patients who presented with signs of sepsis or hemodynamic instability (*i.e.*, shock) as well as those with pancreatitis or serum T-Bil ≥6 ng/dL were excluded from the study. The study protocol was shown in Fig. 1. All patients underwent LC within 24 hours of presentation to the hospital. We performed IOC only in patients who had one or more of the following findings: 1) clinical evidence of jaundice or cholangitis, 2) CBD stone or CBD dilatation over 9 mm on sonography, 3) elevated serum biochemical data including SGOT >55 U/L, ALP >125 U/L and bilirubin >1.3 mg/dL and <6 mg/dL, and 4) CBD dilatation over 9 mm visualized during laparoscopy.

Surgical Procedures for LC and IOC

Patients underwent a four-port laparoscopic cholecystectomy via a standard antigrade approach. However, a retrograde dissection of gallbladder off the liver bed was performed when the anatomy of the Calot's triangle was obscure. Five patients were converted to an open cholecystectomy due to the technical difficulty and were excluded from the subsequent analysis. The width of the CBD was determined by comparing it to the opening of a laparoscopic right angle forceps. The opening of the forceps was controlled by a sheathed sliding traction wire over the joint of the forceps. We marked a scale on the sheath to indicate the width of the opening of the forceps. Following the dissection of the Calot's triangle to expose the cystico-choledochal junction, the laparoscopic right angle forceps was opened to 9 mm to see if the width of CBD was greater than this value. For the patients who met the criteria for IOC, a fifth small port was created with a

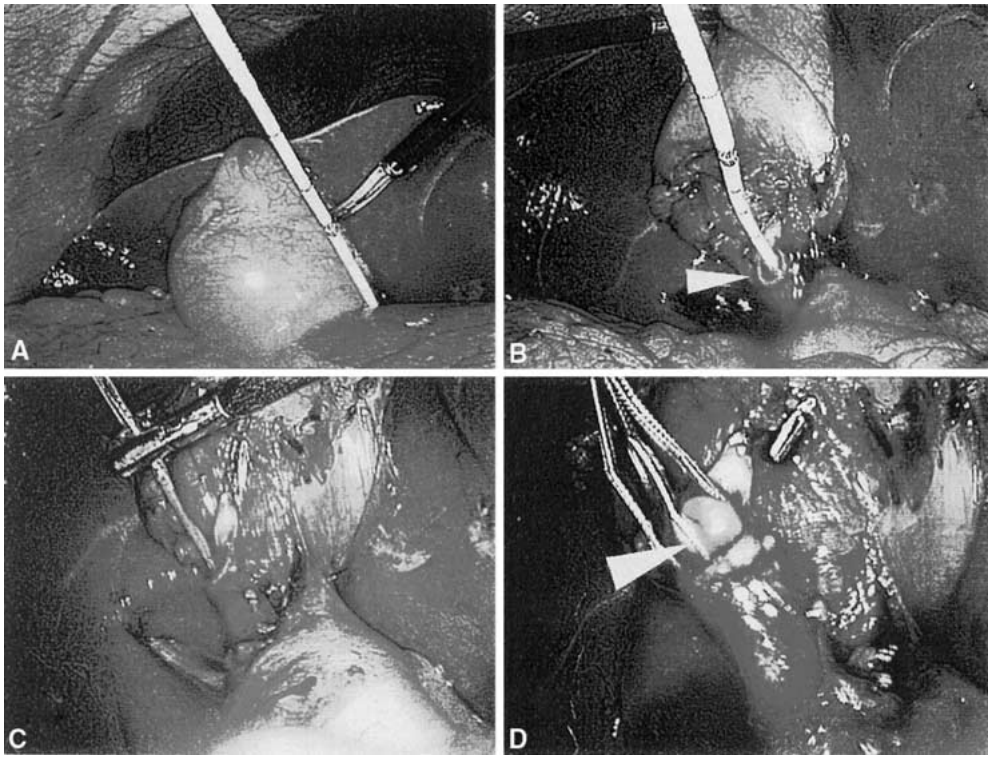

Figure 2. Photographs depict the procedures for the intraoperative cholangiography (2A & 2B) and the transcystic ductal stone extraction (2C & 2D). A five French ureteral catheter was inserted into the common bile duct via an opening of the cystic duct and was used for the dye injection. The arrow indicates an opening of the cystic duct. The common bile duct stone was being retrieved by a endoscopically guided transcystic basket (2D).

14G needle over the right upper quadrant of the abdomen. The needle was removed after penetrating the abdominal wall and the sheath was left *in situ*. A #5 French catheter was advanced through the sheath into the CBD via an opening of the cystic duct. This approach avoided the sharp angle that might occur when using original ports of the upper abdomen to perform IOC or retrieving the CBD stone. The cystic duct and the catheter were then snugly clamped with hemoclips. Twenty ml of water soluble contrast medium was pushed into CBD via the catheter and a standard plain portable X-ray film of the upper abdomen was obtained. When the CBD stones were visualized as filling defects on the X-ray film, a stone basket was advanced into the CBD via the cystic duct to the estimated distal end of the duct calculated by IOC film to remove the stone(s). The stone basket was opened and was extracted with a to-and-flo movement inside the common bile duct. The stone(s) can then be captured and removed out of the cystic duct smoothly (Fig. 2). If the stone(s) were unable to be retrieved out of the cystic duct within 30 minutes (*i.e.*, too large stone or too small cystic duct orifice), the laparoscopic CBD exploration followed by T-tube insertion was performed. The common bile duct was first opened with a laparoscopic scissors. The CBD stone was removed. The T-tube was inserted into the CBD duct usually with little difficulty. The opening of the duct was closed laparoscopically with 4-O Vicryl (Ethicon, Somerville, NJ) sutures to secure the T-tube and to achieve a water-seal closure. In the event that the CBD can not be identified clearly, the duct was distended by infusing 20 ml of normal saline through the ureteral catheter. The anatomy of the CBD then became easily identified. A completion cholangiography was also performed at the end of the procedure to document the CBD was free of stone.

Data Analysis

Demographic data and in-hospital care including operations and the length of the hospital stay of these patients were collected and entered into a desktop computer for subsequent analysis. Data were expressed as mean ± S.D. The comparison of means among groups was determined by one-way ANOVA with LSD multiple comparison. The comparison of the incidence of CBD stone based on predetermined criteria was performed by either Chi-square or Fisher's exact test when appropriate. The significant level was determined at $P < 0.05$.

Table 1.
Selective criteria for intraoperative cholangiography (IOC)

Criteria for IOC	# of patients	# of Positive IOC	Positive rate	PPV	NPV
Biochemical profile					
T-Bil	60	18	30%	0.316	0.973
D-Bil	46	13	28.2%	0.302	0.950
Alk-P	54	17	31.4%	0.315	0.968
SGOT	55	15	27.2%	0.288	0.958
All elevated	30	9	30%	0.300	0.935
Clinical finding					
Jaundice	8	5	62.5%	0.571	0.920
Dilated CBD (> 9mm)					
Ultrasound	32	17	53.1%	0.533	0.966
Under laparoscopy	53	21	39.6%	0.404	0.990
Non of above	152			0	0.760

T-Bil, total bilirubin; D-Bil, direct bilirubin; Alk-P, alkaline phosphatase; SGOT, serum glutamic-oxaloacetic (aspartate) transaminase; PPV, positive predictive value; NPV, negative predictive value.

RESULTS

During the study period, we had total 249 patients and most of them were admitted through the emergency department. The mean age was 52.5 ± 12.4 years (range, 20–85). 143 (57.4%) patients were women and 106 (42.6%) patients were men. The symptoms of our patients included RUQ pain <4 days, abdominal tenderness and peritoneal irritation on physical examination, and positive Murphy's sign. The duration of symptoms was 3.1 ± 0.81 days (range, 2–4). The diagnosis of cholecystitis was suspected from the presenting symptoms and was confirmed by abdominal ultrasonography. Five patients were converted to open cholecystectomy due to the obscure anatomy. The rest of patients underwent laparoscopic cholecystectomy. Pathologic examination of the specimen showed either acute cholecystitis or acute and chronic cholecystitis in all patients.

Patients were selected to have IOC if at least one of the predetermined criteria was present. We had total 92 patients underwent IOC and two of them were unsuccessful due to the occluded cystic duct. Twenty three (25.6%) patients had filling defects in the common bile duct. Positive rate, positive predictive value, and negative predictive value of the criteria used in the study were shown in Table 1. The positive rate of CBD stone detected by IOC among patients who had at least one abnormal biochemical value over control levels was about 27% to 30%. Not a single biochemical test appeared more sensitive than others. There were 30 patients with abnormal findings of all biochemical tests; only 9 (30%) patients had CBD stone. Patients who presented with clinical jaundice on physical examination (*e.g.*, icteric sclera) had much higher positive rate of CBD stone. CBD dilation seen on preoperative abdominal ultrasonography or during laparoscopy had 40 to 53% positive rate.

All 23 patients who had filling defects in CBD duct detected by cholangiogram underwent stone extraction out of the cystic duct with a stone basket. The procedure was successful in 14 patients. In the other 9 patients, laparoscopic CBD exploration and removal of stones were performed. The completion cholangiogram documented CBD to be free of residual stone in all 23 patients. The average operative time for laparoscopic cholecystectomy was 98 ± 27 min. Subsequent management of CBD stone significantly increased operative time: 172.5 ± 48 min for the transcystic duct extraction group and 206 ± 44 min for the laparoscopic CBD exploration group ($P < 0.0001$).

Postoperative Course and Follow-up

Most patients were discharged within 6 days of admission. Additional procedures to remove CBD stone or to place T-tube did not prolong the hospitalization (5.4 ± 2.3 *vs.* 4.9 ± 1.6 days, $P > 0.05$). There were five complications including four umbilical trochar site infections and one cystic stump leakage that required a second laparoscopy to control the leakage. All five patients were discharged uneventfully within 11 days. Patients were followed up to 37 months (range: 25 to 37 months and mean of 26.9 months). Only one patient presented with clinical jaundice 36 months after the cholecystectomy and subsequent ERCP removed a CBD stone. This patient fulfilled the criteria for IOC. However, the procedure was unsuccessful due to the occluded cystic duct.

DISCUSSION

After Dr. Mirizzi first performed operative cholangiography in 1931,[13] the application of operative cholangiography for the evaluation of choledocholithiasis has become more important especially in the ear of laparoscopic cholecystectomy. There are debates and lack of consensus in the routine or selective use of IOC.[2–4,9,14] The main advantage for routine IOC may include the identification of unsuspected common bile duct stones as well as better definition of the extra-hepatic ductal anatomy, which will help surgeons to avoid incidental injury to the bile duct.[15,16] However, the reported incidence of false positive cholangiograms still ranges from 2% to 16%.[17–20] If we follow and abide the results of the routine IOC, it is likely that the rate of unnecessary conversion or postoperative interventional procedures (*e.g.*, endoscopic sphinterotomy) could be unacceptably high.[21] Furthermore, the extra-hepatic duct injury can occur even in the skilled hand of laparoscopic surgeons who advocate the routine use of IOC.[22,23] Thus, the routine use of IOC does not provide insurance for avoiding extra-hepatic duct injury. This prospective study was done to specifically examine four simple criteria that surgeons could easily determine either before the operation or during LC. There were 8 patients who presented with icteric sclera and five of them had CBD stones seen on IOC. Although abnormal chemical profile has been used with good success to "screen" patients for IOC,[24] our study was unable to support this approach. Abnormal values of serum biochemical tests are neither sensitive nor specific. Even in patients who had elevated values in all tests still had only 30% positive rate of CBD stone detected by IOC. In this study we did not determine the levels of serum gamma glutamyltransferase (GGT). It has been suggested that GGT levels greater than seven times of normal values may predict the presence of CBD stone.[25] GGT test is not part of the STAT lab panels in our hospital and the levels of GGT among our patients therefore could not be determined preoperatively. In addition, our data need to be interpreted with caution since we excluded patients with bilirubin ≥ 6 ng/dL for the fear of the presence periampullary malignancy. These patients will benefit from additional preoperative evaluation such as ERCP. Patients with gallstone pancreatitis were excluded from the present study and were enrolled into another study. The dilation of CBD on preoperative abdominal sonography or during the laparoscopy also had about 50% positive rate. This finding is surprising since CBD dilation has been used as a useful indicator of CBD stone. The study by Prat *et al.*, shows that CBD > 7 mm could predict the presence of CBD stone especially in patients younger than 60 years old.[25] However, unlike our study half of their patients underwent elective cholecystectomy. Further studies are needed to investigate whether CBD becomes dilated when visualized by laparoscopy in the setting of acute inflammation. Taken together, it is most useful to use these criteria to screen patients not to perform IOC. Among patients who had normal biochemical profile during preoperative workup and with normal size CBD, none had clinical evidence of CBD stone during the postoperative followup. The cholangiogram appears unnecessary in these patients.

The presence of CBD stone might be difficult to manage during LC. If CBD stone is found preoperatively, many surgeons will favor endoscopic sphinterotomy (EST) to clear the common bile duct before LC.[26,27] However, CBD stone is not easily detected by the abdominal sonography. Liberal use of EST based on the size of the CBD duct or elevated biochemical markers might not be cost-effective since the positive findings are low.[28–30] In addition, certain risks have been shown to be associated with ERCP and EST. Recently, many surgeons have used laparoscopic techniques in managing ductal stones including the transcystic duct stone extraction and the laparoscopic CBD exploration with T-tube insertion.[31–34] These laparoscopic techniques allow surgeons to complete all the needed procedures during LC.[35] In our study, we successfully retrieved CBD stone out of the cystic duct in 14 patients. Nine patients however required laparoscopic CBD exploration and T-tube placement. The performance of IOC increased the operative time by 20 min. Transcystic duct extraction or laparoscopic CBD exploration significantly prolonged the operative time ($P < 0.0001$). The long operative time of our patients studied might be attributed to the technical difficulty due to several adhesion and inflammation of the gall bladder and the surrounding tissue. Despite the prolonged operative time to remove the CBD stone, the admission days were not affected by these laparoscopic techniques. There were five complications in our series including four wound infections and one leakage from the cystic duct stump. The leakage was due to the slippage of the clips that was applied on the severely inflamed portion of the cystic duct that ate through the tissue and fell off. The leakage was easily controlled during a second laparoscopy.

Intraoperative cholangiogram (IOC) was unsuccessful in two patients due to the severe inflammation of gall bladder and the occlusion of cystic duct. One patient subsequently presented with jaundice 36 months after LC. ERCP confirmed the presence of a CBD stone that was removed uneventfully. The remaining patients were symptoms free during the follow-up period. Based on these findings, we believe that in patients whose IOC was

not possible they should have ERCP only if they become symptomatic during postoperative follow up. However, we also have to point out that our data are only applicable to patients with either acute cholecystitis or chronic cholecystitis with acute symptoms. Our findings should not be extrapolated to patients with biliary colic or gallstone pancreatitis.

In conclusion, using four simple screening criteria, we were able to selectively perform IOC without missing any significant CBD stone. In addition, laparoscopic management of CBD stone either by the transcystic ductal extraction or laparoscopic CBD exploration appears feasible and should be considered by biliary surgeons.

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REFERENCES

1. Rijna H, Borgstein PJ, Meuwissen SG. Selective preoperative endoscopic retrograde cholangiopancreaticography in laparoscopic biliary surgery. Br J Surg 1995;82:1130–1133.
2. Stuart SA, Simpson TL, Alvord LA. Routine intraoperative laparoscopic cholangiography. Am J Surg 1998;176:632–637.
3. Robinson BL, Donohue JH, Gunes S. Selective operative cholangiography. Appropriate management for laparoscopic cholecystectomy. Arch Surg 1995;130:625–630.
4. Borjeson J, Liu SK, Jones S. Selective intraoperative cholangiography during laparoscopic cholecystectomy: how selective? Am Surg 2000;66:616–8.
5. Heinerman PM, Boeckl O, Pimpl W. Selective ERCP and preoperative stone removal in bile duct surgery. Ann Surg 1989;209:267–272.
6. Neoptolemos JP, Carr-Locke DL, London NJ, *et al.* Controlled trial of urgent endoscopic retrograde cholangiopancreatography and endoscopic sphincterotomy vesus conservative treatment for acute pancreatitis due to gallstones. Lancet 1988;2:979–983.
7. Spaw AT, Reddick EJ, Olsen DO. Laparoscopic laser cholecystectomy: analysis of 500 procedures. Surg Laparoscop Endosc 1991;1:2–7.
8. Stain SC, Cohen H, Tsuishoysha M, *et al.* Choledocholithiasis: endoscopic sphinterotomy or common bile duct exploration. Ann Surg 1991;213:627–634.
9. Khaira HS, Ridings PC, Gompertz RH. Routine laparoscopic cholangiography: a means of avoiding unnecessary endoscopic retrograde cholangiopancreaticography. J Laparoendosc Adv Surg Tech A 1999;9:17–22.
10. Sahai AV, Mauldin PD, Marsi V, *et al.* Bile duct stones and laparoscopic cholecystectomy: a decision analysis to assess the roles of intraoperative cholangiography, EUS, and ERCP. Gastrointest Endosc 1999;49:334–43.
11. Franklin ME, Pharand D, Rosenthal D. Laparoscopic common bile duct exploration. Surg Laparosc Endosc 1994;4:119–124.
12. Hunter JG, Soper NJ. Laparoscopic management of bile duct stones. Surg Clin North Am 1992;72:1077–1080.
13. Mirizzi PL. Operative cholangiography. Surg Gynecol Obstet 1937;65:702–710.
14. Borjeson J, Liu SKM, Jones S, *et al.* Selective intraoperative cholangiography during laparoscopic cholecystectomy: how selective?. Am Surg 2000;66:616–8.
15. Flum DR, Koepsell T, Heagerty P, *et al.* Common bile duct injury during laparoscopic cholecystectomy and the use of intraoperative cholangiography. Arch Surg 2001;136:1287–92.
16. Ludwig K, Bernhardt J, Steffen H, *et al.* Contribution of intraoperative cholangiography to incidence and outcome of common bile duct injuries during laparoscopic cholecystectomy. Surg. Endosc. 2002;16:1098–1104.
17. Mills JL, Beck DE, Harford FJ. Routine operative cholangiography. Surg Gynecol Obstet 1985;161:343–5.
18. Skillings JC, Williams JS, Hinshaw JR. Cost-effectiveness of operative cholangiography. Am J Surg 1979;137:26–31.
19. Doyle PJ, Ward-McQuaid JN, Smith AM. The value of routine preoperative cholangiography – a report of 4000 cholecystectomies. Br J Surg 1982;69:617–619.
20. Levine SB, Lerner HJ, Leifer ED, *et al.* Intraoperative cholangiography. A review of indications and analysis of age-sex groups. Ann Surg 1983;198:692–697.
21. Lillemoe KD, Yeo CJ, Talamini MA, *et al.* Selective cholangiography. Current role in laparoscopic cholecystectomy. Ann Surg 1992;215:669–74.
22. Sackier JM, Berci G, Phillips E, *et al.* The role of cholangiography in laparoscopic cholecystectomy. Arch Surg 1991;126:1021–6.
23. Vezakis A, Davides D, Ammori BJ, *et al.* Intraoperative cholangiography during laparoscopic cholecystectomy. Surg. Endosc. 2000;14:1118–22.
24. Silverstein JC, Wavak E, Millikan KW. A prospective experience with selective cholangiography. Am Surg 1998;64:654:659.
25. Prat F, Meduri B, Ducot B, *et al.* Prediction of common bile duct stones by noninvasive tests. Ann Surg 1999;229:362–368.
26. Miller RE, Kimmelstiel FM, Winkler WP. Management of common bile duct stones in the era of laparoscopic cholecystectomy. Am J Surg 1995;169:273–276.
27. Sarli L, Pietra N, Franze A, *et al.* Routine intravenous cholangiography, selective ERCP, and endoscopic treatment of bile duct stones before laparoscopic cholecystectomy. Gastrointest Endosc 1999;50:200–208.
28. Wilson TG, Hall JC, Watts JM. Is operative cholangiography always necessary?. Br J Surg 1986;73:637–740.

29. Lygidakis NJ. The incidence and significance of common bile duct dilatation in biliary calculous disease. World J. Surg. 1984;8:327–34.
30. Mueller PR, Ferucci JT, Simeone JF, *et al.* Observations on the distensibility of the common bile duct. Radiology 1982;142: 467–472.
31. Hawasli A, Lloyd L, Cacucci B. Management of choledocholithiasis in the era of laparoscopic surgery. Am Surg 2000; 66:425–430.
32. Hyser MJ, Chaudhry V, Byrne MP. Laparoscopic transcystic management of choledocholithiasis. Am Surg 1999;65:606–609.
33. Ponsky JL, Heniford BT, Gersin K. Choledocholithiasis: evolving intraoperative strategies. Am Surg 2000;66: 262–268.
34. Rojas-Ortega S, Arizpe-Bravo D, Martin Lopez ER, *et al.* Transcystic common bile duct exploration in the management of patients with Choledocholithiasis. J Gastrointest Surg 2003;7:492–496.
35. Cuschieri A, Lezoche E, Morino M, *et al.* E. A. E. S. multicenter prospective randomized trial comparing two-stage vs. single-stage management of patients with gallstone disease and ductal calculi. Surg Endosc 1999;13: 952–957.