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Preoperative Assessment for Laparoscopic Cholecystectomy

Feasibility of Using Spiral Computed Tomography

A-Hon Kwon, MD, Hiroyuki Inui, MD, Atsushi Imamura, MD, Shoji Uetsuji, MD, and Yasuo Kamiyama, MD

From the First Department of Surgery, Kansai Medical University, Osaka, Japan

Objective

The authors investigated the preoperative feasibility of using spiral computed tomography (SCT) after intravenous infusion cholangiography (IVC-SCT) for laparoscopic cholecystectomy.

Summary Background Data

In laparoscopic cholecystectomy, the aberrant or unusual anatomy of the bile duct and severe inflammation or adhesions around the gallbladder sometimes require a conversion to open surgery.

Methods

Laparoscopic cholecystectomies (LC's) were attempted on 440 patients, and preoperative IVC-SCT also was attempted in all of these patients. Using this spiral scanning technique, the bile ducts, cystic duct, and gallbladder were assessed for contour abnormalities, relative position, and filling defects. Forty-seven patients were diagnosed with having stones in their common bile duct or common hepatic duct.

Results

Three-hundred eighty-seven patients out of the 440 patients (88.0%) who were subjected to IVC-SCT had the length and course of their cystic duct successfully determined. Anomalous unions of the cystic duct were seen in 59 (15.2%) of 387 patients with respect to the operative findings, and 48 of 440 patients (10.9%) had severe adhesions to Calot's triangle and the surrounding tissues. In these 48 patients, 45 patients (94%) had a nonvisualized cystic duct on IVC-SCT. The preoperative assessment of the feasibility (dense adhesions obscuring Calot's triangle) of using IVC-SCT demonstrated that the sensitivity, specificity, and accuracy were 93%, 98%, and 94%, respectively. Five patients had to be converted to open surgery, and the overall morbidity rates for patients undergoing laparoscopic cholecystectomy was 0.9% (4 of 440).

Conclusions

The most important factor in assessing the feasibility of using laparoscopic cholecystectomy is not the nonvisualized gallbladder, but the nonvisualized cystic duct on IVC-SCT. IVC-SCT may be of benefit to those patients scheduled to undergo laparoscopic cholecystectomy.

Laparoscopic cholecystectomy may offer significant advantages over open cholecystectomy for the treatment of symptomatic gallbladder disease.[1] The postoperative recovery is very rapid and it is cosmetically much more acceptable to the patient.[2] Therefore, laparoscopic cholecystectomy has replaced open cholecystectomy as the procedure of choice for the treatment of symptomatic gallbladder disease. However, one of the most significant risks of biliary surgery is accidental injury to the bile ducts. The aberrant or unusual anatomy of the bile duct[3] in some individuals, and severe inflammation or adhesion around the gallbladder sometimes requires the conversion to open surgery.[4,5]

Several preoperative examinations have been proposed, including intravenous infusion cholangiography (IVC) and endoscopic retrograde cholangiography (ERC). Infusion cholangiography is a simple examination performed before an open cholecystectomy to determine the mobility or function of the gallbladder and any cystic duct obstructions.[6,7] A nonvisualized gallbladder on preoperative IVC (DIC: drip infusion cholangiography) films indicates the presence of moderate to severe adhesion. However, the images obtained by IVC are occasionally unclear, and it is difficult to assess

Address reprint requests to: A-Hon Kwon, MD, First Department of Surgery, Kansai Medical University, 10-15 Fumizono, Moriguchi, Osaka, 570, Japan.

Table 1. PATIENT CHARACTERISTICS

Disease	Number of Patients	Gender (M:F)	Age (yr) Range	Mean ± SD
Cholecystolithiasis	347	126:221	12–81	55.3 ± 13.1
Gallbladder polyp	45	21:24	25–77	50.0 ± 12.1
Chronic cholecystitis	29	13:16	25–83	54.5 ± 14.6
Adenomyomatosis	19	11:8	15–68	41.5 ± 14.5
Total	440	171:269	12–83	54.1 ± 13.2

the anatomical details of the biliary tract using this technique. Endoscopic retrograde cholangiographs is not a trivial procedure; although the morbidity and mortality rates of diagnostic ERC are considerably less than those of common bile duct exploration.[8] Endoscopic retrograde cholangiographs requires specialized training and may be uncomfortable for the patient. Therefore, it is not feasible as a routine investigation before elective cholecystectomy because of its invasiveness, potential complications, and cost.

Spiral scanning is a novel computed tomography (CT) technique recently introduced to scan complete organs or parts of the body in a minimum of time.[9] The images obtained with spiral computed tomography (SCT) show superior vascular opacification, more anatomical detail, and reduced respiratory artifacts with smaller amounts of contrast agents required. This technique is also particularly important for three-dimensional reconstructions. These images can be rotated on a television monitor, viewed, and photographed from any orientation. In this study, we investigated the preoperative feasibility of using SCT after intravenous infusion cholangiography (IVC-SCT) for laparoscopic cholecystectomies.

MATERIALS AND METHODS

Laparoscopic cholecystectomies were attempted on 440 patients at the Kansai Medical University from June 1992 to December 1996. The mean patient age was 54 years, with a range of 12 to 83 years. There were 269 (61%) women, which yielded a women:men ratio of 1.6:1. All of the patients who had gallbladder disease were questioned in regard to their clinical history and were subjected to a physical examination, laboratory testing, and ultrasonographic evaluation of the gallbladder (Table 1). The patients were referred for ERC if they had elevated serum bilirubin levels, pancreatitis, a dilated common bile duct, or common duct stones revealed by abdominal ultrasonography. Forty-seven patients were diagnosed with having stones in their common bile duct or common hepatic duct. All patients undergoing the laparoscopic cholecystectomy were subjected to preoperative IVC-SCT.

The laparoscopic cholangiography, IVC-SCT, and other imaging results were assessed by two investigators (A.K. and S.U.), and discrepancies in their interpretations were resolved by consensus. Using this spiral scanning technique, the bile ducts, cystic ducts, and gallbladders were assessed for contour abnormalities, relative position, and filling defects. The severity of the adhesions around the gallbladder was evaluated by at least two senior surgeons, and a difficult case of laparoscopic cholecystectomy was defined as one that took more than 30 minutes for experienced surgeons to detect Calot's triangle and especially the cystic duct. The IVC-SCT images were then compared with the difficulties experienced during laparoscopic cholecystectomy to determine the sensitivity, specificity, and accuracy.

SCT With Intravenous Infusion Cholangiography (IVC-SCT)

All of the patients were injected intravenously with 1 mL meglumine iotroxate before the IVC-SCT, and adverse reactions such as nausea, vomiting, dermal reactions including hives and itching, hypotension, vasovagal episodes, and so on were carefully recorded for 30 minutes. Preoperative serum bilirubin levels in all of the patients were less than 2 mg/dL. A 3.0 g dose of dilute sodium iopodate (Biloptin, Schering AG, Berlin, Germany) was given to the patients orally to improve gallbladder opacification on the evening (10 P.M.) before their examination, and all oral intake was prohibited after the administration of the sodium iopodate. Spiral CT (SCT) scanning of the biliary tract was performed after an intravenous injection of 100 mL meglumine iotroxate (Biliscopin 50 mg I/mL, Schering) over 30 minutes. The SCT was performed with a Somaton Plus (Siemens AG, Erlangen, Germany) CT machine, a continuous-rotation scanner with a 1.0 second standard scan time. The SCT was performed in one 24-second scan, with a 5 mm/sec table feed (120 peak kVp and 165 mA). The patients held their breath during the entire scan. With these, spiral data, multiplanar reconstructions (MPR), and shaded surface display (SSD) three-dimensional images can be created. These images were rotated on a television monitor and could be photographed from any orientation. The postprocessing of the three-dimensional SSD and MPR required 30 to 40 minutes to produce an optimal image.

Conventional IVC images were taken at 0, 20, and 40 minutes after the termination of the intravenous infusion of contrast medium, but conventional tomography of the bile ducts was not performed.

Statistics

All of the values were represented as mean ± standard deviation (SD) and were analyzed using the Chi-square test with Yates' correction. A p value less than 0.05 was considered to be significant.

Table 2. DEMONSTRATION OF THE ANATOMY BY CONVENTIONAL IVC AND IVC-SCT IN PATIENTS IN WHOM THE STRUCTURES COULD BE CLEARLY IDENTIFIED

	IVC	IVC-SCT	t	df	p
Gallbladder	313 (71%)	361 (82%)	14.0	1	<0.01
Bile duct	419 (95%)	440 (100%)	19.5	1	<0.01
Cystic duct	176 (40%)	387 (88%)	217.5	1	<0.001

IVC-SCT = intravenous cholangiography and spiral computed tomography

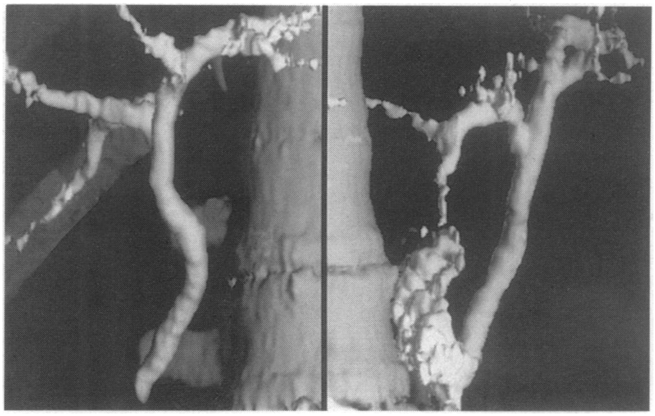


Figure 2. Difficult case of laparoscopic cholecystectomy. Preoperative SSD images using IVC–SCT could not detect the cystic duct and gallbladder at all. Preoperative conventional IVC also cannot visualize the cystic duct and This patient had severe adhesion the Calot's triangle and the surrounding tissue.

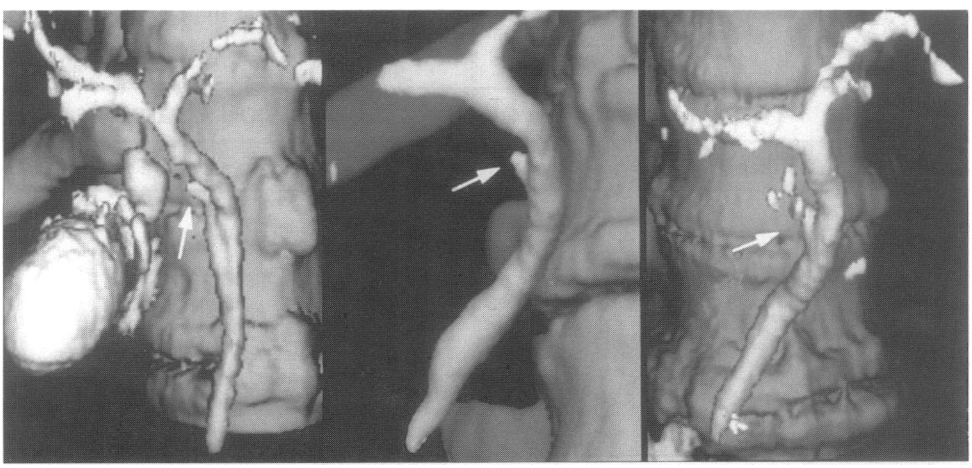
RESULTS

The anatomical details of the gallbladder, cystic duct, and common bile duct were clearly demonstrated with the IVC-SCT technique, and the first or second order ducts also were reliably identified. In a comparison between conventional IVC and IVC-SCT in 440 patients, the gallbladder and common bile duct could be identified clearly in 313 (71%) and 419 (95%) of 440 patients undergoing the IVC, respectively, and in 361 (82%) and 440 patients (100%) undergoing the IVC-SCT, respectively. Significant differences were noted between the IVC-SCT and the conventional IVC (Table 2). Moreover, 387 of the 440 patients (88.0%) subjected to IVC-SCT had the length and course of their cystic duct determined (Fig. 1). However, in 53 (12.0%) of the 440 patients, the cystic duct could not be visualized by IVC-SCT (Fig. 2). Overall, anomalous unions of the cystic duct were seen in 59 (15.2%) of 387 patients. The following anomalies were observed: right hepatic duct entry in 5 cases (1.3%), parallel low entry in 14 cases (3.6%), posterior spiral entry in 32 cases (8.3%), anterior spiral entry in 4 cases (1.0%), and accessory duct entry in 4 cases (1.0%) (Fig. 3). With the exception of the two patients who developed a slight rash or itch, there were no major adverse reactions to the contrast medium.

With respect to the operative findings, 48 of 440 patients (10.9%) had severe adhesions to Calot's triangle and the surrounding tissues. In these 48 patients, 45 (94%) had a nonvisualized cystic duct on IVC-SCT. The mean (SD) operative time was 147 (46) minutes in these cases, and 85 (42) minutes in the other cases with mild or moderate adhesions. The preoperative assessment of the feasibility (dense adhesions obscuring Calot's triangle) of using IVC-SCT demonstrated that the sensitivity, specificity, and accuracy of the IVC-SCT were 93%, 98%, and 94%, respectively. The positive predictive value of IVC-SCT was 85%, and the negative predictive value was 99%. Five patients had to be converted to open surgery (Table 3). Two patients had to be converted because of severe adhesions, and two more patients with internal biliary fistulas had to be converted because they were difficult to remove under laparoscopy. One patient had gallbladder cancer, and an intraoperative frozen-section histopathology revealed an advanced stage of cancer after the laparoscopic cholecystectomy.

Forty-seven of 440 patients (10.7%) had common bile duct stones. In these 47 patients, 40 patients (85%) were recognized to have stones in the common hepatic duct or

Figure 1. Easy cases of laparoscopic cholecystectomy. Preoperative shaded surface display (SSD) images using IVC-SCT clearly showed the cystic duct opening into the common bile duct (arrow). Preoperative conventional IVC cannot visualize the cystic duct, but the gallbladder does not seem to fill with contrast. These patients had slight or no adhesions to Calot's triangle and the surrounding tissues.



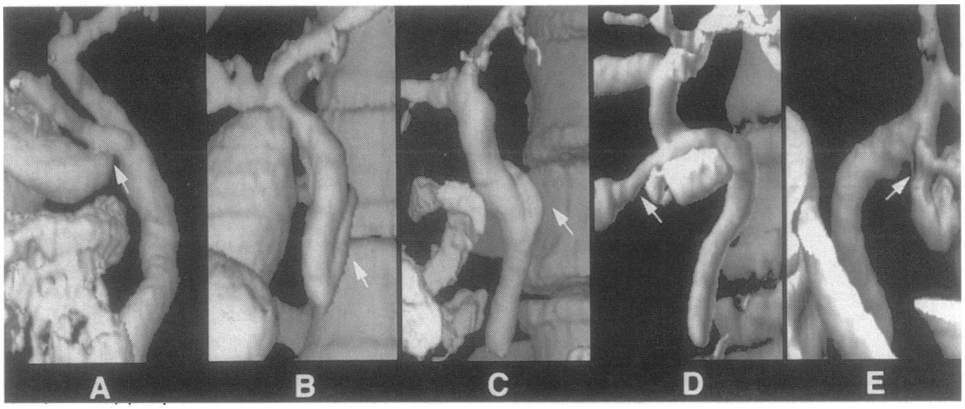


Figure 3. Types of anomalous unions of the cystic duct using IVC-SCT. A: cystic duct opening into the right hepatic duct; B: parallel low entry; C: posterior entry crossing the common duct; D: anterior entry crossing the common duct; E: accessory hepatic duct.

common bile duct using multiplanar reconstructions images (Fig. 4). The sensitivity, specificity, and accuracy of IVC-SCT for the preoperative visualization of common duct stones were 85%, 97%, and 96%, respectively. Thirty-five patients had these stones removed with an endoscopic sphincterotomy (EST) before surgery, and the other 12 patients were treated by laparoscopic common bile duct exploration.

The overall morbidity rate for patients undergoing the laparoscopic cholecystectomy was 0.9 percent (4 of 440). Intraoperative biliary duct injuries occurred in four patients with severe adhesions, and these adhesions were repaired with a laparoscopic primary closure or laparoscopic T-tube drainage (Table 4). No major complications were recorded, and no residual or retained stones had been found during a follow-up period of 3 months.

DISCUSSION

Biliary tract injury is a serious surgical complication, and therefore, it is important to define the anatomical details precisely. In open cholecystectomy, the rate of iatrogenic biliary duct injury is believed to be 0.1% to 0.5%.[3,10,11] In laparoscopic cholecystectomy, it has been estimated to be as great as 2% during the learning curve stage, before dropping to no less than 0.5% with experience.[2,12,13] The incidence of significant anomalies of the extrahepatic bile ducts and cystic duct has been reported to be from 1.7 to 28% of patients.[14–19] Moreover, in patients with an acute suppurative process or with recurrent bouts of inflammation, the anatomical details may be obscured, which makes it difficult to avoid surgical injury.[16] The incidence of conversion to open surgery has been reported to be approximately 1.1% to 13.0%. In most of these conversions, severe inflammation and adhesions were found around the gallbladder.[4,5,20] Iatrogenic injury of the bile duct during cholecystectomy therefore represents a failure of surgical technique, especially for laparoscopic surgery. Therefore, preoperative information on the patient's biliary duct anatomy and adequate training and caution would be helpful in avoiding such injuries, especially during the laparoscopic surgery.

Several preoperative examinations have been proposed to visualize biliary anatomy, including IVC, ERC, percutaneous transhepatic cholangiography (PTC) and magnetic resonance (MR) cholangiography. Endoscopic retrograde cholangiography and PTC can provide better opacification of the biliary tree, but they are not justifiable as routine procedures before elective cholecystectomy because of their invasiveness, complications, and cost. As many as 25% of patients who undergo ERC have a postprocedural increase in serum amylase levels, and the prevalence of clinical pancreatitis after diagnostic ERC is approximately 3%.[21] Magnetic resonance cholangiography uses new imaging techniques that provide direct cholangiograms by using heavily T2-weighted sequences, without the injection of a

Table 3. CASES OF CONVERSION TO OPEN SURGERY

Age (yr)	Gender	Reasons for Conversion	Surgical Procedure	Demonstration of Cystic Duct by IVC-SCT
75	F	Severe adhesion	OC	–
72	F	Severe adhesion	OC	–
55	M	Severe adhesion	OC	–
72	F	Choledochoduodenal fistula	OC Closure of fistula	–
63	M	Gallbladder cancer	OC Lymphadenectomy	+

OC = open cholecystectomy; IVC-SCT = intravenous cholangiography using spiral computed tomography.

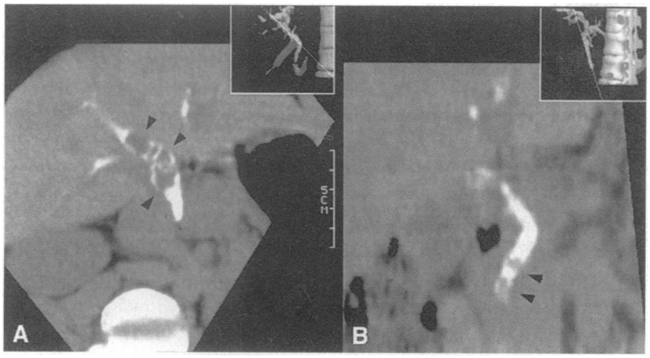


Figure 4. (A) A multiplanar reconstruction (MPR) image demonstrating stones (arrows) in the common hepatic duct and intrahepatic ducts. The common bile duct and common hepatic ducts are dilated to 14 mm. (B) MPR image demonstrating stones (arrow) in the distal common bile duct. The patient has undergone a laparoscopic cholecystectomy and common bile duct exploration.

contrast agent. Its limitations center around its limited availability (in some centers), susceptibility to pulsation and motion artifact, and because it is an operator dependent technique.

Dawson et al.[22] suggested that the routine preoperative use of IVC is not justified in patients considered for laparoscopic cholecystectomy. Intravenous infusion cholangiography fell out of favor after percutaneous transhepatic cholangiography, and endoscopic retrograde cholangiopancreatography became technically feasible and safe. The reasons for this were twofold: (1) Marginal opacification of the biliary tree with a significant percentage (up to 25%) of inadequate or nondiagnostic studies; (2) Toxicity: there is a high incidence of reactions such as nausea, vomiting, dermal reactions including hives and itching, hypotension, vasovagal episodes, and so on.[23,24] Additionally, a significant percentage of patients have elevations in liver function studies and serum creatinine after the administration of contrast material. However, it is generally accepted that iotroxate can be used at greater concentrations in the bile duct and would be less allergenic.[25] The frequency of adverse reactions to IVC is extremely low, and it may be safer than previously suggested.[25,26] In this study, using a slow infusion of meglumine iotroxate, only two (0.9%) patients had an adverse reaction: a mild skin rash and itching that required no treatment. The IVC has been reported to be a reliable and simple adjunct, especially in patients with suspected acute cholecystitis. Moreover, if the gallbladder is not visualized on IVC, then the degree of inflammation and adhesion around the gallbladder is probably severe and may be regarded as a contraindication when removing such an organ laparoscopically.[28,29] However, the images obtained by IVC are occasionally unclear, and it can be difficult to assess the anatomical details of the biliary tract with certainty.

Conventional CT has always provided substantially better contrast resolution than conventional tomography. However, this has not been applied to biliary imaging because each section must be acquired separately and during a different respiratory cycle, which causes the multiplanar reconstructions to be unsatisfactory because of misregistration errors. The principles and procedures involved in SCT adds a new dimension to CT.[9] The major advantage of SCT over a conventional CT for biliary imaging is its ability to produce a high quality, thin-section scan with small-interval reconstruction and three-dimensional SSD and MPR reconstructions, without any respiratory or misregistration artifacts.[30–32] We compared the quality of the images obtained with IVC and IVC-SCT, and concluded that visualization of the biliary tract was considerably better with SCT than with conventional IVC.[33] Moreover, 5% to 10% of the patients with sphincter problems, Billroth II anastomoses, impacted stones, duodenal diverticula, operator inexperience, and a multitude of factors could not be cannulated during ERC in most studies.[34]

The SCT is now emerging as an effective means of identifying complex anatomical relationships, and a preoperative 3-D reconstruction using IVC-SCT can be performed more easily and safely than ERC. Nevertheless, IVC-SCT will never replace ERC because this procedure does not adequately depict the biliary tree in patients with jaundice and because other diagnostic and therapeutic procedures can be performed endoscopically in conjunction with ERC. The IVC-SCT is able to scan stones by the use of thin axial sections, which decrease partial volume effects, and by the addition of biliary contrast material to increase the visibility of noncalcified stones. The MPR and SSD images are both reconstructed from axial images, and we mainly used MPR reconstructions for the diagnosis of choledocholithiasis because MPR reconstructions can make two-dimensional projections that not only show the biliary tree, but also the stones inside.

Tomikawa et al.[35] reported that in 85 patients with nonvisualized gallbladders on IVC, 51 patients (60.0%) had moderately adhesive gallbladders, and 34 patients (40.0%) had severely adhesive ones. Our study demonstrated that the most important factor in assessing the feasibility of laparoscopic cholecystectomy is not the nonvisualized gallbladder, but the nonvisualized cystic duct on IVC-SCT. The development of laparoscopic cholecystectomy has made the preoperative assessment of the biliary tree more important, and we conclude

Table 4. INTRAOPERATIVE BILIARY DUCT INJURIES

Age (yr)	Gender	Diagnosis	Site of Injury	Surgical Procedure
23	M	GS	CHD	LC, PC, ERBD
36	M	GS	CBD	LC, PC, ERBD
45	F	GS	CBD	LC, PC
74	F	GS	r-HD	LC, T-tube

GS = gallbladder stone; CHD = common hepatic duct; CBD = common bile duct; r-HD = right hepatic duct; LC = laparoscopic cholecystectomy; PC = primary closure of the bile duct; ERBD = endoscopic retrograde biliary drainage.

IVC-SCT may be of benefit for both patients and surgeons scheduled to undergo laparoscopic cholecystectomy.

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