

# Helical computed tomographic cholangiography versus endosonography for suspected bile duct stones: a prospective blinded study in non-jaundiced patients

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## Abstract

**Background**—Helical computed tomography performed after intravenous administration of a cholangiographic contrast material (HCT-cholangiography) may be useful for detecting bile duct stones in non-jaundiced patients. However, this method has never been compared with other non-invasive biliary imaging tests.

**Aims**—To compare prospectively HCT-cholangiography and endosonography (EUS) in a group of non-jaundiced patients with suspected bile duct stones.

**Methods**—Fifty two subjects underwent both HCT-cholangiography and EUS. Endoscopic retrograde cholangiography (ERCP), with or without instrumental bile duct exploration, served as a reference method, and was successful in all but two patients.

**Results**—Thirty four patients (68%) were found to have choledocholithiasis at ERCP. The sensitivity for HCT-cholangiography in stone detection was 85%, specificity 88%, and accuracy 86%. For EUS the sensitivity was 91%, specificity 100%, and accuracy 94%. The differences were not significant. No serious complications occurred with either method.

**Conclusions**—HCT-cholangiography and EUS are safe and comparably accurate methods for detecting bile duct stones in non-jaundiced patients.

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Keywords: bile duct; calculi; endoscopic ultrasonography; computed tomography; cholangiography.

One of the crucial issues in the management of suspected bile duct stones is the selection of patients referred for endoscopic retrograde cholangiography (ERCP). Ideally, this potentially risky procedure should be reserved for patients with proven stones, who require endoscopic treatment, whereas pure diagnostic applications should be avoided whenever possible. Unfortunately, the conventional selection algorithms based on clinical, laboratory, and ultrasonographic data are far from being accurate. As a result, 38-80% of patients who undergo ERCP because of suspected stones turn out to have a clear cholangiogram.<sup>1-4</sup> The

need for a safe and accurate diagnostic test for bile duct stone detection is therefore evident.

Endosonography (EUS) and magnetic resonance cholangiography (MRCP) are recent developments in biliary tract imaging. The sensitivities reported for EUS for bile duct stone detection range from 84 to 97%; false positive results are exceptionally rare, hence the specificity usually approaches 100% (95-100%). Not only is EUS accurate, it is also safe, and virtually no complications have been reported.<sup>1 2 4-8</sup> It has been suggested that this method may replace diagnostic ERCP, especially in patients with low to moderate probability of the presence of stones, in whom the need for therapeutic intervention is less likely.<sup>4 8</sup> Presumably, the same applies to MRCP, but the methodology of this technique has not been fully standardised until now; various examination protocols exist, and the interpretation of the results reported is somewhat difficult.<sup>9-12</sup>

Helical computed tomographic cholangiography (HCT cholangiography), first described in 1993, involves HCT scanning after intravenous administration of a cholangiographic contrast material. This technique has been found to be suitable for biliary tree visualisation and useful for detection of bile duct stones.<sup>13-16</sup> However, it has never been compared with other non-invasive biliary imaging tests such as EUS. The aim of this study was to compare the two methods in a prospective blinded manner in a group of non-jaundiced patients with suspected bile duct stones.

## Methods

### INCLUSION CRITERIA AND PATIENT CHARACTERISTICS

Consecutive inpatients referred for ERCP because of suspected bile duct stones were included in this study, provided that they met the following criteria: the bilirubin level was less than 34  $\mu\text{mol/l}$  (20 mg/l), there was no need for immediate endoscopic treatment, no renal function impairment, and no history of iodine allergy. Only adult patients who gave informed consent in writing were included.

The suspicion of bile duct stones was based on clinical symptoms (history of biliary colic,

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**Abbreviations used in this paper:** CT, computed tomography; HCT, helical computed tomography; EUS, endoscopic ultrasonography, endosonography; MRCP, magnetic resonance cholangiography; ERCP, endoscopic retrograde cholangiography.

Table 1 Clinical, biochemical and ultrasonographic features of study patients, either previously or at the time of presentation

	No of patients (%)	
	Previous history	At presentation
Cholecystectomy	38 (73)	–
Gall bladder in situ	–	14 (27)
Gall bladder stones	47 (90)	9 (17)
Cholecholeduodenostomy, endoscopic sphincterotomy	3 (6)	–
Obstructive jaundice	22 (42)	0 (0)
Acute pancreatitis	8 (15)	0 (0)
Cholangitis	16 (31)	2 (4)
Biliary colic	29 (56)	4 (8)
Biochemical abnormalities*	26 (50)	34 (65)
Bile duct dilatation at transabdominal ultrasonography†	25 (48)	22 (42)
Bile duct stones at transabdominal ultrasonography‡	22 (42)	15 (29)

\*Raised serum aminotransferases and/or alkaline phosphatase and/or  $\gamma$ -glutamyl transpeptidase. †>8 mm in patients with gall bladder in situ; >10 mm in patients after cholecystectomy.

‡Stones visualised (unequivocal finding) or suggested (equivocal finding).

jaundice, cholangitis, acute pancreatitis), and/or biochemical abnormalities (raised serum aminotransferases, alkaline phosphatase,  $\gamma$ -glutamyl transpeptidase), and/or pathological ultrasonographic findings (bile duct dilatation, bile duct stones).

Over a period of 7.5 months, a total of 79 consecutive subjects were considered for inclusion in the study. Fourteen of them were excluded because of elevated bilirubin levels, and 13 for other reasons: known iodine allergy (n = 2), age under 18 (n = 1), need for immediate endoscopic treatment (n = 1), lack of patient's consent (n = 5), administrative reasons (n = 4). The remaining 52 patients were enrolled. There were 44 women and eight men with a median age of 57 (range 34–83) years. Table 1 shows the clinical data on the patients enrolled.

#### STUDY DESIGN

All patients enrolled had EUS, HCT-cholangiography, and ERCP performed within a period of one to seven days (mean three days). The endpoint of the study was the presence of stones in the extrahepatic bile duct. Sphincterotomy followed by exploration of the bile duct with Dormia basket served as a reference method. In patients in whom sphincterotomy was not successful or not attempted, ERCP was the standard of reference. The investigators who performed EUS or HCT-cholangiography were blinded to each other's findings as well as to patients' clinical data except for the fact that bile duct stones were suspected.

#### HCT-CHOLANGIOGRAPHY

CT scanning was performed on an Elscint CT Twin Flash helical scanner (Elscint, Haifa, Israel) with two rows of detectors. Patients were examined in the supine position; no fast before the examination was required. Each examination consisted of two phases. The first, pre-cholangiography plain helical CT of the abdomen, was carried out without any contrast material. The scanning parameters were as follows: 120 kVp, 166 mAs, pitch 1.5, collimation 8 mm. Images were reconstructed every 8 mm.

After the first phase had been completed, the patient received an intravenous infusion of a cholangiographic contrast material, meglumine salt of adiodone (Endocistobil 50%,

Bracco, Milan, Italy); 0.35 ml/kg body weight, diluted in 100 ml saline, infused over about 15 minutes). No pretreatment with H<sub>1</sub> antihistamines or corticosteroids was administered. The patient was also given about 500 ml water orally to distend the stomach and duodenum. The second phase was performed 19 to 140 minutes after the end of contrast infusion (mean (SD) delay of 41 (22) minutes). The scanning parameters were as follows: 120 kVp, 166 mAs, pitch 1.5, collimation 5 mm. Images were reconstructed every 2 mm. Multiplanar and maximum intensity projection images were created using an independent console (Omni-Pro; SiliconGraphics).

All scans were interpreted by a radiologist with five years of experience in abdominal CT, familiar with the conventional intravenous cholangiography technique (J P). Unenhanced HCT was considered positive if a calcific area was identified within the extrahepatic bile duct; other criteria for CT diagnosis of choledocholithiasis<sup>17,18</sup> were not used. The quality of the cholangiograms was rated as excellent, good, or poor. The HCT-cholangiography was considered positive if intraductal filling defects were present. Indirect signs, such as abrupt termination of the common bile duct or its dilatation, were not considered indicative of the presence of stones.

At the end of the study, an additional retrospective review of unenhanced CT scans was conducted. All scans were reviewed carefully for the following diagnostic criteria: (a) a hyperattenuating ring surrounded by hypoattenuating bile or (b) a structure with soft tissue attenuation present within the bile duct.

#### EUS

EUS was performed with a 360° sector scanning echoendoscope (Olympus GF-UM20; Olympus, Hamburg, Germany). All examinations were performed by the same endosonographer (MP), whose expertise was based on about 700 previous EUS procedures. Patients were examined in the left lateral position after an overnight fast. Conscious sedation was achieved with intravenous midazolam (mean 4.3 mg; range 1–10 mg). Pulse rate and oxygen saturation were monitored during the examination. A water filled balloon was used to establish the acoustic coupling. No antispasmodic agents were given. The transducer was introduced into the second portion of the duodenum and then slowly pulled back. This procedure was repeated several times. Pancreatic head, periampullary region, and extrahepatic bile duct were visualised from the descending duodenum or duodenal bulb, and searched for pathology such as stones or tumours. The quality of the EUS images was rated as excellent, good, or poor. EUS was considered positive if it showed single or multiple hyperechoic structures located within the extrahepatic bile duct and associated with acoustic shadowing. The time from scope insertion to the end of the procedure was measured.

## ERCP

ERCP was performed in the standard manner using an Olympus TJF 30 or JF 30 duodenoscope. If the endoscopist failed to cannulate the common bile duct, the procedure was repeated on the following day. Endoscopic sphincterotomy was attempted when ERCP disclosed stones or the common bile duct was dilated. In patients with a clear cholangiogram and undilated common bile duct, sphincterotomy was not attempted.

## STATISTICAL ANALYSIS

Sensitivity, specificity, and overall accuracy were calculated according to standard formulas.<sup>19</sup> The McNemar test for matched pairs was applied to assess whether the differences between the methods studied were statistically significant. Values with  $p < 0.05$  were taken as significant. All analyses were performed using StatSoft Statistica PL package.

## ETHICAL ASPECTS

This study was approved by the research ethical committee of the Medical Centre for Postgraduate Education in Warsaw.

## Results

## REFERENCE METHOD

ERCP was unsuccessful in two out of 52 patients (4%) because of failure to cannulate the common bile duct. These patients were excluded from data analysis.

Thirty four out of 50 patients (68%) were shown to have bile duct stones. This group included 31 patients with positive ERCP, and three in whom stones were not seen at ERCP, and were discovered only after sphincterotomy was performed. In 33 patients, stones were removed endoscopically; in one case sphincterotomy was unsuccessful because of large periampullary diverticula. Stones were multiple in 16 and single in 18 cases. The mean (SD) diameter of a stone was 11 (6.4) mm (range 1–25 mm).

In 16 patients (32%), no stones were detected. In five of them in whom bile duct dilatation was found, sphincterotomy followed by instrumental exploration was performed and did not show any stones; in the remaining 11 cases, the common bile duct was not dilated, hence sphincterotomy was not attempted.

In one patient a carcinoma of the papilla was diagnosed. The tumour was removed surgically and staged as pT2N0 (tumour, node, metastasis classification).

## HCT-CHOLANGIOGRAPHY

The opacification of the distal, middle, and proximal part of the extrahepatic bile duct was excellent or good in 98, 98, and 92% of cases

examined respectively. In only one patient (2%) was no contrast excreted into the bile. Minor and self limiting adverse reactions to contrast agent were observed in two patients (4%). One of them experienced nausea during the first few minutes of contrast infusion; another developed a skin rash on his neck, about an hour after the infusion. No serious complications occurred.

Twenty nine out of 34 patients with stones confirmed by ERCP had positive results on HCT-cholangiography. The sensitivity of this method was 85%. In one patient, a 6 mm large stone was missed because of lack of opacification. The remaining four failures occurred in spite of excellent/good opacification. The stones missed were 1 to 10 mm in diameter.

There were two false positive results in 16 patients found to be stone free at ERCP. The specificity was 88%. In both cases a small filling defect, 4 mm in diameter, was seen close to the end of undilated common bile duct. The overall accuracy of HCT-cholangiography for bile duct stone detection was 86%.

The unenhanced precontrast HCT disclosed stones in eight patients. In all these cases, a calcific area was identified within the bile duct. The sensitivity, specificity, and overall accuracy for unenhanced HCT were 24, 100, and 48% respectively. An additional retrospective review of all scans for other criteria of choledocholithiasis did not result in improved sensitivity. Signs such as a hyperattenuating ring surrounded by hypoattenuating bile, or a structure with soft tissue attenuation within the duct were found in none of the patients. All the stones depicted at unenhanced HCT were also seen at HCT-cholangiography.

In the patient with a pT2N0 carcinoma of the papilla, the tumour was depicted at neither unenhanced HCT or cholangiography; a dilatation of the common bile duct was the only abnormal finding in this case.

## EUS

EUS was performed successfully in all patients. The visualisation of the papilla, the distal, middle, and proximal portion of the extrahepatic bile duct was excellent or good in 92, 100, 100, and 90% of cases examined respectively. The mean (SD) duration of the procedure was 10.5 (4.2) minutes (range 4–23 minutes). No complications occurred.

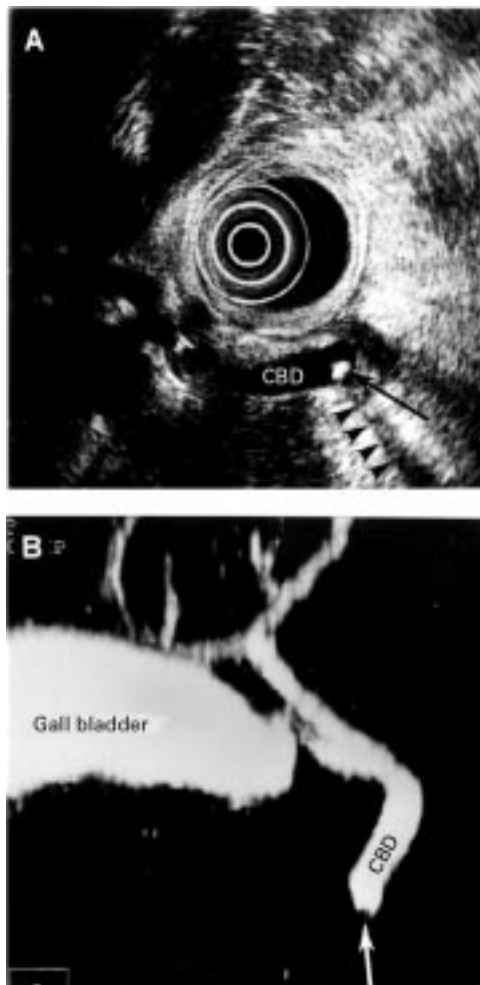
EUS disclosed stones in 31 out of 34 patients who were eventually shown to have stones at ERCP, hence the sensitivity was 91%. There were three false negative results. In two cases multiple small stones, 1–2 mm in diameter each, were missed. In the third case a small soft stone, measuring 3 mm, was misdiagnosed as a polyp of the distal common bile duct. In all these cases, the stones were also not seen at ERCP, and were detected only after sphincterotomy and instrumental exploration were performed.

There were no false positive results for EUS and the specificity for this method was 100%. The overall accuracy of EUS for bile duct stone detection was 94%.

In the patient with carcinoma of the papilla, EUS staged the tumour correctly as T2N0.

Table 2 Endosonography and helical computed tomographic (HCT)-cholangiography in the detection of bile duct stones confirmed by endoscopic cholangiography

	Endosonography	HCT-cholangiography	p Value
Sensitivity (%)	91 (31/34)	85 (29/34)	NS
Specificity (%)	100 (16/16)	88 (14/16)	NS
Overall accuracy (%)	94 (47/50)	86 (43/50)	NS



**Figure 1** Small stone, 4 mm in diameter, in the distal part of undilated common bile duct (CBD). (A) Endosonographic image showing the stone (black arrow) with acoustic shadowing (arrowheads). (B) Helical computed tomographic cholangiography; maximum intensity projection image shows the gall bladder and both the intrahepatic and extrahepatic bile ducts. The small filling defect (white arrow) close to the end of the common bile duct represents the stone.

COMPARISON OF THE METHODS STUDIED

Table 2 summarises the results of EUS and HCT-cholangiography in bile duct stone detection. Although EUS tended to be more sensitive and specific, the differences did not reach the level of statistical significance.

Figures 1 and 2 show examples of cholangiographic and EUS images obtained in patients with bile duct stones.

**Discussion**

Standards for modern tests for bile duct stone detection are set very high. Only methods that offer advantages over EUS or MRCP may be considered eligible. As the safety and accuracy of EUS is well established,<sup>1 2 4-8</sup> and as presumably the same applies to MRCP,<sup>9-11 20</sup> the need for another biliary imaging test may be questioned. However, both EUS and MRCP are not widely available, and their usefulness is further limited by high costs.<sup>21</sup> The relatively low cost of HCT scanning and its high accessibility are reasons why HCT-cholangiography should be considered as an attractive alternative.



**Figure 2** A single 10 mm bile duct stone shown by endosonography (A) and helical computed tomographic (HCT)-cholangiography (B, C). (A) A hyperechoic structure (white arrow) is seen associated with acoustic shadowing (black arrowheads), which is a typical appearance of a stone at endosonography; CBD indicates the common bile duct. (B) HCT-cholangiography; an axial image at the level of the distal common bile duct shows a filling defect (black arrow) which corresponds to the stone seen at endosonography. White arrowheads delineate the cross section of the common bile duct containing contrast enhanced bile. (C) HCT-cholangiography; multiplanar reconstruction image in the same patient. The stone (white arrow) is seen as a polygonal filling defect.

This is the first study to compare HCT-cholangiography and EUS in non-jaundiced

patients with suspected bile duct stones. Both methods turned out to be highly effective in the visualisation of the extrahepatic bile duct, especially of its distal part. The sensitivity and specificity of HCT-cholangiography for bile duct stone detection were 85 and 88% respectively. These figures are close to those reported by Stockberger *et al*<sup>14</sup> (sensitivity 86%, specificity 100%) and Kwon *et al*<sup>16</sup> (sensitivity 85%, specificity 97%). The performance of EUS (sensitivity 91%, specificity 100%) was not significantly superior, but the lack of a significant difference may be a reflection of a relatively small number of cases studied. Both methods are safe, and no serious complications occurred.

The shortcomings of HCT-cholangiography include the ineffectiveness in jaundiced patients and the risk of adverse reactions to contrast material. As in the case of conventional intravenous cholangiography, the use of HCT-cholangiography is limited to individuals with normal serum bilirubin level, and 18% of our patients had to be excluded for this reason. The examination may be performed successfully in some subjects with bilirubin levels between 34 and 85  $\mu\text{mol/l}$  (2–5 mg/dl), but it is time consuming and less effective under such circumstances.<sup>14 22</sup> All this seems to be a serious drawback; however, jaundiced patients are likely to benefit from ERCP and endoscopic treatment, so that other imaging tests are less important in this situation.<sup>23 24</sup> In patients with bilirubin levels less than 34  $\mu\text{mol/l}$ , successful opacification of the biliary tree can be achieved in the vast majority of cases. Kwon *et al*<sup>16</sup> were able to visualise the bile duct in all 440 patients examined, and this result was significantly better than conventional intravenous cholangiography. The technical success rate in our series was similar; the contrast failed to be excreted into the bile in only one patient (2%).

One should always keep in mind the risk of adverse reactions to the contrast material administered during HCT-cholangiography; however, no serious complications have been reported in previous studies<sup>14 16</sup> or the current one. Only two patients (4%) experienced minor self limiting adverse reactions to slow infusion of adiodone meglumine, the contrast agent used in our study. Meglumine iotrexate, a newer agent claimed to be less toxic, should be used to minimise the risk of complications.<sup>14 16 25 26</sup>

Each patient in our group was scanned twice, before and after contrast administration, and each of these two phases had a different impact on the final diagnosis. The aim of cholangiography was to depict stones isoattenuating to bile, whereas unenhanced HCT was intended to detect calcified stones, which could be obscured by contrast enhanced bile at cholangiography. However, unenhanced HCT disclosed only 24% of stones, and all of them were also visible at subsequent cholangiography. We believe therefore that scanning before cholangiography may be omitted in order to reduce the exposure to radiation as well as the cost of the examination.

A serious limitation of our study is the fact that the scanning and reconstruction param-

eters used during the unenhanced HCT differed from those applied in the cholangiographic phase of the examination. The unenhanced images were obtained by using 8 mm thick sections and a pitch of 1.5, and were reconstructed in 8 mm increments. This could lead to blurring of small partially calcified stones with adjacent soft tissue, as well as to obscuring small stones as the result of partial volume averaging. It is possible that the low sensitivity of unenhanced HCT in our series resulted, at least in part, from less than optimal examination technique. This may also explain the discrepancy between our results and those reported by Neitlich *et al*,<sup>18</sup> who performed unenhanced HCT by using a very precise examination technique and achieved excellent sensitivity of 88% and specificity of 97% for direct depiction of stones. Another possible explanation for this discrepancy could be the different diagnostic criteria applied in the two studies. In our study, a stone was considered to be present only if a calcific area was identified within the bile duct. We did not use any other criteria, such as a hyperattenuating ring surrounded by hypoattenuating bile, or a structure with soft tissue attenuation present within the duct, and this may have resulted in low sensitivity. However, an additional retrospective review of all scans for the criteria given above did not improve the sensitivity of unenhanced HCT for stone detection. Further studies are required to decide whether there is a need to combine cholangiography with HCT scanning, or if the latter technique alone is accurate enough to be useful in patients suspected of having bile duct stones.

To conclude, HCT-cholangiography is a safe non-invasive procedure useful for detection of bile duct stones in non-jaundiced patients. The sensitivity and specificity of this method approach those of EUS. We believe that HCT-cholangiography offers a cheaper and more accessible alternative to EUS or MRCP, and that, despite certain limitations, it should be added to the list of modern biliary imaging tests.

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- 1 Amouyal P, Amouyal G, Levy P, *et al*. Diagnosis of choledocholithiasis by endoscopic ultrasonography. *Gastroenterology* 1994;**106**:1062–7.
- 2 Palazzo L, Girollet PP, Salmeron M, *et al*. Value of endoscopic ultrasonography in the diagnosis of common bile duct stones: comparison with surgical exploration and ERCP. *Gastrointest Endosc* 1995;**42**:225–31.
- 3 Chan AC, Chung SC, Wyman A, *et al*. Selective use of preoperative endoscopic retrograde cholangiopancreatography in laparoscopic cholecystectomy. *Gastrointest Endosc* 1996;**43**:212–15.
- 4 Prat F, Amouyal G, Amouyal P, *et al*. Prospective controlled study of endoscopic ultrasonography and endoscopic retrograde cholangiography in patients with suspected common-bile duct lithiasis. *Lancet* 1996;**347**:75–9.
- 5 Shim CS, Joo JH, Park CW, *et al*. Effectiveness of endoscopic ultrasonography in the diagnosis of choledocholithiasis prior to laparoscopic cholecystectomy. *Endoscopy* 1995;**27**:428–32.
- 6 Aubertin JM, Levoir D, Bouillot JL, *et al*. Endoscopic ultrasonography immediately prior to laparoscopic cholecystectomy: a prospective evaluation. *Endoscopy* 1996;**28**:667–73.
- 7 Sugiyama M, Atomi Y. Endoscopic ultrasonography for diagnosing choledocholithiasis: a prospective comparative

- study with ultrasonography and computed tomography. *Gastrointest Endosc* 1997;**45**:143-6.
- 8 Canto M, Chak A, Stellato T, *et al*. Endoscopic ultrasonography versus cholangiography for the diagnosis of choledocholithiasis. *Gastrointest Endosc* 1998;**47**:439-48.
  - 9 Chan YL, Chan AC, Lam WW, *et al*. Choledocholithiasis: comparison of MR cholangiography and endoscopic retrograde cholangiography. *Radiology* 1996;**200**:85-9.
  - 10 Holzkecht N, Gauger J, Sackmann M, *et al*. Breath-hold MR cholangiography with snapshot techniques: prospective comparison with endoscopic retrograde cholangiography. *Radiology* 1998;**206**:657-64.
  - 11 Reinhold C, Taourel P, Bret PM, *et al*. Choledocholithiasis: evaluation of MR cholangiography for diagnosis. *Radiology* 1998;**209**:435-42.
  - 12 Zidi SH, Prat F, Le Guen O, *et al*. Use of magnetic resonance cholangiography in the diagnosis of choledocholithiasis: prospective comparison with a reference imaging method. *Gut* 1999;**44**:118-22.
  - 13 Klein HM, Wein B, Truong S, *et al*. Computed tomographic cholangiography using spiral scanning and 3D image processing. *Br J Radiol* 1993;**66**:762-7.
  - 14 Stockberger SM, Wass JL, Sherman S, *et al*. Intravenous cholangiography with helical CT: comparison with endoscopic retrograde cholangiography. *Radiology* 1994;**192**:675-80.
  - 15 Kwon AH, Uetsuji S, Ogura T, *et al*. Spiral computed tomography scanning after intravenous infusion cholangiography for biliary duct anomalies. *Am J Surg* 1997;**174**:396-401.
  - 16 Kwon AH, Inui H, Imamura A, *et al*. Preoperative assessment for laparoscopic cholecystectomy: feasibility of using spiral computed tomography. *Ann Surg* 1998;**227**:351-6.
  - 17 Baron RL. Common bile duct stones: reassessment of criteria for CT diagnosis. *Radiology* 1987;**162**:419-24.
  - 18 Neitlich JD, Topazian M, Smith RC, *et al*. Detection of choledocholithiasis: comparison of unenhanced helical CT and endoscopic retrograde cholangiopancreatography. *Radiology* 1997;**203**:753-7.
  - 19 Goldman L. Quantitative aspects of clinical reasoning. In: Wilson JD, Braunwald E, Isselbacher KJ, *et al*, eds. *Harrison's principles of internal medicine* (12th ed). New York: McGraw-Hill Inc, 1991:5-11.
  - 20 Bearcroft PW, Lomas DJ. Magnetic resonance cholangiopancreatography. *Gut* 1997;**41**:135-7.
  - 21 Baron RL. Diagnosing choledocholithiasis: how far can we push helical CT? *Radiology* 1997;**203**:601-3.
  - 22 Goldberg H. Helical Cholangiography: complementary or substitute study for endoscopic retrograde cholangiography. *Radiology* 1994;**192**:615-16.
  - 23 Cotton PB. Endoscopic retrograde cholangiopancreatography and laparoscopic cholecystectomy. *Am J Surg* 1993;**165**:474-8.
  - 24 Barkun AN, Barkun JS, Fried GM, *et al*. Useful predictors of bile duct stones in patients undergoing laparoscopic cholecystectomy. McGill Gallstone Treatment Group. *Ann Surg* 1994;**220**:32-9.
  - 25 Nilsson U. Adverse reactions to iotrexate at intravenous cholangiography. A prospective clinical investigation and review of the literature. *Acta Radiol* 1987;**28**:571-5.
  - 26 Lindsey J, Nottle PD, Sacharias N. Preoperative screening for common bile duct stones with infusion cholangiography: review of 1000 patients. *Ann Surg* 1997;**226**:174-8.